

OFFICIAL JOURNAL OF THE
INSTITUTE OF EXPLOSIVES ENGINEERS
JUNE 2017

Explosives Engineering

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The application of continuous
free-space microwave
interferometry to explosively
driven case fragmentation
experiments

Page 28

Resonant Acoustic Mixing
of energetic materials



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Cover picture:
3D model of a
fragmenting stainless
steel cased charge.
(See page 18).



Explosives Engineering

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VOICE OF THE EXPLOSIVES INDUSTRIES



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The President speaks

I am delighted to report the success of our recent AGM and Conference held at Norton Park, Winchester. The feedback received was some of the best for many years and although numbers attending has remained relatively constant it is felt that the quality and value of the event has improved greatly. The credit for this rests with Vicki Hall (Office Manager) and Charlene Firkins (Marketing Co-ordinator) who have barely broken step before beginning to plan next years event(s). We are looking to evolve the AGM and conference calendar next year and will be looking to hold two major events. The first will be in April and will include the AGM, a mini conference package, practical demonstrations and a gala (black tie) dinner to which partners will be invited. This event will be held over a weekend with a view to allowing greater member attendance at the AGM and inclusion in the professional networking and social aspects. The second event will be held later in the year (September dtbc) and will be a two day conference package aimed at bringing together a wide range of explosives related professionals for knowledge sharing, networking, CPD and industry awareness. This conference event will be held mid week and also provides an opportunity for some of our affiliated organisations to join alongside us for the conference period. Further information on both events will be published shortly however, in the meantime, any suggestions or a wish to be more actively involved in the events (perhaps as a speaker or provide a demonstration) should be directed to Charlene Firkins (CharleneFirkins@iexpe.org).

It is very pleasing to note the continued efforts of our overseas members who have been gathering at a series of events over recent months. By way of a reminder, any member wishing to host or organise a networking event can access support and funding on the basis the event is aimed at members. Other events which are

perhaps more speculative or marketing-based can also be supported but would be evaluated based on likely benefit and efforts already being expended in a given sector. We rely heavily on the knowledge and network of you, the members, and as we continue to grow in number we wish to remain in tune with industry developments, opportunities and the needs of all our members. We welcome feedback which can be provided via the various email contacts outlined within the journal, via the website or indeed over the phone. Equally, members are always encouraged to engage with council members whenever you encounter them and ask 'what they are doing on your behalf'.

This edition of our journal includes, as ever, a variety of articles across a very broad spectrum of topics and industry areas. I would, however, wish to highlight the report from our Projects Co-ordinator (Chris Tunstall) which has some useful information regarding the broader SSSG and associated work strands and which may be of interest to those not familiar with the work of the SSSG group.

Finally, at the time of writing (Tuesday 23rd May) this President Speaks, my thoughts are drawn to the shocking events unfolding in Manchester. All those working in the field of explosives understand well the capabilities of these highly energetic substances when put to positive use, but their use for nefarious gain always reinforces the need for vigilance, appropriate controls over access to such substances and the continued need to support the efforts of our invaluable Police and security services. Our thoughts are with the families of those who lost their lives in this attack along with those individuals who are now undergoing treatment for their injuries.

Stay Safe and be Vigilant..

Dave Welch FCMI MIExpE MIABTI
President

Are you missing out!

Monthly updates are sent out via email. If you are not receiving these, please contact head office.

Telephone: 01785 594136

Email: vickihall@iexpe.org

We may not have your correct details


VOICE OF THE EXPLOSIVES INDUSTRY
FELLOWS' LUNCH
 The Moor House
 Lower Penkridge Road, Acton, Stafford, ST17
 Wednesday 20th September 2017
 13.00
 Lunch per head £25
 Contact: chris@iexpe.org if you wish to attend, limited spaces available

New Members:

Congratulations and a warm welcome to our new Institute Members and those transferring grades

Approval Date 8th February 2017

Colin Philip Mew
Michael John Heppell
Paul Sims

Glyn Hannah
Colin Grant
Patrick James Stagg McMaster
Robin Gilles Gonard

Approval Date 24th March 2017

Paul Kristan
Gemma Holton
Richard Charles Hope
Kevin John England
Barry Stephen White
Christopher Andrew Hester
Jonathan Stephen Attwood
Robert Reid Cargill
Michael Hammond
Ian James Powell

Peter Malcolm Waters
Michael Sean Connorton
Luke Joseph Mittins
Andrew Taylor Gray
John Michael Fitzgerald
Lisa Jane Tang
Jonathan James Dainty
Caroline Emma Allen
John Lindars

Approval Date 2nd May 2017

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Obituary - Lieutenant Colonel John KP Coghill OBE MIExpE

17th July 1929 to 4th February 2017

John spent his early professional years in the Royal Army Ordnance Corps (RAOC) as an Ammunition Technical Officer (ato) having been educated at The Royal Military College of Science (RMCS) and trained at the Army School of Ammunition (AS of A) Bramley. He was later based at Hounslow and supported the Metropolitan Police Bomb Squads when they were in need. His knowledge of the London area stood him in great stead as life developed.

On leaving the Regular Army he had an idea which he developed internationally, the great task of co-ordinating and organising International Conferences on Terrorist Devices (ICTD). A subject he made his own. He attracted a host of like-minded experts and this international group helped UK in its work as researchers, developers and practitioners to be the world's leading nation at that time and in helping the western world in its fight against terrorism. We were of course also dealing with the matter in our own backyard, a point not lost on the various Home Secretaries who knew John.

As an aside, John with another colleague David could successfully give you "The Odds" on many four legged friends. He even had a long



running bet by Diana, his own lady, who survives him with their three daughters...on how long to clear the domestic garage. The odds on that proved to be very, very long...but they did support him at the various social functions of the ICTD to ...encourage him!

His membership of the Institute, with which most ato are associated, was achieved in 1989.

A kindly and true gentleman, expert and family man, who would lunch at Deepcut or RMCS Shrivenham with various colleagues, such as Professor James Turnbull, Colonel "Mac" Mackenzie-Orr AM, Robert Leindecker and other international experts to review the "State of the Nation" over a warm beer... and who stood a chance in the 3.15 at Kempton.

Sadly missed by his family and his worldwide community.

Mike Groves, ato MIExpE MIMCSE

EUExcert UK report

EUExImp Project

8th International Conference on Explosives Education and Certification of Skills

The 8th ICEECS will be held at the Best Western Arlanda Hotellby, Arlanda, Sweden on 13th to 14th June 2017.

The overall objectives of the conference are to contribute to the harmonization of training and qualification of personnel in the explosives sector, for the development of a transferable certificate of Explosive Competences, through the discussion and sharing of knowledge, as well as experiences on the training and procedure of accreditation of individual competencies. The conference addresses all people occupied and active in the sector of explosives (explosives, propellants and pyrotechnics) from Governmental Agencies, Education Institutions, Employers and Employees Societies, Public and Private Companies in the Civil and Military areas.

The call for papers and details of registration can be found at <http://www.euexcert.org/pdf/The-8th-International-Conference-on-Explosive-Education-and-Certification-of-Skills-2017-final.pdf>

Handbook for the implementation of occupational standards in the explosives sector

The second of the project's 'intellectual outputs', a "Handbook for the Implementation of Occupational Standards in the Explosives Sector", will be launched at the 8th ICEECS. This handbook should be of interest to anyone who has a desire to define or measure the competence of individuals in the explosives industry. The Occupational Standards and processes described in the handbook can be used in qualifications or as management tools, in training development or delivery, the handbook has something for most people in the explosives industry. Whether you or your organisation is a training provider, individual candidate, organisation seeking qualifications or another way of measuring competence of explosives-workers in the workplace, a regulator or other interested party, there is useful information here for you.

The handbook is intended to provide the reader with the how and why of implementing Occupational Standards for Explosives, Munitions and Search Occupations. The 'how' is succinctly demonstrated through the associated 'Step-by-Step Guide to the Implementation of Occupational Standards'. The 'why' is demonstrated through the case studies of each of the 'industry partners' in the EUExImp project.

Meetings

Since the last report, the following meetings have taken place:

- PT Partner Meeting, Penafiel – 20th to 22nd February 2017
- SE Partner Meeting, Karlskoga – 6th March 2017
- UK Partner Meeting, Ashcott- 14th March 2017
- Project Meeting, Coimbra – 27th March 2017
- PT Partner Meeting, Coimbra – 28th March 2017

These meetings are planned:

- Project Meeting, Karlskoga – 12th June 2017
- International Workshop, Karlskoga (8TH ICEECS) – 13th and 14th June 2017

Partner activities

Estonia – The member of Voglers Eesti who is working towards L3 qualification for Explosives Safety Management – Supervisor has had confirmation that her portfolio meets the Standards required for her qualification and she is now awaiting the award of her qualification. The Tallinn University of Technology (TUT) members of staff responsible for their part of the project are working through the project case study in preparation for incorporation into the proposed handbook. TUT and Voglers are also working to make use of the Standards in the Estonian vocational qualifications framework for other explosives workers.

Germany – Having conducted the comparison study, the partners are considering whether the NOS might be useful in practical terms, given that explosives qualifications are enshrined in law in Germany. They are working on their case study for the Handbook.

Portugal – The two assessors qualified in February 2017 and have begun to assess the candidates for L4, L3 and L2 qualifications in Explosives Operations. These candidates have been registered through an accredited HSQ qualifications centre and it is hoped that they will qualify before the end of the EUExImp project. GJR still has an aspiration to become a qualifications centre in its own right, providing externally verified qualifications for other explosives operators in Portugal.

The company and the assessors are now working on the case study for the Handbook.

The University of Coimbra partner is also on the executive of the Portuguese association for explosives engineers (AP3E), which held its annual conference on 28th March 2017, which included a presentation from the project technical advisor, entitled 'UK Occupational Standards for ESA and EUExImp'. The presentation was well received and it is hoped that it provided some food for thought and impetus to the desire for national qualifications for explosives workers.

Sweden – The driver for their partnership in the project is their work towards ISO 17025 accreditation, which requires an organisation to ensure that its staff are competent to conduct their work. At the March meeting, the project technical advisor gave a presentation on the principles and practices of assessment in the workplace, which was followed by a continuation of the discussion about the practicalities of providing assurance for their ISO 17025 bid and the complexity that they have been trying to overcome in integrating the NOS with their existing HR system.

To help them understand the practical use of the NOS as a means to demonstrate competence across the company, we looked at the structure of NOS for ESA and some for radar operations and specialist photographic applications.

At the Coimbra project meeting, the president of BTC informed the members of the project that he had decided not to pursue the direct use of the Standards for his explosives workers but they will make use of appropriate principles and methods from their experience in the project to develop a competence framework for their instrumentation staff as well as the explosives workers.

UK – following on from the development of SFX qualifications, they are designing new training and assessment courses, mapping their existing training materials to the NOS to identify gaps, and developing an assessment strategy that will satisfy their end-users and the HSQ awarding organisation. This work continues and at the development meeting on 14th March 2017, a considerable amount of effort went into the development of training and assessment materials.

Outputs

The two 'intellectual outputs' (EC terminology) from the project are: A step-by-step guide which will provide users with the mechanics of implementing the occupational standards. The first edition of the step by step guide was published by KCEM AB on the EUExcert website on 27th June 2016.

<http://www.euexcert.org/pdf/EUExImp-Step-by-Step-Guide-to-Implementing-Occupational-Standards-First-Edition.pdf>

The handbook is described in greater detail above. It is due to be published at the end of the project, in the summer of 2017.

EUExcert Association

As the EUExImp project enters its final stages, the partners are considering the sustainability of the EUExcert Association, which still has the potential for further developments (BREXIT notwithstanding) and support for members.

Ken Cross MBE CEng MSc BSc(Hons) FIEpE

Chairman, EUExcert UK

Registrar report

Professional Registration

Professional registration statistics as at 30th April 2017

	CEng	IEng	EngTech
QUALIFIED	28	6	3
IN PROGRESS	4	3	0

Application forms sent but not yet received back - 52.

Continuous Professional Development

Continuous Professional Development (CPD) is one of the main attributes of a professional explosives engineer and it ranks alongside ethical behaviour as one of the key commitments made by a professional registrant at any grade. I am pleased to say that in my various journeys among our members, I see the desire for 'professionalism' across the board, from the academics and military to the trails safety manager, shotfirer, special effects operator and explosives licensing officer. These members, be they Student, Associate, Technical Member, Member or Fellow, all share a desire to act professionally and to be seen as working in a professional way.

You are all aware, from my previous ministrations, that the Institute expects all professional registrants to undertake and record at least 30 hours' CPD per year. Keeping up with current legislation, developments in explosives science & technology and developments in other fields that might have a bearing on our sphere of work, are all elements of CPD that I have little doubt that all of us try to achieve with varying degrees of success. We all operate in a high-hazard, thankfully low-frequency of incidents, sphere and almost any incident has the potential for gaining unwanted media attention. In the worst cases, it might lead to external investigation and possibly court cases. In these circumstances, ignorance of changes to legislation etc. are no excuse and I therefore exhort all members of the Institute to commit to planning, undertaking and recording some CPD this year and beyond.

I suspect that almost all of you will say that you don't have time. Remember that our definition of CPD is framed around the simple question "have I learned something from this?" Technical meetings, briefings and presentations you attend or give are highly likely to have some element of learning on your part when you think about it.

Mycareerpath

Mycareerpath is a 'free for the user' CPD recording application that is available to all members of the Institute and I recommend its use to all. It is easy to register and use; entries can be made from your smartphone, tablet, laptop or PC.

From the website, start here...

<http://iexpe.org/information-library/careers-development/mycareerpath/>

I look forward to seeing some new users on the system and greater use by those who are already registered, to improve our usage statistics:

Special Registration Events

AWE hosted a very well-attended Special Registration Event on 9th February 2017 and we are working on a DE&S ShareShop, a QinetiQ Shoeburyness event and a BAE Systems event at Warton.



Ken Cross MBE CEng MSc BSc(Hons) FIEpE

kencross@iexpe.org

Project Coordinator's report

Gratitude and thanks

Before continuing please allow me to express my gratitude and thanks at being introduced, by you, into the explosives community! Everywhere I have been I have encountered a multitude of knowledgeable individuals, and have always been made to feel very welcome. And I have been to a few places these last few months; my google timeline has never seen so much activity:

The majority of the activities I have been involved in thus far, relate to the Sector Skills Strategy Group (SSSG). I am pleased to share with you the changes that are taking place within this group.



Brief SSSG history

Before I do that, I am acutely aware that not all people know what the SSSG is or does. In brief, I will try to provide some background history, bearing in mind that six months ago, I didn't know myself! The SSSG, or again the Sector Skills Strategy Group, was formed on the back of the 'ESA Entity Feasibility Study' undertaken by Prof J.Akhavan & Dr D.Tisley on behalf of the MoD. In their report, they emphasised the already widely recognised risk of a loss of skills/competence that was in decline within the ESA (Explosives Substances and Articles) community. The report, as the title suggests, set out to identify the possibility of a single entity to address the decline within the UK's explosives workforce.

In the years after the report, the Institute of Explosives Engineers put forward a proposal for a 'Sector Skills Strategy Group'; the entity described within Prof J.Akhavan & Dr D.Tisley's report. In the early months of 2011 the group was formed. It was supported by the DOES (Development Office for Explosives Standards) that was run by the Institute and contracted Allan Hinton as the Programme Manager.



What is the SSSG now?

The SSSG is now made up of the UK's top defence companies with the Institute at its core. It holds quarterly meetings which are attended by the top influential people of those companies. Underneath the group are the EWGs (Expert Working Groups) who gather on a regular basis and perform tasks in keeping with meeting the aims and objectives of the SSSG; they share best practices and provide updates on activities within the community.



Early Careers Focus Group

One initiative of the SSSG was the creation of the Early Careers Focus Group (ECFG) and is made up of and run by apprentices, graduates and those within the first 10 years of their career. The ECFG was set up to ensure that those personnel are fully represented in the planning that will shape the sector. A real jewel in the ECFG crown is the Early Careers Symposium which is highly valued by the SSSG and the delegates who attend.



Recent activities and the future of the SSSG

I attended my first SSSG meeting on the 8th March, since receiving the baton from Allan Hinton. It went very well, and both Mark Hardman (SSSG Chairman) and I were able to convey our vision and aspirations to the rest of the group. It was well received and we found that the rest of the group were all of the same mindset. This was encouraging and it showed how passionate the leaders of the UK defence sector are about retaining and growing explosives skills within the UK.

The main words to sum up these changes are; 'task focused'. The Expert Working Groups (EWGs) are being reorganised so their main focus is the completion of tasks. Historically the meeting of like-minded individuals has enabled a good platform for networking and the sharing of knowledge. But now is the time to work more to achieve the SSSG's main objectives to retain explosives skills and attract new talent to the UK explosives sector. This is not to say that networking and sharing knowledge and best practices are not

important; there is a time and place for these also, and these activities will take place in the form of designated networking, CPD or conference styled events.

SSSG structural changes

To enable a more task-focused approach, the EWGs are being restructured to be more streamlined, and ultimately, easier to manage. The EWGs in their current format of seven individual groups will be restructured into three, going from this:



To this:

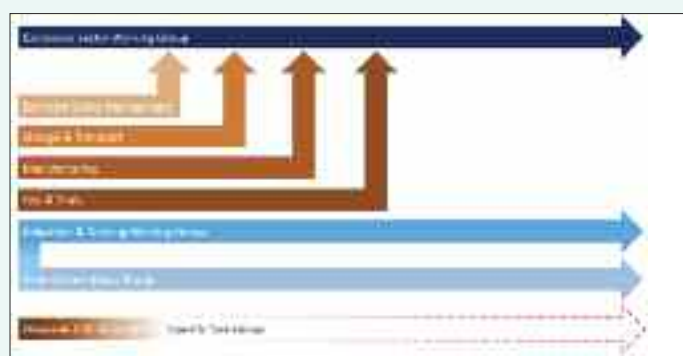


As you can see, the 'Education & Training Group' (E&TG) stays as it is, and so does the Early Careers Focus Group (ECFCG) but with the difference that the ECFCG will be steered by the E&TG. All of the other groups will form what was being dubbed the 'supergroup', but is now the 'Explosives Sector Working Group' (ESWG). Although this group may seem generalised there will be opportunity for themed meetings that explore all aspects of the explosives sector. When a need is identified for a specific task to be performed by those within a particular area, a 'Specific Task Group' (STG) will be generated.

EWG migration

The migration of these changes can be demonstrated by the illustration on the next column. Note that the Disposal group is now being classed as one of the specific task groups, so they can solely focus on their task at hand.

The ESWG will be chaired by QinetiQ's Peter Honey and will be made up of co-chairs from the previous individual working groups. Amongst other tasks this group will continue to work on the 'Past Accident Review' (PAR), and will discuss specific topics within the UK explosives sector and will feed back the need for the creation of a specific task group to the SSSG.



Formation of a plan

With the ESWG, E&TG & ECFCG all feeding back to the SSSG the need to address specific aspects of retaining explosives skills in the UK, the SSSG will be able to offer more direction and more focus, and ultimately, a plan. A simple analogy I gave within the last SSSG meeting was buckets! Buckets have a capacity, and you can fill your bucket right to the top, which is fine, but then you have over-fill. The trick is to fill your bucket and know your capacity, with the over-fill you pour that into the next bucket, so on and so forth. And there you start to develop a plan! There's a bit more to it than that, but like I said, 'a simple analogy'!



What is current

Amongst all these changes the existing groups continue their work. The Education and Training Group are close to delivering a level 2 course on basic explosives knowledge. The individual members making up the SSSG still support the degree level 6 WOME apprenticeship currently in development, and has seen wide support across the industry. Organisation of the 2017 OME symposium in Shrivenham is going well, dates for that event are the 31st October and 1st November, visit <https://www.cranfield.ac.uk/events/symposia/sym-ome> for more details and to book your place. The Early Careers Symposium has been rescheduled and will now take place on the 13th and 14th September 2017 at the Oxford Belfry in Milton Common, Thame OX9 2JW. It is set to be the best Early Careers Symposium yet!

Future work

A main focus to come will be to set up an informal mentoring network made up of experienced people from the explosives community. With support from the SSSG these people will provide a steer for those looking for help and guidance in their career. Not only is the SSSG focusing on retaining skills, but it is also horizon scanning and looking into skills that might be needed for the future.

One last thank you

Lastly, let me again thank you all for your continued support, I look forward to working with you all over the coming months. Please feel free to contact me any time and share with me your own thoughts on how we can retain explosives skills within the UK.

Chris Tunstall IExpE Project Coordinator

Further information: christunstall@iexpe.org.

EARLY CAREERS SYMPOSIUM 2017

REGISTRATION OPEN!

The Early Careers Symposium is in its third year. The event draws together a range of industry and government professionals who are involved within the explosives and weapons sector, most of whom are within the first 10 years of their careers in the field.

The conference is organized by the Early Careers Focus Group (ECFG), a sub-group of the Sector Skills Strategy Group.

WHAT TO EXPECT

- Diverse presentations
- Networking opportunities
- Attendance counts toward CPD
- Team building
- Demonstrations
- Poster competition

Book your place today.

Fees: **£300** for two days, including formal evening dinner and networking reception

Additional night accommodation: £100 Day only rate: £78

Contact the Early Careers Team or your company representative to book your place today!

earlycareersymposium@gmail.com

13TH & 14TH SEPT 2017
THE OXFORD BELFRY
THEME:

COLLABORATION



TOPICS OF DISCUSSION

- Working with Health and Safety
- Materials
- Protection, Detection and Analysis
- Emerging Technologies

SEEKING EARLY CAREERS SPEAKERS

Do you want the opportunity to present on a topic of your choosing to a community of your peers?

Enhance your profile within the community and make valuable contacts within the field of your knowledge & expertise

If you wish to propose a talk for an early careers slot, include the title of your proposed talk when submitting your symposium registration.



Networking events

Presentation at Camborne School of Mines

In today's economic climate students entering into Camborne School of Mines alumni have very few interactions with companies who have uplifting news about potential jobs. They often find themselves confronted with few or no job opportunities or guidance as to where they can take their degree. In March a visit from the IEXPE was very well received; although exposed to explosives at both university and respective placements, the opportunities the explosives industry has to offer are not well known to students. Both Rob Parry and Andrew Pettit gave a stimulating insight into a new and diverse option the IEXPE and associated industries have to offer. Students at CSM who didn't know what options were available to them left the talk with certainty that their well renowned CSM degree put them in good stead in more than just the mining world. Rob Parry represented the options for a life in the MOD while Andrew shared experiences and options for trained explosive engineers, and with certainty if connections were continued to be made between CSM, IEXPE and the MOD then all parties would benefit greatly.

On behalf of the students I would like to extend our gratitude to Rob and Andrew and hope that they continue to return to CSM.

Nathanael Halkes-Wellstead

CSM Student President

Further information:

Nathalkes@gmail.com



Andy Pettitt and Nathanael Halkes-Wellstead, Student President, discussing career options at the Camborne School of Mines.

Andy Pettitt presenting at the Camborne School of Mines.



Networking in the USA

Under the direction of David Ayre MIEpE a Texas (USA) regional networking meeting was held on 16th February 2017. This meeting was hosted by Halliburton's Jet Research Center (Alvarado, Texas) in their conference facility. The region of Texas from Fort Worth to Houston contains a large number of personnel involved in explosives for the oil and gas, and defense industries. Most local explosives development organizations were well represented by the 28 attendees, 4 of which are current Institute members. David Ayre of BP opened the meeting with a welcome and introduction to IExpE and the benefits of membership. This was followed by a technical presentation by Mike Fortner, Adjunct Lecturer of New Mexico Tech, on the origins of Insensitive Munitions (IM) Policy and a detailed discussion of some practical IM applications used for solid rocket motors. Tom Burky (MIEpE) of Halliburton then presented the rationale, reaction mechanisms and practical aspects of utilizing Thermobaric Explosives (TBX). The evening was closed by an off-site social gathering and informal discussions. Several individuals expressed interest in either new or renewing their memberships to

the Institute and application materials were provided. Following such a positive response, further networking meetings are planned for the coming months.

A further Texas, USA, regional networking meeting was held on 24th April 2017 under the direction of Tom Burky MIEpE. This meeting was hosted by Halliburton's Jet Research Center (Alvarado, Texas) in their conference facility and was scheduled to coincide with the Houston area networking meeting hosted by David Ayre MIEpE the week before. The core local explosives product development organizations were well represented by the ten on-site attendees, three of which are current Institute members, as well as one on-line attendee. Tom Burky of Halliburton opened the meeting with a welcome and introduction to IExpE and the benefits of membership. The increasing network activity of the Institute was highlighted by this event as well as the upcoming event in Germany. This was followed by a technical presentation by Andy Pettit FIEpE, on the Terrorist Use of Improvised Explosive Devices, though it also discussed terrorist tool and strategy beyond just this scope. The meeting was closed by an off-site social gathering and informal discussions. The final details for at least three new applications for membership were discussed, with Andy providing clarification of this process as well as chartering of engineers. Further networking meetings are planned for the coming months as several prospective technical presentation topics have been offered.

Thomas Burky MIEpE

Further information:

Thomas.Burky@halliburton.com



Tom Burky at the USA networking event.



David Ayre made a presentation at the event in Texas.

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Please email your CV quoting the appropriate Ref. No. to David Smalley at Daniels Smalley Partnership, Pencoed Technology Centre, Pencoed CF35 5HZ
david@dspsearch.co.uk

See Institute web site for more information

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IExpE AGM, Dinner and Conference 2017: a personal view

The 2017 AGM, Annual Dinner, Conference and networking event was held at the Norton Park Hotel, Sutton Scotney, Winchester in April. Thanks are due to the sponsors Cranfield University, Frazer Nash Consultancy, ISSEE, Ramora UK, Event Horizon Limited, System Design Evaluation Limited and H&G Explosives Limited and to the efficient organisation by Vicki Hall and Charlene Firkins from the IExpE office.

The AGM was held in the Hampshire Barn at 4.00 pm on Monday 3rd April; it was attended by 58 members in an amazing structure of a Tithe barn. There were drinks before the event allowing members to meet and greet old friends and make new ones. Opened and spearheaded by the President Dave Welch, the relaxed atmosphere allowed a quick and painless AGM with reports from the various VPs and the legal eagle, before everyone dispersed to relax before the Dinner.

Everyone assembled on time for pre-dinner drinks, allowing some more networking and excellent discussions and information swapping to take place, before being piped in to dinner by the splendid sight of kilted Bob MacNaught on the bagpipes. Here members were given the opportunity to take their seats, but with a twist. Council members were allocated tables, to allow members to question them on the preceding events and any other matters they wanted; this in itself proved invaluable with much discussion taking place.

The meal was very good, the wine and beer flowed followed by toasts with a very nice port, then a mystery speaker, who was in fact, our departing, but not quite departing yet, VP finance Ian McKay. A frank but very interesting and enlightening resume of his life and IExpE followed; music during the meal was provided by our erstwhile piper. After the meal the majority adjourned to the bar for more lively discussion, laughter and consumption of large amounts of liquid. A few stragglers still maintained a presence until 3 am or thereabouts enjoying the hospitality of the hotel. It was interesting to note the reactions of the many members of "the public" who were also in residence. Everyone I saw read all of the literature on display and whilst looking at members as if they came from another planet, although they did it surreptitiously.

The Conference was held in the Norton Suite on the following day and was attended by 72 members and non members. The opening address was once again from the President Dave Welch, highlighting the last year's achievement and hopes for the day. A slight change in order was introduced, with the President announcing a new prize, the President's Prize, to be presented this year to Vicki Hall, the Office Manager, for her outstanding



Vicki Hall received the President's Prize.



Refreshments before the AGM.



Rob Parry, Fiona Smith and Ian McKay at the AGM.



The AGM underway in the historic barn at the Norton Park Hotel, Sutton Scotney, Winchester.

Institute News

contribution to the Institute, especially in the past few months with many extra unpaid hours and weekend work moving the office to its new location.

The keynote speaker, John Anderson MD of Qinetiq, likened the Institute to a family, with a home for everyone, that supported all, especially in such challenging times where all aspects of the industry seem to be in decline. His vision was for us to aim at sustainability, bringing in new blood, via sector skills. He said it is up to us to build our future capability and pass on our knowledge. So saying even with the industry under siege there is an exciting challenge ahead for us to drive forward and deliver the future. Technology is going to play a large part in this, for and against and we must apply ourselves and it to ensure we are all part of this excitement. Do we inspire, can we inspire, to survive we must!

A presentation by Andy Pettitt followed showing us the application of technology in IED development, as part of work he is carrying out for his PhD. It had a massive "wow" factor to me, we all see the effect of IEDs, we all know of what they can do, but this is normally in isolated single incidents or attacks. Here we were presented with a history and progression of these, focusing, frightening and to me absolutely amazing. It is not just what has happened, what is possible and what the future holds that is burned into my mind.

A break to allow oxygen, nicotine and caffeine in which ever order you want followed, well laid out and very welcome, once again allowing a good networking opportunity and the chance to stretch and meet the sponsors.

Euan Stoddart kicked off the next session and amazed us with an incredibly technical and very interesting presentation on his and others' work on structural integrity, for me it crossed "t"s and dotted "i"s on things I have often wondered about, in my line of work. The simulations used and at his disposal were amazing, obviously for use in architecture and design but as a tool that would be used in the explosive family. The way the models were presented is, I imagine, a very brief shot into a highly complicated area I've never had the opportunity to see and it was really interesting.

Our own "legal eagle" followed this, Ruth Barber, who has prosecuted for the HSE, gave her slant and much appreciated advice on what to do and what not to do, if things go wrong, from a very practical and experienced viewpoint. It was definitely a listen, look and learn, it gave us all a flavor of whatever our personal feelings are there are ways and means of dealing with situations, visits, audits that can only help all of those involved. Copious notes were taken by me at least, from which I can ensure that I am on top of my game all of the time, hopefully it captured everyone else's attention in the same manner as the amount of information was amazing, not only for the legal content, but for the organisational and common sense approach that one can take in most situations.

Mark Hardman, a very brave man in my opinion, shared some safety lessons from experience; he opened up on a prosecution they had against them from the HSE, few of us like to admit to our mistakes, even when they are discovered so for an individual and a company to come forward and allow themselves to be put in the spotlight as such, allowing all of us a chance not to make the same mistakes I found really heartening. It was a good opportunity for all of us to look inwards, to self-assess whilst listening to a tale that any single one of us could or may have experienced.



Gathering before the Annual Dinner.



Bob MacNaught, who piped in the guests for the Dinner, with President Dave Welch.



The Annual Dinner.

Just before lunch the President carried out the awards:

Shaun Dooley – Rosenthal Silver Salver – Nominated by Marketing, in recognition of support to the Institute.

Bridget Clifford – Editor’s Award – for an outstanding article published in “Explosives Engineering” journal.

Martin Philpot and David Price – Journal Awards Competition 2016

Raleke Ralus Okeke – Journal Awards Competition 2016

Ian McKay – Journal Awards Competition 2016

Vicki Hall - President’s Award

After lunch, HM Chief Inspector of Explosives, Richard Daniels, spoke as a man who wants Great Britain to work well, as I hope we all do. Are we doing right, are we doing enough for ourselves, our members and others was the question I felt he put to us. Do we have ownership, do we have enough outreach? Is our voice for everyone, are we all encompassing, are we the “Heineken institute”, do we reach parts others do not reach. There are many barriers in life, so do we bridge gaps for everyone or are there perceived barriers that we are missing that need to be looked at. We possibly need to anticipate what is happening in the future and plan for this, to have foresight, to share our success and get ahead of the curve. Effective leadership, supporting the work of others and the security of the Institute need to be our priorities.

Andy Hubble finished off this next session by providing us with an overview of what was happening in the fireworks industry; the majority of those involved within the industry are of a mature age which is a problem as with the rest of the industry. More youth is needed within the firework industry as well. There have been accidents abroad which have had a bad press and impact on the industry. Andy has been to China to look at the production and quality control involved there and had a very successful trip finding no problems but learning and fact finding.

This presentation demonstrated the diversity within the Institute - blasting, military, EOD, special effects, propulsion and fireworks to name but a few - all are represented and welcomed, embraced as one.

The last break of the day followed, last minute networking chances made, names swapped, then into the final session

This was on the Falcon Project. What can one say, Daniel Jubb carried out a presentation last year which I did not think he could top, this year he topped it. For the sake of those who had missed last year, he quickly ran over last year’s presentation then brought it up to date, all within the space of his presentation slot, it was a real, turbo-boosted session, carried out just like his rockets with massive presence. From a very small start to where his is now (or what he could tell us), watching the video of the latest test firing was an amazing journey, one which is far from over, from the ranges in Otterburn to the facility he has now is similar to the change from the industrial age to the moon but at warp speed, and yes, you need to get your application in soonest.

The President Dave Welch then gave the closing remarks, before we all dispersed our very many ways, an excellent Conference but we cannot rest on our laurels, we need to expand, get more members, ensure those who are members become more inclusive and grow the family.

Roy Davis MIEpE



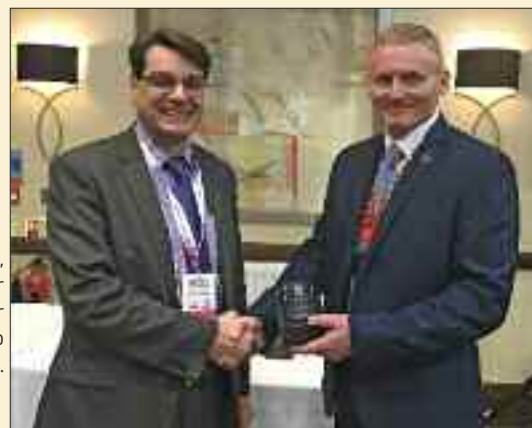
Andy Pettitt after his presentation.



Sean Dooley received the Rosenthal Silver Salver.



Ruth Barber after her presentation to the Conference.



Richard Daniels, HM Chief Inspector of Explosives, after his presentation to the Conference.



Andy Hubble gave a most amusing presentation.



Bridget Clifford, Keeper of Tower History, Royal Armouries Museum, HM Tower London, received the Editor's Award.



Dr David Price and Martin Philpott of AWE, were presented with their Journal Awards Competition 2016 award for their joint-authored paper. (See page 18).



Mark Hardman gave a most interesting talk.



Daniel Jubb of the Falcon Project. (See page 28).

Annual Dinner – After Dinner speech

Many of you may know that I joined the Institute in 1987 as one of the HSE's Explosives Inspectors. There was at that time heated discussion around the Council table about professionalism which lead inevitably to the question, which is the world's oldest profession? No doubt, said the doctor, that, as God made Eve out of Adam's rib, medicine is the oldest. Ah! said the lawyer, the Lord created order out of chaos and to create order you need laws, so the legal profession is the oldest. But the civil servant just smiled and said, "and who do you think created the chaos"?

The first meeting of the infant Institute had been on 22nd May 1974 and from the outset those involved were determined that the cornerstones of the Institute's beliefs and objectives would be the maintenance of the highest standards and a commitment to education. When I joined the Council there is no doubt that the Institute was still, professionally, a small child. It could do very little for itself and it needed help and advice, education and encouragement, from any source which it could tap.

There were many then on the Council who could look back on years of experience, often gained by blowing up power stations or chimneys or whatever. Having a regulator on the Council was quite a novelty.... There were some no doubt who wondered just what was happening.

What was happening was that the Institute was starting to grow up – it was in possibly what you'd call its adolescence. So, like all adolescents, it was trying out its wings. Sometimes it might be over-confident and indeed clumsy, but the important point was that it was learning.

The use of civil explosives was shifting away from the traditional self-sensitised compositions based on substances like NG and the quarries were going over to AN based explosives such as emulsions. The military were looking at insensitive munitions and how to store



Introducing Ian McKay the After Dinner Speaker.

Ian McKay, the After Dinner Speaker, being presented with his Journal Awards Competition 2016 award at the Dinner.



their materials ever more safely and securely. The oil industry was looking for resource in harsher and harsher conditions and in less friendly places. So the explosives world was changing in response not only to technological change but to political and social influences and pressures. The UK acquired European standards and legislative requirements, which lead to new members joining from organisations such as the Health and Safety Laboratory. One of their staff became the 1000th member of the Institute.

So the membership of Council itself was subtly changing to reflect these influences. There were fewer tree-stumpers and pithead demolishers, not the least because most of the pit heads had been demolished! There were, for example, more representatives from the military, from the oil exploration field and from organisations engaged in demilitarising operations. This meant that the knowledge base available to Council was enormously increased. At the same time, the difference between the sectors represented by different Council members lead to some fairly robust arguments about what the Council and the Institute should be doing. Always, however, there has been the acceptance that there can be minority views even within a majority decision and the Institute was determined to press on with its objectives.

One example would surely be the sometimes long, sometimes tedious and sometimes fascinating discussions about ammonium nitrate. Like AN, these discussions generated more heat than light and had a disquieting habit of spontaneously decomposing. But it was important that the issues were aired and that the Institute could take a reasoned and technically defensible position on what was a difficult but topical subject. It is a measure of the Institute's professional standing and credibility that the Chief Inspector of Explosives addressed us on the issues and our voice was heard in appropriate government departments. The fact that we had an aura of respectability was recognised by Council then – and of course it still is – and our professional reputation is one of our most valuable assets.

This was clearly demonstrated again some time later, when, as one of the jewels in our crown, the Institute gained the ability to offer professional registration of its members through the Engineering

Council - CEng, IEng Eng Tech. This does not mean that the Institute says it is at the front, it means that a credible third party says we are at the front.

In order to encompass the changes necessary to the Institute to allow it to cope as the world about it changed, there was a period when the bye-laws were required to be changed almost on a month-by-month basis. Far too much valuable Council time was spent debating how these changes should be implemented. The first step to resolving this was the adoption of a Constitution - which did not need to be changed – which supported a network of procedures, which could be changed by the Council in response to the members' needs. That was a start. The decision to become a Company limited by guarantee, which took place late in 2011, was a significant improvement again, because not only did that embody the Constitution in the Articles of Incorporation, it made it quite clear to Council that the Institute had become an organisation which could and should be operated as a business. It had reached maturity.

The Council was then finally freed from making the day-to-day business decisions and carrying out the administration of the Institute. It could safely entrust that to a person like Vicki, without whose contribution as the Office Manager we would be in a much poorer position and I, for my part, wish to acknowledge and thank her for all her efforts on our behalf.

Finally, before the coffee goes cold, you might reasonably ask of me, what did I achieve when on Council? I should reply, "I achieved little. We achieved a great deal". Let us not diminish what the first Council achieved – in the 1970s and 1980s commercial life was beset by a number of problems, not the least connected with labour relations. In the face of these significant pressures on the country as a whole and on the explosives industry they succeeded in establishing, nurturing and growing this Institute. Their work, and that of subsequent Councils, has led to this becoming one of the world's foremost Institutes in the explosives field. I am pleased and proud to have served it and I hope that the Institute continues for many years to be the respected and honoured voice of the explosives industries.

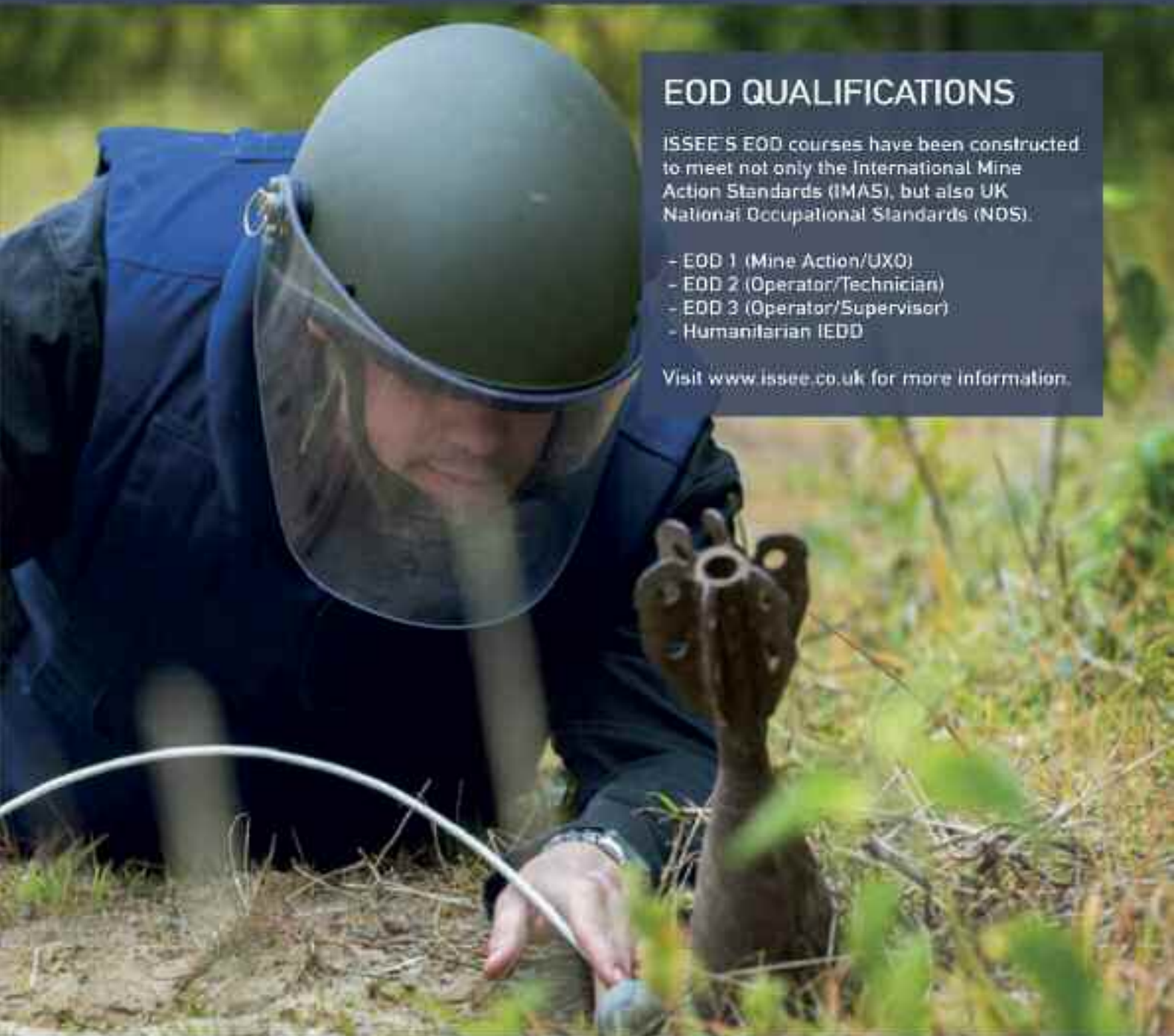
Ian McKay FIEExpE

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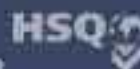
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IExpE Conference - Keynote address

By **John Anderson** FIEpE (Hon)

Firstly I must thank the Institute for my election as Honorary Fellow and for being asked to open the proceedings today. I accept this with humility and some pride of course - thank you.

It is for me somewhat ironic that my election as Honorary Fellow is bestowed as soon as I find myself, for the first time in 40 years, at least on a daily basis, no longer focused on explosives.

As some of you may know, as of 1st April last year I was invited to take a new role in QinetiQ's transformation, leading its Air and Space business. I have to say the parallels are remarkably similar. Air and Space are both high hazard environments, possibly even more tightly regulated than the explosives industry. In coming to speak today I reflected upon the tenets that the Institute records on its website.

"We are a membership organization promoting the highest standards in the explosives industry.

Encouraging liaison and raising explosive industry standards.
Supporting members' professional development.
A home for everyone working in the explosives industry"

If I compare this to other professional Institutes I see many laudable parallels, which one would expect. This Institute has made great strides, especially so reflecting on its size and hence available resources. The work it has done to facilitate and encourage sector skills strategy, and, in particular, its success in inspiring and supporting early career members who have shown such enthusiasm is a huge success.

However, here comes my BUT, and I hope you will forgive me for offering a challenge on this occasion. I assure you that it is borne out of a personal commitment to help take the Institute forward. For



Keynote Speaker John Anderson

some decades now we have operated in an industry moving through decline, certainly in terms of scale of operations in manufacturing of primary materials and also in their scale of use in operations.

Perhaps, correctly, a lot of focus has been placed on sector skills strategy, and probably more correctly on its sustainment. This has resulted in a strong commitment from industry to build future capability, encouraging a new generation to join the industry, supported now by a Governmental approach with the foundation of the Centre of Excellence in Energetic Materials. We have addressed the need to build a strong foundation for skills sustainment.

This has been a very necessary phase of our development, but maybe sometimes the way we talk about ourselves, it could appear an industry under siege. Perhaps now is the time that we should begin to bring out the excitement and challenge of the technologies of our industry and how we can drive innovation forward to deliver a future relevant to society.

It's true that we are unlikely to see the scale of manufacture that we saw in past decades, and some might say that is a positive development in societal terms. However, we will continue to play a pivotal role in the security of our nation through many streams of our activity. Further, our efforts in supporting the professionalization of our community - and here I go back to our ambition to be "a home for everyone working in the explosives industry" - has to bring greater security, safety and prosperity to our community and the general public.

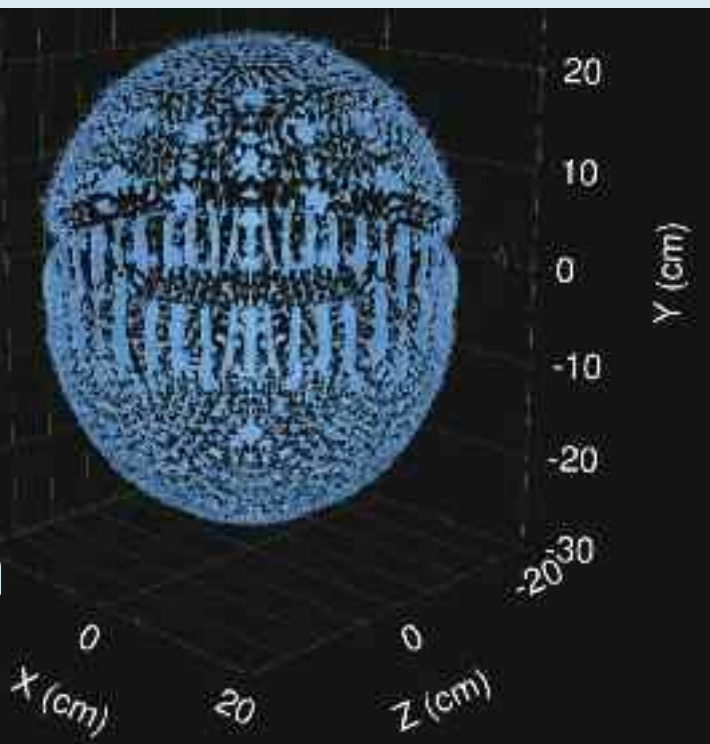
If I could compare it to the general approach taken by the Aeronautical and Space industry - they use much of their web presence focused on the excitement and application of technology at the forefront of innovation. This is perhaps a model we could easily follow, and it might add a new dimension to the excellent work we have already done in attracting the next generation into our sphere of operations. I offer this as a thought for the future.

And perhaps also if I could return to a comment I made earlier about the similarities of our industry and that of the aerospace environment, and its regulation. Whilst I would not encourage regulation for regulation sake, I wonder if we could draw benefit from thinking in terms of Accountable Manager and the Duty Holder concept we see in the aerospace domain. There are potential pitfalls to this approach and I would certainly counsel an approach that seeks the adoption of only best practice. It does underscore the professional competencies that are expected of our individuals, giving greater clarity and understanding of the importance of their role and also making this clear to those who depend on their skill. It also adds gravitas and relevance to continuous professional development.

I hope my challenges are seen as constructive and helpful to the development of our Institute, and with that I will leave you to enjoy the input of others throughout your conference.

John Anderson FIEpE (Hon)

The application of continuous free-space microwave interferometry to explosively driven case fragmentation experiments



By **Martin Philpott** and
Dr David W Price MA MRSC MInstP MBCS CChem CSci

Continuous free-space microwave interferometry has been applied to an explosively-driven case fragmentation experiment with the objectives of measuring the case expansion and the time of fracture. The displacement of the case material was measured for a period of $\sim 46 \mu\text{s}$ until fragmentation occurred. The data was then compared to an Eulerian simulation of the explosive event, which included case fracture and fragmentation. The agreement indicates the viability of the diagnostic and the potential for application to many forms of similar explosively driven events.

Introduction

Case fragmentation is a widely studied phenomenon in the munitions industry, material science and for the safety basis for facilities. In order to improve our understanding of this phenomenon and provide data for our models, we designed and fielded a simple steel cased explosive device at an open explosive range. A low power, low cost, continuous free-space microwave interferometer has been used to measure the displacement of this explosively-driven case in the open range conditions. The microwave system was constructed from commercially available components and operates on similar principles to a police Doppler radar gun. The diagnostic reveals the time-resolved velocity history of a small area on the surface of the case and indicates the time of case fracture. Post-fracture analysis can reveal multiple projectile velocities in the far field although this is not discussed in this work. The case expansion measurements have been used to confirmed calculations from a 3D Eulerian model that includes a fragmentation algorithm.

Experimental setup

The explosive device used in our trial consisted of a 304L stainless steel case packed with PE4 explosive, a 2D representation of which is shown in Figure 1. The steel case was made in two parts, a cylinder with a hemispherical closed end (shown in blue in the figure) and a hemisphere (shown in pink in the figure) joined with a glued

spigot joint. The device was detonated with the aid of a Reynolds RP83 detonator (shown in orange in the figure) which was centred on the axis of symmetry of the device level with the case joint. The device was placed on a wooden table, 1.5 m above the ground, at the centre of an arc describing fragment capture diagnostics, with the interferometer modules positioned 5 m away.

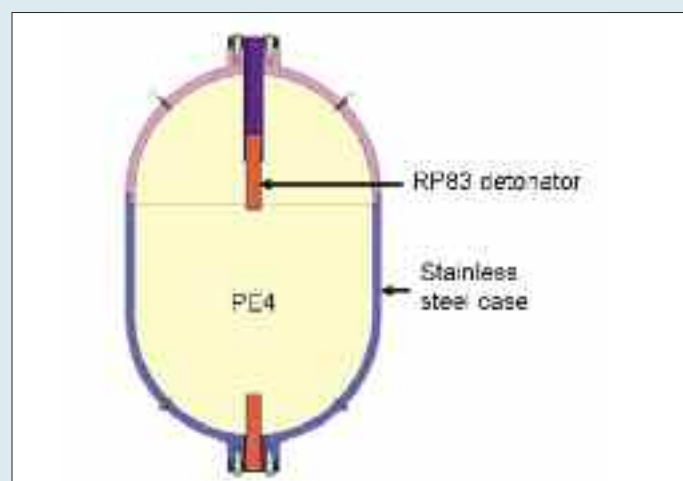


Figure 1. Cased charge design (upper section of case shown in pink, lower section of case shown in blue and redundant safety detonator shown at bottom)

The interferometer modules have a low power continuous wave transmitter ($<10 \text{ mW}$) with a source frequency of 24.15 GHz providing two continuous quadrature output signals (denoted I and Q signals). The microwave emitter/receiver component is approximately 5 cm square and mounted within a waterproof plastic box, so that the module can still operate in wet weather conditions. The operating bandwidth of 500 kHz allows velocities in the range of 0.1 ms^{-1} to 3100 ms^{-1} to be measured. The modules have proven to be capable of measuring small objects approximately 12 mm in diameter at a distance of 5 m to larger

objects approximately 200 mm in diameter at a distance of 40 m. The power limits of the antenna beam (-3.0 dB) may be approximately described by two angular terms 12 and 25 degrees. This is particularly useful for experiments conducted in open range conditions as precise alignment is not required.

Two modules were deployed orthogonally observing separate regions on the surface of the case from a range of 5 m, one with a collimated view through a 5.0 cm horizontal by 28.0 cm vertical slot in a 5083-O aluminium alloy witness pack, the other module with a direct wide angle view. The collimation was located at a distance of 44 cm from the charge centre and was introduced to reduce the signal collection from wide angles in the early stages of the event. The wavelength of the microwave source, 12.3 mm, limits the spatial resolution on the surface of the case, although devices are commercially available with higher source frequencies and higher bandwidth. The modules used in this work are considered as consumable items as the total cost of construction and component parts is low in comparison to the general costs of a trial.

Data analysis

The motion of the expanding case imparts a Doppler shift in the frequency of the microwaves reflected from the case. The returning signal is combined with the source to produce two composite signals (I and Q) that beat at the same frequency as the Doppler shift. It is possible to consider the analysis of the composite signals in terms of either frequency or phase. The relation between the measured beat frequency f_b and the velocity $v(t)$ of the target towards the receiver is given by,

$$v(t) = \frac{\lambda f_b}{2} \quad (1)$$

Where λ is the source wavelength (m).

The relation between the displacement $x(t)$ of the surface towards the receiver and the phase $\phi(t)$ of the signal is given by,

$$x(t) = \frac{(\phi(t) - \phi(t_0))\lambda}{4\pi} \quad (2)$$

$\phi(t_0)$ is the initial phase condition in radians.

In the initial stages of case expansion before fracture, the signal is simplistic and approximately sinusoidal; during this stage phase analysis may be applied to determine displacement. It is possible to make use of the peaks and troughs within the raw voltage signal such that the displacement is simply attained by fringe counting. Using this form of analysis a 24.15 GHz quadrature system provides a discrete measurement every 1.5 mm of movement of the object. Quadrature signals enable more advanced methods of continuous phase analyses such as elliptical fitting or by the creation of the complex analytic signal. It is possible to use the relative phase of the signals to distinguish between a surface that is approaching or moving further away from the module; a property that translates to the frequency domain. Methods such as the short time Fourier transform (STFT) and the pseudo Wigner-Ville distribution (PWVD) frequency distribution have been applied to the data. An example of PWVD is provided in the results section, see figure 6.

Numerical modelling

Simulations were carried out in the 3D Eulerian code CTH¹ from Sandia National Laboratories in Albuquerque, USA. Simulations were run to 200 μ s, by which time the fragments of the case were fully formed and explosive products were escaping the confines of the case and passing through the fractures². The MieGruneisen Equation of State³, Elastic-Perfectly Plastic Model and Johnson-Cook Damage Model⁴ were employed in the steel to model the material, its strength and casing fracture, while the JWL Equation of State⁵ was used for the C4 (PE4 equivalent) explosive and products. The Sesame tabulated Equation of State was used for air⁶. The case profile, and some of the subsequently formed fragments, were followed with the aid of marker particles placed in the mid-point of the thickness of the case in the initial model (shown as red dots on the surface of the case in Figure 2). These particles stay associated with the material in which they were initially placed and temporally and spatially follow that material.

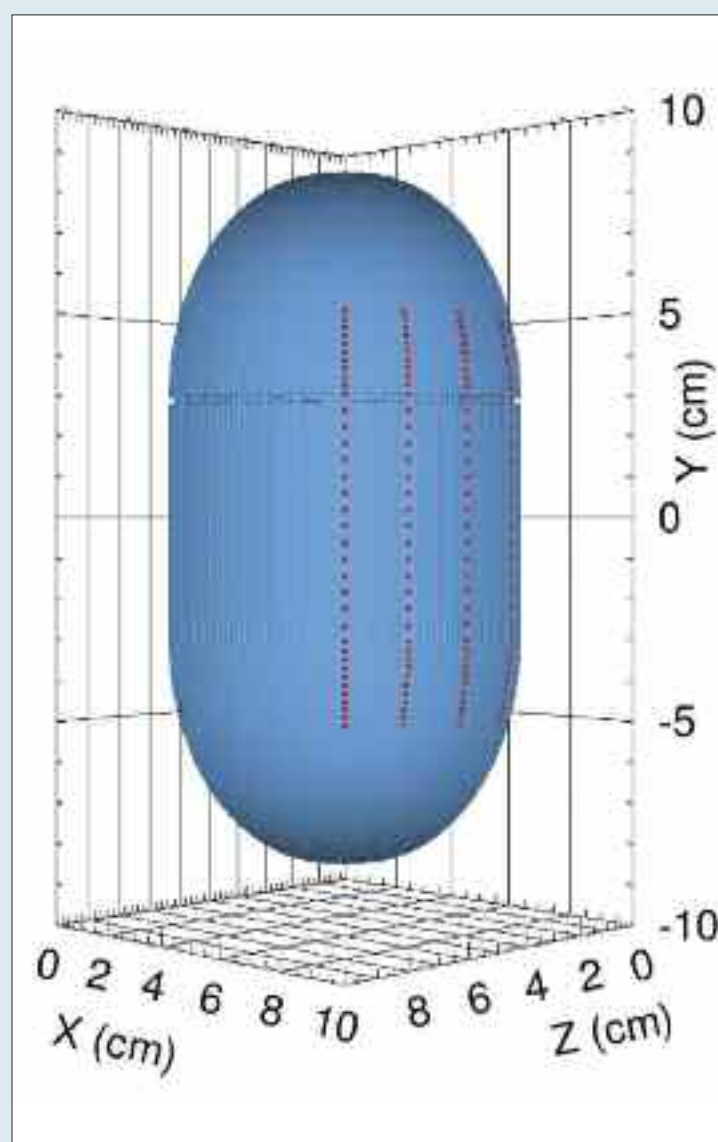


Figure 2. Initial 3D model (t=0) showing some of the positions of the marker particles as red dots.

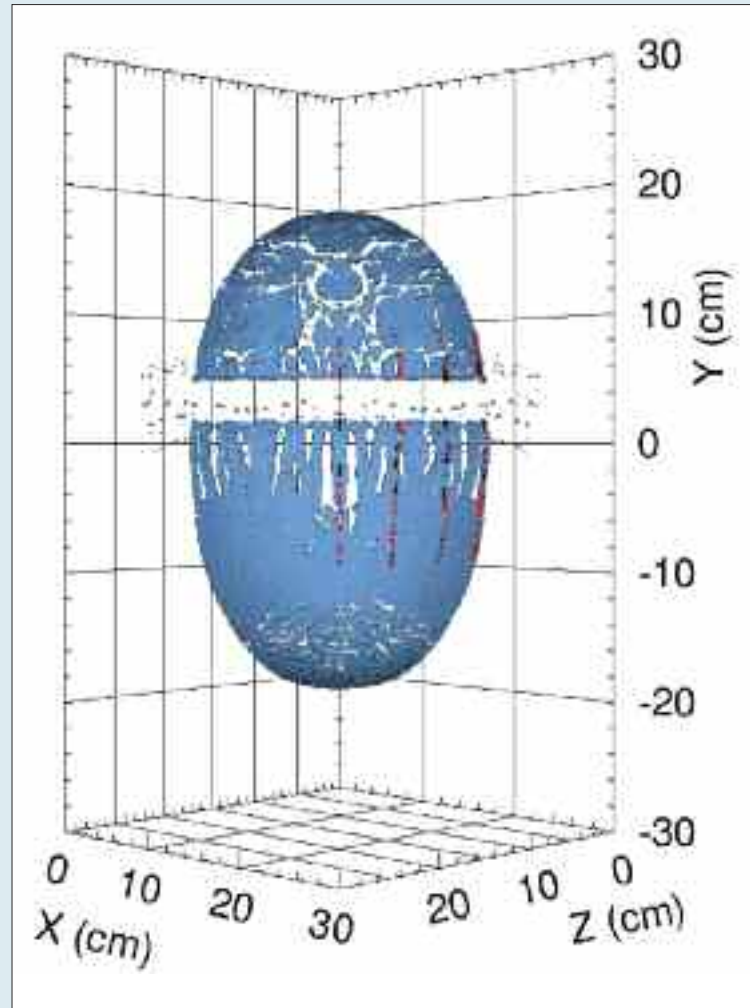
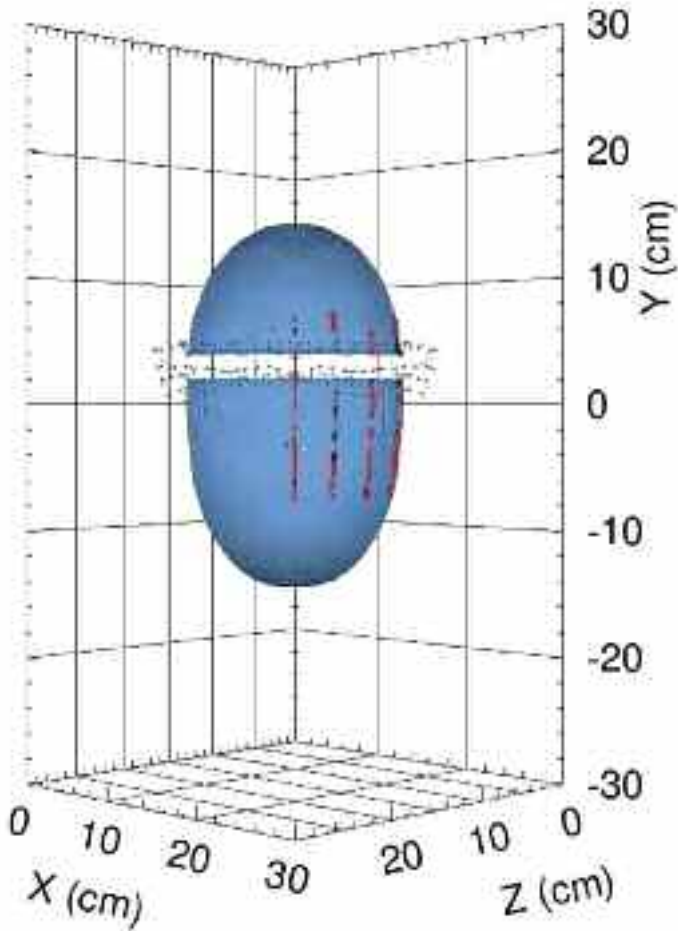


Figure 3. The case after 45 μs (left) (showing the separation of the modelled case joint) and 65 μs of simulation time (right) (showing the nascent fragments). The explosive and its products are not shown in either picture.

The position of the expanding case over time was monitored and two frames from the simulation are shown at 45 μs and 65 μs after detonation in Figure 3 on the left and right, respectively. From the left-hand frame shown in Figure 3, it is clear that the case joint ruptures first allowing the gaseous explosive products to begin to escape. The right-hand frame indicates how the long fragments form in the waist area of the device, firstly by long fractures appearing at the waist parallel to the axis of the device.

Doppler Radar Results

The original quadrature time-voltage signals from the collimated module are shown in figure 4a. At the start of this signal, there is a period of electrical noise, which is common to both I and Q signals and likely to have been generated by the firing pack. Figure 4b shows a high speed video frame at approximately 12 μs in which the detonation products have begun to breach the case at the joint. It should be noted that a corresponding short duration spike of broad band electrical noise can be seen in the voltage signal at 11 μs . Then, at approximately 15 μs , the I and Q signals separate as the case starts to move and the red sinusoidal signal leads the blue signal indicating that the motion is towards the module. The frame shown in Figure 4c shows the case expanding at 17 μs . The case accelerates for a period of 46 μs before fracture occurs; notice that the second high frequency noise spike in the signal at 65 μs . This spike maybe attributed to a rapid release of detonation products escaping through the fractured case and has been observed in several experiments. After case fracture occurs the returning

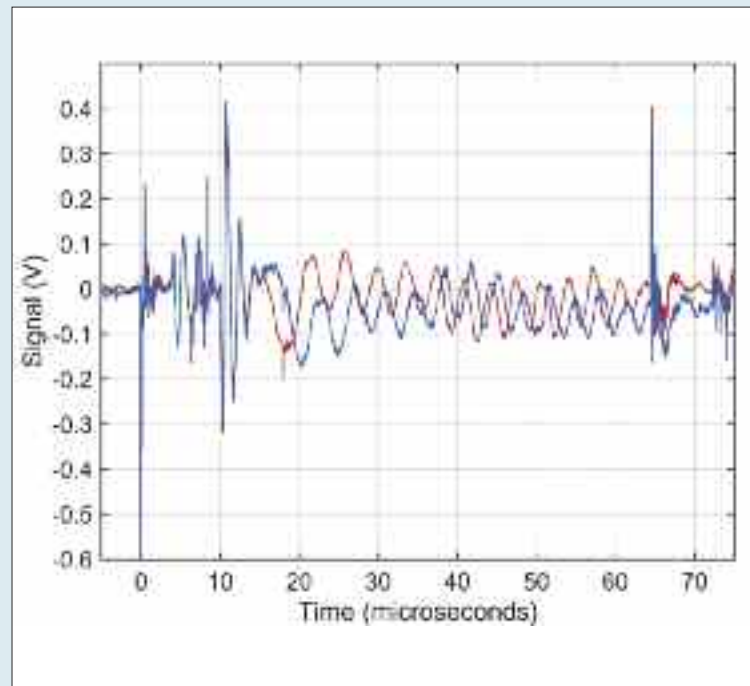


Figure 4a. Raw voltage time signals (I and Q) for the collimated view.



4b. Detonation products breach case, frame at +12 μ s.



4c. Case expanding, frame at +17 μ s.

microwave signal is constructed from many spatially incoherent sources, these may be edges or newly formed surfaces. The signal becomes immediately more complicated precluding the possibility of phase analysis. However this provides a clear indication of the time at which case fracture begins.

The signal from the wide angle view before fracture was found to be more difficult to analyse, however it was possible to continue the phase analysis for a short period after the spike at 65 μ s. This may have been possible simply due to the random fragment size distribution, or perhaps due to the larger area visible on the surface of the case. Figure 5 shows both the measured displacements compared to the model as red and black points for the collimated and wide angle views, respectively. The displacement data measured from two separate regions on the surface of the case indicates that the device expanded symmetrically; this is consistent with the high speed video and the simulations highlighted above, data from which is included for comparison in Figure 5. The two displacement measurements are so similar that they are difficult to distinguish on the scale shown in Figure 5, both data sets are in agreement with the model.

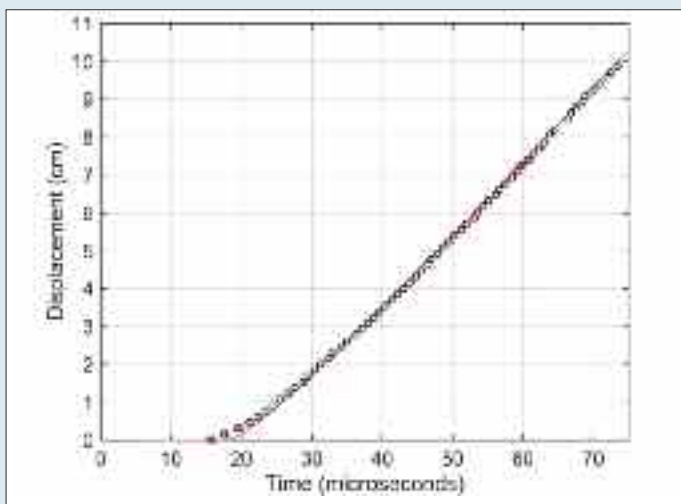


Figure 5. Displacement analysis compared to the numerical model shown as the pink line. The red and black points are from two separate modules observing from orthogonal positions.

Figure 6 above shows the velocity time history of the expanding case analysed using the PWVD method of frequency analysis. The PWVD method has a more localised frequency distribution in comparison to the STFT although produces multiple interference terms, these terms have been suppressed in the figure for clarity.

The blue line is the velocity of one marker particle within the calculation, and the red line is the interpolated velocity.

Close to the time of fracture, the measured velocity shown in Figure

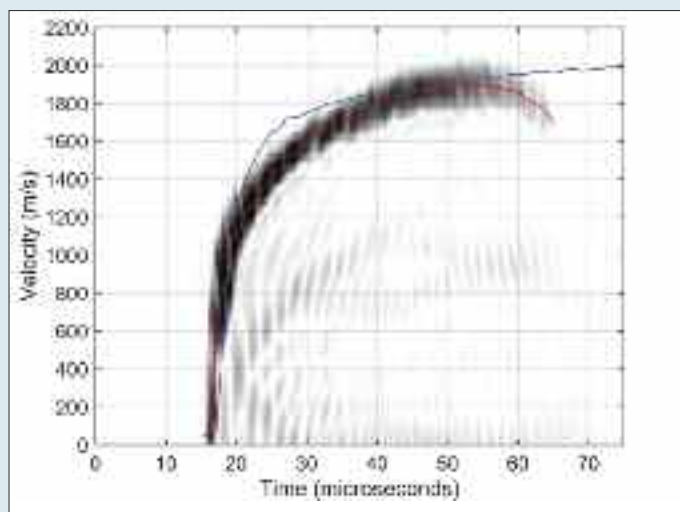


Figure 6. Pseudo Wigner-Ville analysis with suppressed interference terms.

6 reduces. This retardation was not commonly observed in the calculation although some marker particles had similar velocity profiles.

Conclusions

Continuous free-space microwave interferometry has been used to measure the motion of an explosively driven stainless steel case in open range conditions. The diagnostic described has been designed to be low cost, low power, robust and does not require precise alignment. These attributes make the approach desirable for work involving explosives in open range conditions.

The diagnostic provides a measurement of the free surface velocity and an indication of the time at which the case begins to fracture. The agreement with simulations carried out with the CTH Eulerian code from Sandia National Labs in Albuquerque lends credence to both the simulations and the results obtained with the diagnostic.

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Developments, issues and solutions in the fireworks sector



Andy Hubble sitting at the broadcasting desk promoting safe use of fireworks.

By **Andy Hubble** MIEpE, Director Star Fireworks Ltd

After the initial thought of what an honour it was to be asked to give a presentation to the IExpE Conference again, I soon moved on to thinking about what I would talk about.

This year (2017) is the twenty-fifth year that I have worked in support of government or industry interests in one way or another, working to promote the safe use of fireworks and being part of the team helping to ensure industry has a voice that is heard at all levels.

When I first started in the early 90s, I acted as a fireworks consultant to the Department of Trade and Industry's Publicity Branch, who were responsible for running the annual Firework Safety Campaign. I remember fondly regular meetings with the publicity branch manager Guy Nissen at 1 Victoria Street, Westminster where we discussed the messages that the campaign was focusing on and what approach they wanted me to take.

My role back then was threefold, and involved (1) giving interviews to the press in support of the consumer firework safety campaign whenever the Minister was unavailable, (2) attending regional publicity events arranged by local DTI offices or the fire service and being available for interviews, and (3) working on the production of the DTI firework safety TV commercials, being responsible for all fireworks that appeared in shot and making sure that above all else, nothing in the film broke the all important Fireworks Code.

I did this role for something like ten years. Some years were busier than others as firework accidents peaked and a greater prominence was given to the campaign, and eventually as accidents dropped to acceptable levels the campaign was stopped (although I continued for some time after addressing press queries and making sure that people knew how to enjoy fireworks safely at home).

John Woodhead of Standard Fireworks and Guy Nissen of the DTI are the two people I have to thank the most for such an early start to my career. John recommended me to Guy and the rest is history. Through my DTI work I sat on the GMTV sofa many times over the years and appeared on location with them all over the country, appeared as a guest on This Morning, gave interviews on virtually every major TV news and radio programme and appeared in all of the

national newspapers. I remember one time in particular being chased through some streets in North London (together with Guy Nissen), by a drunk who was wielding a glass bottle. He was unhappy we were taking location shots for the next firework safety campaign TV filler near the pub he was drinking in and decided to take his anger out on us!

As a one-off (and never to be repeated) I played a few clips to the conference from TV work I had been involved in back in the 90s.

Now step forward to this century and the last twelve years have seen me serving on the Management Committee of the British Pyrotechnists Association, with five of those spent as Chairman. The BPA exists to promote the highest standards in the professional fireworks display industry and to represent its members at all levels of local and national government. From

Display shell manufacturing.





Factories now produce more parts in house rather than sourcing materials from outside suppliers.

presentations in Brussels and CEN meetings in Delft, through to packaging testing in Grangemouth and even a ministerial meeting at the Palace of Westminster, my BPA work has been both interesting and rewarding over the years and together we've achieved a lot to advance training and qualifications within the industry and ensure that member interests are represented at the highest levels in the UK and Europe.

Turning now to current issues, and 2016 saw the industry facing the prospect of a parliamentary debate in Westminster following a petition posted on the 10 Downing Street website calling for limits on when fireworks could be used by the public. An active group of animal welfare campaigners used social media to very effectively recruit a huge number of supporters for their cause, which translated into signatures on the petition page. They wanted the public to be limited to using fireworks only around Guy Fawkes and not all year round, which they said scared animals and affected armed services personnel suffering from Post Traumatic Stress Disorder.

The petition reached the magic 100,000 mark, the number needed to be selected for debate. Indeed a debate was scheduled, and faced with the prospect of a one-sided story being promoted in the media by the campaigners, the consumer side of the industry decided to nominate a press spokesman to field interviews and defend its record.

This was also potentially significant to the consumer fireworks industry, in the worst case a successful debate could see an eventual ban from sale for domestic fireworks and the market being dangerously driven underground as it has been in Ireland. Product could be imported from the continent which was untested and which could bear instructions that were not in English, with serious consequences. Equally though, the industry had previously invested six-figure sums

with animal charities to promote steps that could be taken to reduce the impact of fireworks upon pets at home, and it was the industry which introduced a voluntary ban on noisy fireworks including the air bombs and mini-rockets - and these points needed highlighting.

I was asked to be the press spokesman and on the day of the debate gave over 30 interviews to the media. In the end, the Minister said that the government felt current legislation already adequately dealt with the issues in hand and no further action would be taken. Perhaps one of the most striking things to take away from all of this was just how effective social media is today for championing a cause like this. This was the first time the fireworks industry had experienced such a well-organised and well-supported campaign. Even though the numbers of petitioners represented only a small fraction of one percent compared to the number of people who enjoy fireworks in the UK each year, it's something that the industry will keep a good watch on now, ready for the next effective petition (in case one should ever appear).

Like many industries within the explosives sector, fireworks have faced many challenges with European legislation and face further issues now with Brexit. Many believe the old British Standard for fireworks (BS7114:2:88) was better than the current CE system and whilst it would be hard to go back to it, we may be able to adopt some of its old working methods (or indeed have no choice). Ironically, just a couple of weeks before the Brexit vote I gave a presentation at the European Commission in Brussels arguing the case for a British government-backed view on a related part of a European pyrotechnics Directive. I guess that work won't be necessary now!

CE marking requires notified bodies (NB's) to undertake conformity assessments and issue certificates prior to a product being placed on the market. There are no guarantees we will have access to NB's post Brexit and even if we do, would we still have a place at the table to be able to influence the way those NB's approached their

Star Fireworks Director Sean Durcan viewing some finished display shells in a drying room.





A selection of finished fireworks selected by the factory ready for the evenings demonstration.

work. For example, would we be entitled to have a say in discussions concerning procedural changes to the way their work is done?

We are fortunate in the UK in so far as we already have the experience of operating a standards system for fireworks - and recently too. New consumer fireworks have only had to fully comply with CE since 2013, and some professional fireworks even at the time of writing now can still operate on under the old British Standard. One of the key differences between BS7114 and CE is that the British Standard did not require the involvement of separate organisations or certificates to demonstrate conformity. The duty fell upon the importer to ensure compliance; many had their own test regime in the UK to ensure conformity to BS.

I have no doubt that the harmonised standards and many elements of CE are here to stay for some time, but some say that it may well be that we revert to a similar system to the old BS in terms of conformity. Notified bodies could be abandoned for fireworks, with consumer firework importers being responsible for their own compliance testing, backed up by random sampling by enforcers at the ports. Category 4 professional fireworks could come out of CE altogether, with existing domestic legislation providing the safeguards to ensure sound product is imported (as was the case before we had CE). This would benefit large numbers of UK professional importers and remove the huge cost burden of CE compliance that has seen some companies stop importing altogether and buy from trade suppliers. On the other side of the argument are the trade suppliers though, who have invested sometimes considerable sums of money to comply with the European Regulations. Some professional trade suppliers may wish for CE/notified bodies/conformity assessment to continue long after we leave the European Union, whilst others have the view that Europe was costing industry huge sums and disadvantaged smaller companies, where the old system worked perfectly well. Whatever happens, we have interesting times ahead and you'll just have to watch this space.

Finally, to matters very close to the values of the Institute, competence and professional fireworks display training. The professional fireworks display industry is fairly unique in that it requires larger numbers of firers to set up and fire displays for a

relatively short amount of time around Guy Fawkes. Although we do work all year round, the months away from November 5th usually need far less people than the bonfire night period. It's impossible to employ so many people full time, so the industry instead employs thousands of people who all have other day jobs - from doctors and nurses through to teachers, military staff and even people from other industries in the explosives sector.

Firework displays have a large number of potential hazards with multiple fatalities being a serious outcome without proper training and safety procedures.

The British Pyrotechnists Association has operated its firers training scheme for well over a decade now and it's the only accredited training scheme for the role. The scheme has two levels of qualification for firers and senior firers (individuals who might be responsible for the running of a display). A syllabus and full training manual support mandatory training sessions and an examination. Before they can take an exam candidates must demonstrate sufficient experience within the field comprising a set number of displays within a set time frame for each respective qualification. Displays are recorded in a log book which is signed by a company principal. Training can only be delivered by trained trainers, all of whom work for BPA member companies.

The course has been accredited by City and Guilds for around five years, an achievement that did not come without a great deal of hard work from the BPA administration. The course is under continual development from updates to the course notes to the filming of new professional quality demonstration videos for use in training sessions. Currently the BPA are working on a new, modernised examination system that will aid delivery and assist with qualification renewals every five years.

Of course, there's a lot more to fireworks than just the above, but by and large with two active trade associations and a government lobbying group, whose members collectively cover the vast majority of the industry, all working hard to represent the interests of fireworks in the UK, I think the industry does a lot to keep its house in order and continuous development is at the core.

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The future strategic direction of health and safety

By **Dr Richard Daniels** BSc(Hons) PgDip(Physics) PgDip(Health and Safety) PhD, HM Chief Inspector of Explosives

I recently had the pleasure of attending the IExpE 2017 Annual Conference in Winchester this year. It was great to meet a number of you and to hear of the work of the Institute and the various activities of its members. I was asked – and immediately accepted the offer – to produce an article building on my presentation. I attempt to set out the direction of travel for the next few years of the health and safety system in Great Britain and also, closer to home, the areas HSE will be putting particular focus and resource in the Explosives sector.

Helping Great Britain Work Well – a system strategy

Great Britain's health and safety record is the envy of much of the world. Central to this is protecting people by managing risk in a proportionate and effective way, supporting innovation and increasing productivity. The challenge is to improve even further on this impressive record.

While HSE's position as a regulator ensures it will remain the key player, there is a role to play for everyone who has a stake or interest in improving health and safety in the workplace. This is what is called 'the system', not an abstract concept, but networks of organisations and individuals, including, among others, employers, employees, industry and trade bodies, supply chains, third-sector bodies, insurance and legal bodies, workers' representatives, professional institutions and government, as well as co-regulators and many others. Put another way, this means all those who undertake, or influence, workplace activities and attitudes.

The focus of the Helping Great Britain work well (HGBWW) strategy, published in 2016 after engagement across all sectors, is to provide direction to the wider health and safety system for Great Britain and all those who are involved in, or interact, with it so that a much greater collective contribution to improving outcomes can be made. HSE is committed to playing its part to improve outcomes and deliver on its responsibilities as the independent regulator and prime mover in the system.

The six priority themes in the HGBWW strategy will help Great Britain work well and address those issues which have the greatest impact on the health, safety and productivity of British business.

Acting together – Broader ownership of health and safety is key to Helping Great Britain work well. Health and safety is not a responsibility assigned to an individual or part of an organisation, but is an integral part of everyone's role. We need to have a much broader collective ownership of issues, reflecting local circumstances and sector priorities. HSE will clearly retain a key role in providing targeted advice and taking enforcement action. However this theme will be best delivered by everyone collaborating to reach those who may be less engaged.

Members of the IExpE have a key role to play here in promoting the aims and objectives of the Institute and taking opportunities to share knowledge and experience to support others in addressing issues and challenges.

Tackling ill health – In 2014/15 work related injuries and ill health cost the UK an estimated £14.1 billion, with millions of working days lost. This reflects the human costs of the impact on over one million people's lives, not just those directly affected but their family, friends and colleagues. Ill health is a problem for every section of society and a greater awareness of the harm and costs and preventability of work related ill health should drive collective action to improve health outcomes. Addressing ill health requires long term coordinated action and HSE is working with partners, such as the NHS, to support long term behavior change.

Although no common cross sector occupational health issues have been identified as priorities for the explosives sector there is a need for a greater focus and awareness of health issues, while continuing to ensure that maintaining standards around safety remains a priority.

Managing risk well – Successful organisations understand that sensible proportionate risk management is integral to delivering their business. However we all know instances where risk management has been disproportionate, with companies paying for unnecessary consultancy services or implementing expensive measures to address minor issues. Simplifying risk management supports growth, enables innovation and protects people. Helping businesses of all sizes get it right in an efficient and effective way will build trust and improve standards.

Feature

As the professional body for the explosives sector you clearly have a role to play in challenging disproportionate risk management and supporting each other in identifying, implementing and communicating good risk management.

Supporting Small Employers – Although the explosives sector has a number of large multinational businesses, the majority are small employers (SME's – small and medium enterprises), providing critical services across the breadth of the sector, from demolition and mineral extraction to pyrotechnics and specialist products. All multinational businesses were once SMEs and ensuring SMEs have simple advice so that they know what to do to achieve satisfactory control is key to supporting their business growth. Reaching smaller businesses can be difficult, but it is not impossible.

The networks developed through the IExpE provide an ideal opportunity to pass on this advice and provide support. Much has been done, but there is an opportunity to work smarter. Identifying the key influencers of SMEs is critical, and working through them to raise awareness levels about the support that is available will be key to the success of HGBWW. You may be that key influencer, for example, as the company contracting an SME to provide goods or services for your organisation. So how can you use this opportunity to provide support and pass on good practice?

Keeping pace with change – Tackling the problems of tomorrow today is a responsible investment that protects workers, enables different approaches and provides new knowledge, skills and expertise Great Britain can share internationally. Great Britain leads the world in anticipating and tackling the new health and safety challenges that come with social, economic and technological changes and HSE already uses its own capabilities to help businesses worldwide improve health and safety, as well as business, outcomes.

Many of you will work on new and emerging technologies, developing new and novel products and so to remain a world leader in risk management we need to develop high quality capability, anticipating challenges and using flexible approaches to solve issues and enable innovation.

Sharing our success – Everyone can take pride in Great Britain's world class reputation for health and safety and promote its success at home and abroad. Although the strategy focuses on improving standards for Great Britain we should look to share best practice and latest thinking and innovation worldwide. The explosives sector is a truly global sector.

Many of you reading this will work for international companies or travel worldwide, giving you a unique opportunity to influence health and safety systems across the globe. Will you do this?

Delivering the system strategy

There are two primary routes for delivery of the strategy, one led by industry and one led by HSE.

Industry led: In November 2016 the HSE launched the first 'Commitments' publication – <http://www.hse.gov.uk/strategy/assets/docs/commitments.pdf> at the Imperial War Museum in London. This document brought together over 100 examples demonstrating the delivery of the themes of HGBWW from across all sectors and from all sizes of organisations, from single companies to large trade organisations and professional bodies. The explosives sector was

included, with the work of the Sector Skills Strategy Group (SSSG) demonstrating what can be achieved when people 'Act Together' to develop and maintain a competent workforce for the explosives sector. The Commitments document also offers an opportunity for the explosives sector to learn from the experiences of other sectors in identifying solutions to new or ongoing challenges.

Your President attended the launch event as one of my guests, representing the Institute, and I had the great pleasure to introduce him to our Minister Penny Mordaunt MP.

But I firmly believe there must be other exciting initiatives across the explosives sector – large or small - which could be publicised. I encourage you to highlight and share this work so that others can learn from your experiences.

HSE led: HSE's delivery of the strategy has two key strands; the Health and Work strategy and Sector plans;

Health and Work strategy - HSE has a key role in helping Great Britain deliver wider health and safety priorities. Health challenges are many and varied from well understood to emerging and the Health and Work strategy sets out the approach HSE will be taking on three key health issues: Occupational stress, Musculoskeletal Disorders and Occupational Lung Disease. These three issues are the cause of the highest numbers of days lost due to work related illness or workplace injury and have the greatest impact on people's lives. Addressing these issues from purely a health and safety perspective does not take into account the diversity of factors which need to be taken into if we are to address these issues fully. HSE is therefore adopting a strategic approach, working with others, championing the need for prevention, and focusing our inspection and enforcement where it can have the most effect.

Explosives Sector Plan – HSE has published 19 sector plans, covering sectors from commercial customer services and fairgrounds and theme parks to offshore energy and agriculture. All sectors have their priorities for action and the sector plans set out what HSE will do to address those priorities. The Explosives Sector Plan has been developed through extensive consultation and outlines HSE's priorities for its work with the explosives sector. You can read the plan on the HSE website – <http://www.hse.gov.uk/aboutus/strategiesandplans/sector-plans/explosives.pdf>

The sector plan outlines HSE's work for the next 3 – 5 years and therefore outlines broad work themes; each year HSE Business Plans and internal work plans will provide the detail. The plan highlights the current position of the sector, in particular the diversity of activities and that although historically the number of incidents is relatively low, the consequences of a single incident can be catastrophic. There is no room for complacency. Despite the diversity of the sector three common challenges were identified as those having most impact on the sector;

- The need for effective leadership across the sector
- The decline in core skills and an ageing workforce
- Security issues, including security of supply, physical security and cyber security.

These areas will form the focus of HSE's future work with the sector in the coming years. But how will HSE best use our resources to support the industry in addressing these issues?

We will lead and engage with others to improve workplace health and safety:

- We will use our knowledge and experience to support intelligence led policy making and regulatory approaches. This means using our technical and regulatory expertise to inform any new, or amendments to existing, legislation and ensure that we have targeted and proportionate approaches to inspection and enforcement.
- HSE's unique position enables us to act as a UK centre of explosives knowledge, providing support to international policy makers and regulators, for example as we currently do at the UN Committee of Experts on the Transport of Dangerous Goods, representing the UK's interests on proposed changes to the UN Model Regulations. We will continue to act as a prime mover in the international arena, recognising the international nature of the explosives sector.
- Developing our understanding of the future explosives sector landscape is key to ensuring potential health and safety issues are considered and addressed at the earliest stage. We will look for opportunities to engage in collective research, and are always interested to hear from industry on areas of research, in particular in relation to new and novel technologies.

We will secure effective management and control of risk:

- We will continue to work with business and across Government on key issues such as security and competence. We are supporting work not only to understand the future capability needs of the explosives sector, but also to address the decline in core skills and an ageing workforce. HSE supports the work of the Sector Skills Strategy Group (SSSG) and the use of the National Occupational Standards across the explosives sector.
- Many of you will be aware of the recent HSE review of licensing (see Martyn Sime's article in Explosives Engineering, December 2016). One of the outcomes from this was the potential for developing a more effective and efficient permissioning regime and work has started to deliver on the recommendations from the review. The wider Government digital by default agenda also means that we will look to use some of this learning, and the wider HSE use of technology in permissioning, to improve other explosives permissioning processes such as classification.

We will reduce the likelihood of low-frequency, high-impact catastrophic incidents:

- Although we will be looking to increasingly act as an enabler to support others in the addressing health and safety issues HSE will still deliver its regulatory role. We will continue to carry out risk-based inspections, assess safety reports and where necessary take enforcement action.
- We will continue to be the UK Competent Authority for the safe transport of explosives and the Market Surveillance Authority ensuring the safety of pyrotechnics and explosives products placed on the market in the UK. This combination of regulatory activity enables us to focus on key risks and issues using our resources to best effect.

We have been consulting on the explosives sector plan for the past few months, including at the recent IExpE conference, and the final plan will be published in July 2017.

Helping Great Britain Work Well is your opportunity to keep building a 21st-century, world-class occupational health and safety system.

By working together we can, not only maintain the gains made in safety, but address common challenges, which in turn will help improve productivity, keep business costs down, help keep workers safe and well, and protect members of the public. So whoever you are, in whatever capacity and in whichever subsector of the explosives industry *what will you do to Help Great Britain Work Well?*

I also challenged the audience and the Institute at the conference in the following way as a means of stimulating debate and, hopefully, action:

The Institute states that "It is the voice of the explosives sector".

My challenges are:

- *What is the sector you say you are the voice for?*
- *Are you fully representative of all parts of it?*
- *What is the voice (or messages) that you are promoting?*
- *To whom are you addressing the voice for change?*
- *How effective do you believe you are actually being?*

I also reflected on the fact that you are the Institute of Explosives Engineers. Words are a powerful medium. They can inspire or they can hurt. They can stimulate creativity or they can act as a blocker.

There are many people working in the sector who are not – or do not see themselves – as engineers. Yet they are doing vital work. *Is the label that you apply to yourself actually a barrier (whether real or perceived) to wider representation, engagement and membership? Is it time for a change?*

No doubt this will trigger an interesting and lively debate within the Institute. I do look forward to seeing and hearing the outcomes of the various challenges I have set out in the article.

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Dr Daniels was appointed HM Chief Inspector of Explosives in October 2013. He is responsible for HSE's national team of inspectors (both specialists and regulatory), policy advisors and business support staff whose work covers all aspects of the explosives sector.

Resonant Acoustic Mixing (RAM) of energetic materials



18-inch Hybrid Firing 001.

By **Daniel Jubb**

The Falcon Project Ltd specialises in fast-track, bespoke R&D, design, manufacture and testing of rocket motors and rocket engines. Falcon's 34-acre Westcott facility is located at the home of the former Government Rocket Propulsion Establishment.

Introduction

ResonantAcoustic® Mixing (RAM) is an innovative and disruptive technology and may enable more responsive production of rocket motors, warheads and pyrotechnics. The technology developed by Resodyn Acoustic Mixers, comprises an electromagnetically driven platform (LabRAM I&II) or servo driven for the larger machines (RAM 5&55). Unlike other mixers, which use a shaking action, the RAM automatically finds the resonant frequency of the platform and holds it at accelerations of up to 100G.

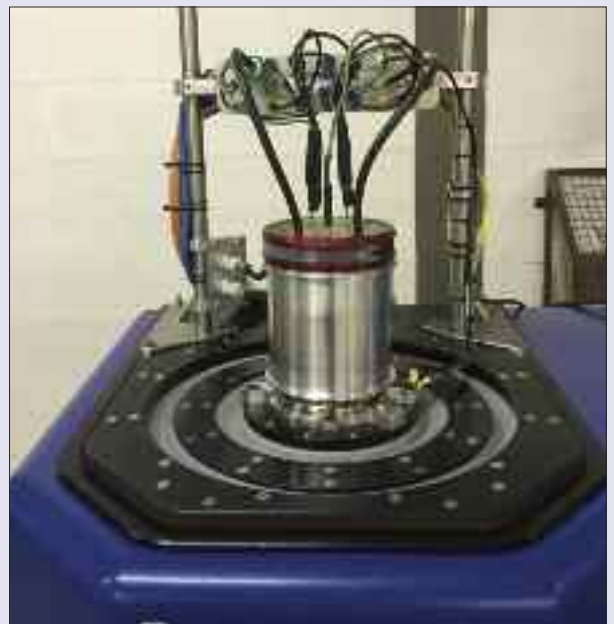
In the UK, DE&S (DOSG) initiated research into the use of RAM technology for energetic materials.

The potential advantages of RAM include:

- much shorter mix times
- no moving parts within the mix vessel
- no issues with rotating shaft seals and lubricants
- ability to process high viscosity materials
- could remove variance between machines/sites
- moderate shear, throughout the entire mix
- "one shot" mixing
- ability to "mix in case"
- continuous mixing.

The potential disadvantages or challenges of RAM include:

- the fundamentals of the mixing process are not yet understood
- limited capacity of the LabRAM's/high unit cost
- control system/software limitations
- temperature build-up/control
- electrostatic build-up
- limited vacuum provision
- the mix time is so short that bonding agent/process aid chemistry may not have enough time to achieve the required effect
- clearance and certification of finished product.



Falcon LabRAM II titanium mix vessel.

Moving from theory to practice

Falcon's initial approach was to gather as much information as possible about prior use of the RAM with energetic material and the issues and limitations users had experienced. The limitations of the standard system were recognised and modifications implemented during commissioning.

A lack of fundamental understanding of the process and principles, which underpin the operation of the RAM (particularly at small scale), must be considered a hazard until proven otherwise. The use of RAM itself should be considered a higher risk operation, as it is a novel process.

The LabRAM I has a nominal payload of 454 grams, while the LabRAM II has a nominal payload of 1,000 grams. While the purchase price of RAM systems (compared to their capacity) is high, shorter process times and much easier



Firing of a 5-inch diameter rocket motor using 14 batches of RA mixed composite propellant.



2-inch rocket motor with double cone and cylinder charge design.



Firing of a mixed in case rocket motor.



2-inch slotted radial motor firing.



5-inch firing.

cleaning mean that a compelling business case can be made for the purchase of a machine and the savings will rapidly cover the cost of the machine.

The LabRAM I has control software for remote operation, however a software based system was not considered sufficient to meet the safety requirements. Falcon added a hardware based E-Stop, which can remotely remove power to the unit.

Other users, working with plastic vessels, had reported significant temperature build-up (in some cases sufficient to melt plastic vessels). To address the potential issues with static and heat build-up, Falcon replaced the standard clamp and plastic pot arrangement with custom metallic vessels. Key mitigations against temperature build-up are the use of a metallic vessel, temperature monitoring and temperature control. To avoid metal to metal contact, the lid is made from Polyether ether ketone (PEEK), which has excellent chemical compatibility. The lid has a thinned section to provide a blow-out panel, it also has provision for three thermocouples, a vacuum port and a vacuum gauge port. Three thermocouples monitor the temperature of the mix at various heights.

Charge separation (generation) could occur in the RAM vessel during mixing, just as they can in a conventional mixer. The Electrostatic Discharge (ESD) environment in the RAM is not well understood. Key mitigations against electrostatic build-up include: the use of a metallic vessel, grounding the vessel through the base, grounding of the mix through the thermocouple sheaths and monitoring of ground lines.

Another challenge is that the mixing times are so short, that bonding agents and process aids, such as Tepanol[®], may not have time to fully react and the ammonia which is released may not be fully removed from the mix. The solution may be to select bonding agents, which work faster or do not produce gaseous reaction products or it may be a question of process order and breaking the mix into multiple stages. For example, with automation and multiple mix pots, a number of mixes could be conducted in the morning, then left for a period of time to enable full reaction, with the first mix being selected in the afternoon for the curative to be added.

Another challenge will be the issue of certification and approval of energetic materials made using RAM. Traditionally batch proofing is used for rocket motors, but in the case of a more limited capacity mixer, where one or more batches may be used in a single article, this approach cannot be used. Much tighter process control and new analytical techniques may be the answer.

In 2014 a LabRAM I was installed at Westcott with an improved vacuum system and a new instrumentation and data acquisition (DAQ) system to monitor temperatures and vacuum levels.

Initial mixing trials were conducted on composite propellant simulants, these inert mixes used the correct binder/plasticiser system with the energetic materials replaced with a bimodal inert filler. Unlike traditional mixers where the entire mix may be conducted at a single mixer speed, the RAM appears to benefit from different settings for each stage of the mix. An initial "wetting" stage requires relatively low acceleration and is intended to take the materials from the order they were loaded, to a partially mixed condition. This is followed by a bulk mixing stage, which is generally conducted at a higher acceleration. The final step is degassing, which is conducted at low acceleration. The optimum settings vary from mix to mix and seem particularly linked with viscosity.



5-inch motor firing.

Experiments were conducted to establish the initial settings for future live mixes. During this period, the importance of loading order and vacuum level were realised. The order in which the ingredients are loaded has a significant impact on the ease of starting the mix. Vacuum is a key control parameter which is adjusted during the three stages of mixing.

A safety case was completed and maintained as a “living document”, being updated to include the results of each experiment. The inert trials showed that the metallic vessel worked well at dissipating the temperature build-up. A method of approving energetic materials for use in the RAM needed to be established. With a protective plate installed to protect the mixer and the building cleared of all other materials/equipment, 1gram samples of each material were subjected to progressively higher accelerations followed by an extended period at 100G, without any grounding. Although some particle size modification was noted with Ammonium perchlorate, no ignition occurred. Initial live mixes were conducted at 5gram scale, then progressively increased to 100grams. It soon became apparent that the RAM could achieve comparable mixing to a conventional mixer in less than a quarter of the time. Propellants were initially cast into grains and tested in 38mm rocket motors, with a simple core burning charge design. Samples were compared to propellants mixed in a Baker Perkins dual planetary mixer. The ballistic performance of RA mixed propellants appeared comparable to that of conventionally manufactured propellants, however it was clear that a more neutral motor was required for propellant characterisation.

Falcon developed a 2-inch diameter rocket motor with a double cone and cylinder charge design, intended to give a neutral burn profile. The motor has a charge mass of around 180 grams and was designed to be filled from a single batch of propellant on the LabRAM I. This motor uses a simple sonic nozzle and has proved a reliable tool for assessing propellant ballistics. The 2-inch motors can be filled directly from the Falcon RAM vessel. By firing each formulation with three different nozzle throat diameters, the burning rate and pressure exponent of a formulation can be determined. By firing one of those throat diameters at high and low temperatures, the effect of temperature on burning rate (πk) can be determined. Firings of RA mixed propellant have been conducted at $-50\text{ }^{\circ}\text{C}$ and $+60\text{ }^{\circ}\text{C}$. Recently, the first firings have been conducted to assess the “batch to batch” ballistic variation.



Mixed in case propellant grain.

Mixed in case rocket motor fixture on LabRAM I.





High viscosity composite propellant.

Some scale-up experiments have also been conducted; in 2014 14 batches of propellant were made on the LabRAM I and each batch was cast in a vane mould. The 14 vanes were bonded into a 5-inch diameter motor case. The motor was static-fired successfully and is the largest rocket motor in the world using propellants made on a RAM. Recently, multiple batches of propellant have been filled into a single slotted radial charge in a longer 2-inch motor. Multiple static firings have been conducted and all have been successful.

The original stainless steel vessel was replaced with a titanium vessel (reducing the mass by around 150grams), this increased the amount of propellant, which could be mixed on the LabRAM I. A further improvement involved the addition of water cooling passages to the vessel and an outer aluminium jacket, this enabled temperature control. Increasing the temperature allowed the viscosity of the binder to be reduced, improving the initial wetting stage. The system is used in a cooling role during the bulk mixing stage to keep the mix at the optimum temperature. A new control box and software were developed; this controls the LabRAM directly and provides the hardware e-stop. It also controls the temperature of the water circulating around the vessel and the vacuum level. The parameters for each stage of the mix can be saved and mixes run automatically.

As the research progressed, Falcon acquired a LabRAM II, this has an increased payload capacity. With Falcon's custom lightweight, water jacketed, titanium mix vessel, we have been able to mix 1.2 kilograms of composite propellant using the LabRAM II and fill up to five 2-inch motors from a single batch.

RAM advantages

Without any moving parts within the mix vessel, RAM avoids the blade to bowl contact risk and blade clearance issues associated with traditional mixers. Traditional mixers with gearboxes tend to have issues (especially under vacuum) with rotating shaft seals failing and allowing lubricants to contaminate the mix. The RAM has demonstrated an ability to process very high viscosity materials, in fact some of the materials which have been mixed are being characterised by Shore A hardness rather than viscosity. This may enable production of reduced sensitivity Polymer Bonded Explosives (PBXs) with entirely small particle size filler and hence less crystal defects/potential for "hot spots". High burning rate rocket propellants, with very high proportions of small particle size AP can also be produced. In theory, RAM should not suffer from the issues associated with different mixer configurations at different sites, producing slightly different end products. Traditional mixers

have very high shear between the blade and the mix bowl and very low shear throughout the rest of the mix, whereas RAM has moderate shear throughout the entire mix. While this can be less effective at breaking up agglomerates, it could enable more sensitive materials to be mixed. Given that the mix times are so short, the curative can be included from the start of the mix, enabling "one shot" mixing. Several formulations, which traditionally require multiple addition steps for the solid fill, can now be mixed with all ingredients loaded from the start. The simple geometry of the RAM vessels enables easier cleaning. The amount of solvent required for cleaning and the quantity of explosive contaminated waste generated during cleaning are reduced significantly.

Fundamental principles

Fundamental investigations into how the RAM process works are currently being conducted. These involve using a variety of techniques in an attempt to quantify mix completeness. Near Infrared (NIR), ultrasound, high speed video and X-ray tomography (XRT) have all been used to investigate the process and finished product. In addition to improving the RAM process and optimising the mix setting, this work is providing new insights into the binder fill interactions and has provided further opportunities for improved propellants and PBXs.

Mixed in Case

RAM also has the potential to mix an energetic material in the final article case, this includes rocket motors or warheads. Falcon has made and static tested several prototype "mixed in case" motors. The first "mixed in case" rocket motors were developed and static tested at Westcott in 2015. The motors had a relatively complex 6-point star charge design. Some challenges remain, however this technique has great potential, especially for extremely viscous materials.

Continuous mixing

Rather than a simple batch process, the RAM can also be used in a continuous mixing configuration. Resodyn have demonstrated experimental continuous mixing of powder/powder systems and PBX/composite propellant simulants. The powder/powder systems work extremely well, although some challenges with the mixing of highly viscous composite materials remain.

Summary

RAM has indicated its potential advantages for processing energetic materials, with substantial reductions in process times and the ability to process materials which cannot be processed by conventional techniques. Resodyn have now developed the LabRAM II H, which is specifically designed and rated for hazardous environments. The RAM has also demonstrated a high degree of versatility, it has been used for AP milling and mixing pyrotechnics such as boron/potassium nitrate. RAM has been used to aid production of energetic co-crystals. It can also be used for sieving and particle coating. Fundamental scientific questions, regarding how the RAM actually mixes remain, along with questions about its industrial use, process order and certification of finished products. The next stage of work includes: further fundamental mixing investigations and mechanical analysis of composite propellant samples.

*All images courtesy of The Falcon Project Ltd.
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The views expressed are those of the author:

Columnist Sidney Alford OBE MSc PhD reminisces

Call Me Unqualified If You Will

Little did I suspect that the disdain which I expressed for Dubya Bush and Blair's inappropriate use of the word Homeland in pursuit of their "Crusade" against the godless but oil-producing heathen¹ would lead to the publishing of Denise Clarke's most expansive Letter to the Editor² of which the first page bore not only a simplistic definition of "homeland" but failed to explain the word's relevance to the title of a purportedly professional qualification. It also implied that I possessed qualifications of which I am innocent. This was followed by a page extolling the support of the value of her company's awards and, to consolidate this support, a third page of seventeen (presumably) unsolicited but anonymous testimonials of its former students' appreciation of the course which led to their qualification.

Miss Clarke's presumption that I value the attainment of a qualification in general and her generous assumption, albeit accompanied by a question mark, and that I possess some qualification myself are quite correct – although none bears the word homeland in its title. But I owe it to her, and to our dear readers, to admit that I cannot recall having any formal qualification in anything related to explosives. My first significant qualification was a doctorate from one of the older universities³. It concerned the synthesis of derivatives of euparine, a then little studied substance to be found in the roots of hemp agrimony (*Eupatorium cannabinum*) and which has never been known to explode⁴. Then off to the University of Tokyo to do a bit more chemistry before defecting to Waseda University to study the local language more intensively. That was followed by a brief period in a reputable British pharmaceutical company out of which I was very soon thrown when my penchant towards honesty about some of the industry's products caused some alarm. Then some research on the fatty components of brain tissue at the Nuffield Institute of Comparative Medicine, London, followed by a master's degree in Environmental Pollution Science at a much newer establishment just down the road from London, paid for in part by interpreting at MoD conferences. And what do I have to show for all this? A few letters after my name of which only three - and they only recently acquired - for services to a non-existent empire, albeit related to explosive ordnance disposal.

My first practical acquaintance with explosives derived from experiencing the effects of German conventional bombs, flying bombs and large rockets which were delivered from the *Vaterland*⁵ and dropped on houses close to my own, to the detriment of windows, roofs and lives, during my early childhood. Clearly, these fearsome effects I realised derived from their explosive contents, and this led to an enduring interest in chemistry as a young schoolboy which, by the fifth form, was put to good use organising a group of my school fellows to prepare, in memory of the well-meaning Guy Fawkes, bigger and better bangers than those available from shops. The fill consisted of a mixture of the filings arduously prepared from recovered German Elektron incendiary bombs and potassium permanganate, and the tubes were rolled from the strong paper photographic film backing provided for the purpose by Mr Dann of Dann's Chemists & Opticians⁶.

Sixth form chemistry included discussion of the chemistry of such substances as nitroglycerine, picric acid and TNT but the formal

syllabus included no practical work with them. This gave me no alternative to making them myself at home, an endeavour in which Gants Hill Public Library was invaluable⁷. Proof of success also necessitated the additional preparation of enough lead azide or mercury fulminate to get them easily to detonate. Our enlightened chemistry master invited me to lecture to the sixth form on practical aspects of preparing these substances followed by demonstrations behind the former air raid shelters which served as football changing rooms. (Fortunately the school stood far enough from houses, hospitals and royal residences and the HSE had not yet been invented.)

Many years later, after returning to live in my motherland, I realised that the British military was being required to render safe home-made bombs constructed by inhabitants of both parts of Ireland, but that they were using unsuitable disruptive techniques and apparatus which had been devised for German steel-cased munitions which were quite inappropriate for dealing with bombs hidden in ladies' handbags, motor cars, dead dogs and dying donkeys. Feeling a duty to try to help military methods to change with the times, but having no official access to explosives at the time, my house became my laboratory and testing facility. Complaints by nosey and unpatriotic neighbours resulted in an inquisitive visit by the police and then by a very polite gentleman from the Security Service. Fortunately their sense of priorities was such that my work was not interrupted. The situation improved at a stroke when news of my gadgetry fell on the ears of an army officer who had been obliged to drive his car the day before with a very dubious package on the back seat. He immediately arranged for me to be given access to a suitable military range and all the plastic explosive and detonators that I needed to pursue my experiments.⁸ The results of that work led to the forming of my present company and the wide range of EOD equipment that my company now provides.⁹



In defence of a higher calling.

- 1 *JlExpE*. December 2016
- 2 *ibid*. March 2017
- 3 *The University of Paris*, apparently the second oldest, having been just preceded by the University of Bologna (ca AD1000)
- 4 Let readers with spare time type "euparine alford" into Google
- 5 Also referred to, according to context, as the Mutterland
- 6 After his retirement, Messrs Boots kindly undertook to order chemicals for my domestic experiments.
- 7 Today's public libraries seem no longer to cater for this user requirement.
- 8 None other than Col John Coghill OBE. (See obituary page 10).
- 9 End of advertisement: a mere 25 words!

The Bennett file

Our columnist John Bennett's thoughts on 'dangerous' fireworks

Few believe that laws and regulations are unnecessary and that flouting them is acceptable and, to be honest, doing so is usually unwise. I have not recently driven down a motorway on the right side of the road! So, it may perhaps surprise some to know that most of the deletions to the ranges of fireworks (in the days when fireworks available here were also made here) were voluntarily made by the UK manufacturers. This was, of course, before the 1990s and early part of this century when the Fireworks (Safety) Regulations, the Fireworks Bill and subsequent regulations took over. Partly this change was necessitated when fireworks sold in our shops were no longer made in this country. But, also, there had been accidents involving public use of shells. Perhaps the remarkable thing was that not more had occurred – who really thought that shells (and indeed what are now known as Category 4 fireworks) were suitable fireworks for use by the general public without any training? And, while their use was a throw-back to the days when attitudes to all matters relating to safety were very different, it had taken a long time for the country to wake up to it – especially given the campaigns which exaggerated the dangers of fireworks.

So, I am going to treat 'unsuitable fireworks' in order of danger until I end up with those which seemed to be dangerous but which actually caused very few accidents.

I was talking to the late Tim Warren (while preparing an article) about a firework produced by his company – and he expressed surprise that it might have been considered dangerous. Strange since the item was a stickless rocket. Place it on the ground and light it. It goes to show how public – and industry – attitudes have changed in the sixty plus years since his company, Wallop Fireworks (also known as Victory Fireworks) ceased to manufacture fireworks. That the firework, the famous (infamous?) Wallop Wobbler, has a place in the hearts of firework enthusiasts might perhaps stem from the fact that no one I know ever possessed one, the company having never been well-known. What perhaps is even less well-known is that the major manufacturers also produced stickless rockets. Standard were still manufacturing them – the Golden Arrow and the Silver Bullet – in the 1930s. To replicate the effect of these items one could snap the stick off a rocket and lay it on the ground before lighting it. However, I don't recommend the experiment!

I think we can all link the stickless rockets with shells as fireworks we can do without, although the Spanish – 'cultural differences' are usually given as the reason – would probably disagree. I have only to remember my last visit to Valencia, where the borrachos (borracho means drunkard) – a fearsome firework, similar to, but vastly larger than, a Wobbler consisting of a tube filled with potassium perchlorate, sulphur and charcoal was thrown about with little concern for safety. They are not designed for the river bank where the majority perform but police on motor bikes were pelted with them and reacted with complete nonchalance. But then fireworks are used in the streets there and people skirt round them, sometimes without even appearing to notice them.

And it does make us think – given that no accidents were reported in Valencia during my visit – just how dangerous the fireworks which were excluded from ranges really were. What about saucissons –



Prior to Firing Argos Jumping Cracker.



Silver Bullet - a 'wobbler'.



Wessex Gremlin - a saucissons (flying dragon).



Golden Arrow - a 'wobbler'.

flying dragons which, with a much smaller tube than the Wobbler, performed a similar task of sliding and whizzing along the ground – the Wessex Gremlin (my all-time favourite firework) was one of this type – but its progress rarely involved danger. The expression chosen by the manufacturers as a criterion which exposed a firework to voluntary exclusion was 'a firework of erratic flight'. By this standard, the saucisson definitely qualifies as does the much maligned – but greatly loved – jumping cracker. As for tourbillions – those beautiful aeroplanes, they almost define the phrase. I am not sure how the mini-rocket qualified while much larger rockets continued to appear. Their disappearance was blamed on the fact that they were 'used by hooligans'. This spelt the end, too, for the single shot flash candle, while later – and much more powerful – flash-powered cakes continued to come into the country.

Ground spinners – Pain's Spinning Top being a case in point – perhaps qualified as a firework of erratic progress, rather than 'flight' although it disappeared long before the expression first appeared. And perhaps, for some of this type of firework, the complexity of – and thus cost of – making them was a relevant factor.

The advent of, particularly, Chinese imports brought a range of fireworks which, while they might satisfy the safety industry on the basis of lack of erratic flight, had the sort of power for the general public that could only have been dreamed of when British fireworks were the norm. Which could bring us onto the British Standard, the European Standard, Brexit and... but then perhaps not!

John Bennett is editor of Fireworks, a magazine for enthusiasts and the trade. It is obtainable, by credit card on the website www.fireworks-mag.org or, by post, from Fireworks, PO Box 40, Bexhill TN40 1GX (tel: 01424 733050; email: editor@fireworks-mag.org). £10 annual subscription payable to Fireworks Magazine. Fireworks is also available electronically (See website).

A focus on early careers: The importance of networking

The IExpE, through the Journal, would like to draw attention to those of us in our early careers in the explosives sector. The aim is to explore the issues, topics and discussions that are important to those readers who are the future of the sector. Having recently attended the Institute's AGM and conference and with the 3rd Annual Early Careers Symposium for weapons and explosives workers planned for 13th to 14th September 2017, this first article will discuss the importance of networking, with the aim of encouraging you to get out into the wider sector and engage with your peers.

It is fair to say that the majority of those employed in the explosives sector have either a science or technical background and, although we know that business skills such as networking are important, we may not fully appreciate the benefit to our careers. There are common themes that run through the various definitions of networking, such as exchanging information and building professional relationships. Furthermore, a key part of networking that is commonly misunderstood is that it is about identifying opportunities and not about selling.

So why is networking important, in particular to those in their early career? Some of the reasons are particularly pertinent to those working in the explosives sector. Our sector is small in comparison to, for example, the IT or manufacturing sectors, and arguably the competition for jobs is tougher when you have a pool of highly skilled applicants competing for very few opportunities. Add to this the challenges involved in knowing where to search for vacant positions in the explosives sector and it soon becomes apparent why networking is important to someone early in their career. For example, you can use networking events to establish current opportunities and also keep well-informed as to where in the sector future opportunities may arise. A second issue pertinent to the explosives sector stems from the recognised decline in some explosives sub-sectors such as manufacturing and mining. This decline has generated an experience gap in the explosives sector, a gap that sits between those very experienced, more senior workers and those in their early careers. It is very possible that as more of those experienced colleagues retire we will lose vast amounts of knowledge and expertise. Networking is an excellent way to draw on the experience of those experts in the explosives sector and to establish opportunities where individuals can mutually share knowledge and information. This is not the only answer to retaining that historic knowledge and experience, but will certainly contribute to doing so.

Networking is not confined to large external events, such as conferences or symposia; we should also seek out more intimate, smaller and often internal opportunities to use this business skill. Obviously if you work for a company with only a handful of employees then internal networking events may be limited. However, a large number of those in the explosives sector work for large public organisations. In my experience I have found the use of internal networking vital to both my career and, more importantly, my work. When you work for an organisation that employs nearly 5000 staff developing a broad professional network of colleagues can be an excellent tool. I am sure many of you will be working on projects or tasks that will have a number of key stakeholders. In this situation, it is possible that silent or unknown stakeholders will impact upon the progress of a project. Internal networking is an ideal way to establish who those stakeholders are, to engage with them and avoid potential project delays. Another excellent benefit of internal networking is that



it can build your confidence and skills before attending larger external events where you may only know a few people, if anyone at all. It is a good idea to set the goal of introducing yourself to someone you don't know at every internal event you attend and it can be a good time to develop your opening personal introduction. As your internal network broadens, you will establish a deeper understanding of your organisation and will develop a group of people that you can introduce to others and who will introduce you to their contacts.

With such a diverse sector as the explosives industry external networking events can be very useful, particularly to those in their early careers. Networking at events such as the Institute AGM and Conference and the Early Careers Symposium is a great way to broaden your knowledge of the sector. For example, many of the projects and tasks that I have been involved with are not completed purely by an internal team. Often work is completed by an external partner. Having a broad external professional network can assist you when identifying suitable external partners. On a wider scale external events such as focus and working groups can offer the greatest opportunity to really broaden your professional network.

Here are five top tips about networking to take away:

- Always take the opportunity, no matter how 'small' the event, to meet new people or develop professional relationships.
- Get to an event early. If you go with a colleague don't just spend the whole event talking to them.
- Stay in contact with your professional network.
- Be mindful of opportunities where you can add value to a professional contact, maybe through a secondary referral/introduction; networking relies on people asking "how can I help?" and not "what can I get?"
- Use internal events to build your confidence and improve your networking skills.

Remember take every opportunity to develop your professional network. If done right networking can lead to a recurrent cycle; meeting more people leads to a greater network offering professional opportunities, which leads to meeting more people growing the network leading to more opportunities, and so on. I hope to meet you at the next networking opportunity.

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EFEE 9th World Conference on Explosives and Blasting, 2017

The 2017 EFEE conference will be held in Stockholm, Sweden on the 10th to 12th September in The Brewery Conference Centre. The conference has established itself as one of the most important international blasting events. It all started in 2000 with the 1st EFEE World Conference in Munich and after Prague 2003 it continued on a regular basis every other year. All eight of our previous EFEE World Conferences proved how really important events are where experiences and skills can be mutually shared. The 9th Conference is expected to attract about 450 delegates from around 50 different countries and is organised in cooperation with the Swedish national association –Swedish Rock Construction Committee.

One of the most important facts to highlight in relation to the conference is that Alfred Bernhard Nobel was born on 21st October 1833 and was known as a chemist, engineer and innovator worldwide as well as inventing dynamite. The Conference Gala dinner will be held at Winterviken in the former Alfred Nobel factory.

Further information: www.efee2017.com

Glowing bacteria key to disposal of landmines

Scientists have created a way to detect buried landmines using glowing bacteria and lasers in a breakthrough that could lead to a safe method for the disposal of the devices. Researchers at the Hebrew University of Jerusalem successfully mapped the location of unexploded mines in a test field using engineered bacteria that glows when it comes into contact with vapour released by the mines.

There are an estimated 110 million armed mines buried across the world that are responsible for up to 20,000 injuries and fatalities a year. But the methods used to detect and dispose of landmines have remained largely unchanged since the Second World War. Using the glowing bacteria method, disposal teams could target their efforts more securely.

Daily Telegraph, 14th April, 2017

Security & Counter Terror Expo, 2017

The Security & Counter Terror Expo was held on 3rd and 4th May at Olympia, London, and has a reputation for showcasing technology for the first time in Europe. Visitors were able to see the first ever drone capable of transporting human passengers. It is set to revolutionise the movement of people and has generated a lot of interest amongst the police, military and security professionals.



www.counterterrorexp.com

Dear Editor,

I read with great interest (as I always do) Dr Alford's column in the March issue of "Explosives Engineering". Yet again, and in his own inimitable way Dr Alford raised a number of points that should encourage all of us to question our preconceptions and challenge orthodoxy. This was particularly evident in relation to the properties of 2,4-Dinitrophenylhydrazine, which sharing Dr Alford's orthodox approach to chemical nomenclature, I will continue to refer to as 2,4-DNPH, This being despite my copy of Meyer's Explosives using the abbreviation 2,4-DNPh, and nine of the top ten hits on an internet search for 2,4-DNP throwing up references to dinitrophenylhydrazine rather than dinitrophenol (including both Wikipedia and the website of a major chemical supplier). To my mind this suggests that rather than not inspiring confidence, CLEAPSS' (Consortium of Local Education Authorities for the Provision of Science Services) approach and interchangeable use of 2,4-DNPH and 2,4-DNP was more about ensuring that the messages they were trying to get out to schools were received and understood, rather than ensuring that the sensibilities of purists like me were not offended.

Dr Alford's column highlighted a number of other issues. Perhaps the most relevant of these is how important it is for all of us to understand, even if it is only at the most basic level, the fundamental properties of the materials we acquire and handle. I would be surprised if many of the laboratory technicians in the UK's schools realised that they were making up solutions from a material that is classified as a desensitised explosive and that their safety and the safety of others might rely on the 2,4-DNPH remaining water wet. Perhaps this is evidence of a failure in wider scientific education or, in our increasingly risk averse society, a belief that anything you can buy must be completely safe - 'this coffee may be hot!'. But whatever the reason I agree with Dr Alford that one of the ways to address this deficiency is by ensuring that students undertake hands-on laboratory work and practical engineering in an appropriately equipped workshop in addition to ensuring that school chemistry teachers possess sufficient knowledge to be able to understand the risks that they and their technicians are managing.

Dr Alford's column identifies a further matter that would, no doubt, have Trevor Kletz, the ICI chemist credited with introducing the concept of inherent safety to the chemical industry, holding his hands up in horror. Dr Alford tells us that that it is Brady's reagent that is used for the detection of aldehydes and ketones rather than 2,4-DNPH itself. Given that the reagent is generally used at concentrations of 2,4-DNPH of between 2 – 4% w/v and pre-prepared Brady's reagent is advertised on at least one chemical suppliers website as a 'substitute for the explosive solid' it would appear to me that any economies that might have been achieved by purchasing wetted solid rather than the made-up reagent would be eaten up in preparation costs for solutions, increased effort in monitoring on-going safety of the remaining 2,4-DNPH, and no doubt significant disposal costs when, after many years of storage in an all too likely uncontrolled environment, the 2,4-DNPH is found to have dried out. As Dr Kletz might have said, what you haven't got can't go bang!

Martyn Sime

BSc (Hons) PGDip MRSC CChem MIEpE

Conferences/Exhibition Diary

8TH INTERNATIONAL CONFERENCE ON EXPLOSIVES EDUCATION AND CERTIFICATION OF SKILLS

Arlanda, Stockholm, Sweden, 13th to 14th June, 2017.

Objectives are to contribute to the harmonization of training of personnel in the explosive sector and for the development of a transferable certificate of explosive competences.

Further information: www.euexcert.org

EFEE 9TH WORLD CONFERENCE

The Brewery, Stockholm, Sweden, 10th to 12th September 2017

World conference on explosives and blasting

Further information: info@efee2017.com, www.efee2017.com

DSEI 2017

Excel, London, 12th to 25th September 2017

The World leading defence and security event.

Further information: enquiries@dsei.co.uk www.dsei.co.uk

EARLY CAREERS SYMPOSIUM

The Oxford Belfry, 13th to 14th September, 2017

Topics of discussion: Working with Health and Safety; Protection, detection and analysis; Materials; Emerging technologies.

Further information: events@iexpe.org

UK SECURITY EXPO 2017

London Olympia, 29th to 30th November 2017

Further information: www.uksecurityexpo.com

ORDNANCE MUNITIONS AND EXPLOSIVES SYMPOSIUM

Defence Academy of the UK, Shrivenham, 31st October to 1st November 2017

The theme for 2017 is "Design Certification, Qualification and Life Assessment"

Further information: www.symposiaatshrivenham.com

44TH ANNUAL CONFERENCE ON EXPLOSIVES AND BLASTING TECHNIQUE

San Antonio, Texas, USA, 28th to 31st January, 2018

Further information: www.isee.org

HILLHEAD 2018

Hillhead Quarry Buxton, Derbyshire, 26th to 28th June 2018

The biennial showcase for the quarrying and construction industry. Last year featured 476 exhibitors and an ABC-audited attendance of 18,601.

Further information: harvey.sugden@qmj.co.uk, www.hillhead.com



In a Flash

Andy Carr CEng MIEpE



Age 39.

Occupation Engineer.

Current Position

Chief Engineer, Torpedoes at BAE Systems.

Responsibilities in job/work activities

I provide governance over all Underwater Weapons Products, support and services by ensuring that engineering activities are conducted appropriately. I am responsible for signing the Certificate of Design allowing their use. I also carry out Design and Technical Bid Reviews across BAE Systems and act as an internal consultant as required.

Why are you involved in IExPE?

I think it's important to give something back to the explosives community and enjoy the opportunity to talk to colleagues involved in a diverse range of activities. We're all faced with similar issues and the Institute is working hard to support and develop the professionalization of the industry. I'm particularly focused on training and education and helping to ensure this is delivered to a high standard to people of all disciplines to enable them to act effectively now and to ensure we have the skills for the future.

What are the benefits for you of the IExPE?

The IExPE has given me a wealth of benefits; from the wide network of contacts and networking opportunities, to being able to see aspects of the industry beyond my current work, excellent CPD events and an opportunity to find out what the state of the art is across the sector.

What alternative career might you have followed?

If I'd not joined BAE Systems, I would probably have joined Rolls Royce to work on Titanium and Nickel based systems used in Jet Engines. Whatever I'd have done would have involved engineering!

Who do you most admire on the current world stage and why?

I have to say I have a lot of respect for Barack Obama and his family. I think they've genuinely had a positive influence on the world and have always approached things with grace and good humour.

Who would you most like to meet from any century and why?

I find this a really hard one to answer as so many people spring to mind, from the great engineers of the past where Isambard Kingdom Brunel is a personal hero, to great musicians with David Bowie providing the soundtrack to much of my life. I find it hard to choose between the two, so won't!

What are your favourite activities/hobbies?

I've always had a passion for Martial Arts, particularly Jujutsu although I've had a break from this for a while (it's amazing how you can get used to waking up without any bruises or pain!). Nowadays I spend my time with the family and generally taking a beating from my two boys (aged 1 and 3).

What is your ideal holiday?

I tend to alternate between wanting to chill out with the family in a nice hotel on a good beach to getting off the beaten track and really exploring somewhere, particularly in Asia. I think my record is 13 flights and three boats in 3 weeks!

What is your favourite type of food?

I really love Thai food, one of my favourite meals was with my wife in Bangkok; Tom Yum soup with young coconut to start followed by blue rice with soft shell crabs, a papaya salad! Oh, and don't forget a decent beer.

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IExpE Journal calls for papers

Deadline for September 2017 issue is July 31st 2017.
1500 - 3000 word articles and papers will be considered for publication and should be accompanied by digital illustrations eg. photographs, drawings and tables.

E mail the Editor: editor@iexpe.org

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