SAFEX INTERNATIONAL EST-1954

SAFEX NEWSLETTER
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This is you Captain Speaking

Francois Hay (BME South Africa)

Francois is 41 years old and started with the Omnia Group in 2000 and has been with BME since 2003 - first as Financial Director and then promoted to Managing Director in 2007. He is married to Hilde and has 3 boys, Johan, Hanro and Francois. BME has been in operation since 1984 and has been very successful especially in the South African open cast mining. Since the late 1990's it has been expanding into the rest of Africa and today operates or supplies products to 13 African countries.

In its 28 year existence BME has developed an impeccable safety record. However, a year ago, we lost 3 employees in a most unfortunate accident. Never again shall I comment about safety from an emotional distance, or an arrogant sense of achievement. Never shall I regard safety as something that we can achieve completely and adequately. Never can we say, enough has been done, we have arrived at our destination.

In life, we grow and become who we can be by learning from what goes wrong. That is the economy of grace – that nothing is wasted, but even our worst mistakes can be used to bring us to the full solution. Similarly, in safety no accidents should be wasted; what we learn should guide us towards the solution. Therefore, I want to share with you 2 of my learning's, which guide my perception of safety. Firstly, safety is a team effort, and secondly, safety is about so much more than ISO.

The full implication of safety as the responsibility of everyone in a team reaches deeper than we realise. We need to function as teams in the fullest sense of the word to create a safe working environment. Teamwork requires trust; trust that the company's success impacts each one positively; trust that we want more from a company than short term gains; trust that all of us work towards the values of integrity and ethics. How do we trust each other in an environment where the century-old divide between management and labour is still alive and kicking, its underlying conflicts still being fueled by those who fail to understand our common goals? It saddens me that so often our efforts are not directed at lifting each other up, celebrating each others' successes, meeting each others' needs, but at working against each other. Ever since the Industrial Revolution, there has been a great divide between management and labour. We still blame each other; management is blamed for greediness and selfishness –

sometimes not without reason; labour is blamed for carelessness and selfishness – sometimes not without reason. When will we realise that we're not on opposite ends anymore? The only way to learn to trust each other, is to get to know each other. We must learn to understand better. Let us build our trust with intent. Is the *heart* of safety not about truly wanting to protect each other? Where have we lost the real reason for working safely?

Part of the realisation of the team as a primary motivator for safety, comes the implication of my own membership in the team. My own integrity is one of the building blocks upon which my team will practice safety. The way I drive, the way I solve my problems, the way I exhibit my anger or frustrations, the decisions I make - all of these contribute to a safe, trusting environment, or to an aggressive, it's-all-about-me culture. If I stand for safety, I cannot be complacent about dangerous transport on dangerous roads – even if I am fortunate enough not to have to use those. How can we stand for safety in one aspect of life, but ignore the wider societal safety concerns – perhaps just because we ourselves and our own families are reasonably well protected and to some extent exempted? That is not integrity.

What we need most in our country and in our businesses, are activists - people who won't stand for complacency. We need people with integrity to do what is right and safe in their own lives, in their own cars, in their own businesses and in the lives of those around them. If this was an easy challenge, we would have had more people who stood up for the heart of safety. No, it requires patience, perseverance, and willingness to change, starting with myself. We have to overcome many barriers, within and across countries – culture, language, education, perceptions, historical context, fears. But we have come far, we have travelled vast distances on the road to Africa's full solution; we can see this through.

Never stop doing the right thing. Never get complacent. Never think that your journey towards safety – in your organisation and in society – is in vain. What you do, counts. Our attempts to stand for what is right, add up. Let us keep each other safe.

Meet our New Governors

At the recent Ordinary General Meeting of members held during the XVII SAFEX Congress in Istanbul, the following new Governors were elected:

- Terry Bridgewater (Chemring Group PLC)
- Carlos Orlandi (Enaex Servicios S.A.)
- John Rathbun (Austin International)
- Thierry Rousse (Groupe EPC)
- Mark Thomas (Orica Mining Services)

We will be introducing the new Governors to our readers in forthcoming Newsletters as we did with Terry Bridgewater, Carlos Orlandi and John Rathbun. It is now our pleasure to have you meet Thierry Rousse.

Thierry Rousse

Thierry studied chemistry at the Pierre et Marie Curie Université in Paris VI, France, before joining the 'Institut de pétroléochimie et de synthèse organique industrielle' in Marseille. He graduated as a Chemical Engineer ESIPSOI in Marseille in 1988 before majoring in Business administration IAE in Aix en Provence in 1993. Thierry adds several more certificates to his qualifications, among them, Polymers in Montpellier and Organic Chemistry Synthesis in Marseille.

He joined EPC Group in 1989 as an R&D engineer. In 1996 he became the R&D Lab manager. He was then promoted to Plant manager for the production of civil explosives and chemical products in 1998 before being appointed as Technical manager in 2001. During that time, Thierry was also overseeing as project manager the erection of plants in Africa and Central Europe. Since 2005, Thierry has been in charge of Health Safety & Environment at corporate level. In this role he covered all aspects of the explosives business including drilling, blasting and demolition in Europe, Africa and the Middle East. For the past 6 years, EPC has concentrated its efforts on the development of a safety culture throughout its different subsidiaries worldwide. Thierry is very proud of the part he played in implementing the EPC Groupe 'safety culture'. The culture is based on behaviour change which must be implemented within the context of the local culture and language.

Thierry attended his first SAFEX congress in 2005 in Geneva and was elected Governor at the Istanbul General Meeting in 2011.

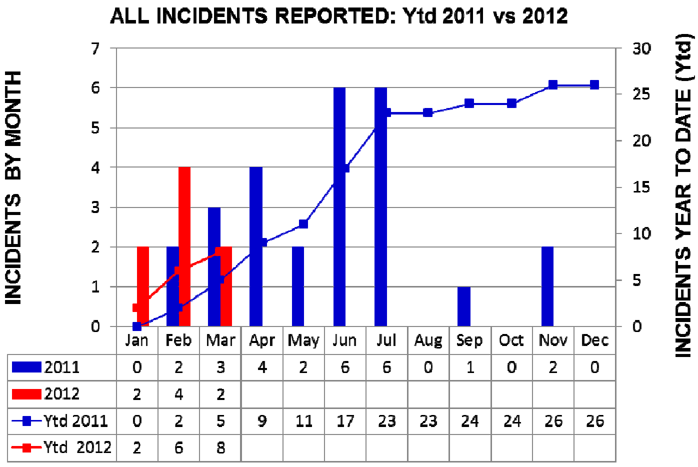
When not working, Thierry enjoys swimming, travelling abroad with his family and a rucksack on his back. He also has a special interest in prehistoric sites. Over the week-end he likes to cook for family and friends: He has a simple philosophy: "The longer I spend in the kitchen, the better the meal." His meals are served with French wine which has been allowed to mature in his wine cellar for several years.

Incident Reporting

Monitoring our Reporting Performance

"Every incident that is reported may prevent another from occurring. You can save a life by reporting an incident - including a near-event."

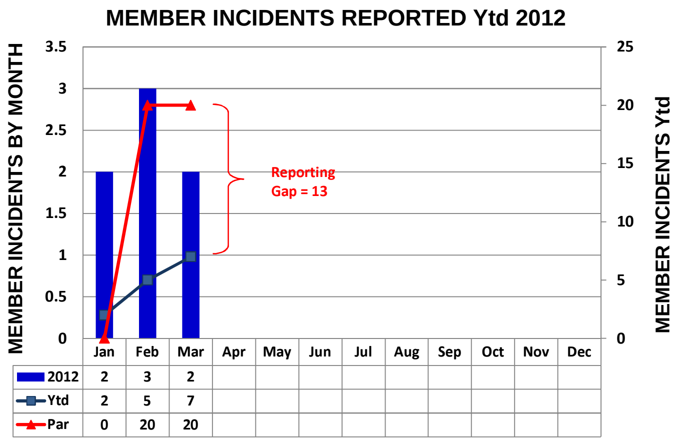
SAFEX learns from its members' experiences through the incident reports we receive. By applying these lessons we can prevent similar incidents recurring. That is why we track our incident reporting performance as follows:



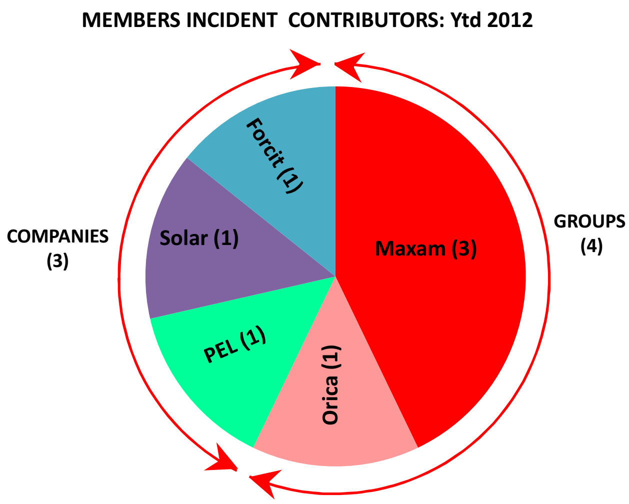
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	0	2	3	4	2	6	6	0	1	0	2	0
2012	2	4	2									
Ytd 2011	0	2	5	9	11	17	23	23	24	24	26	26
Ytd 2012	2	6	8									

All the incidents reported. This chart compares the sum of non-member and member incidents reported to SAFEX every month this year to the previous year. We have reported more incidents this year than in the same period in 2011. It may not be as result of more incidents but rather due to members being more conscientious in reporting the incidents we are having. Remember, every incident not reported is a lost learning opportunity. Also, it's never too late to report an incident.

Member incidents reported. Because they give us the best learning opportunities, we track member incidents (MI's) separately in the chart on the right. PAR is an estimate of how many MI's are occurring based on the severity of the MI's that were reported in a particular month. The gap between the number of MI's reported and PAR is our Reporting Gap. The Reporting Gap suggests that only ⅓ of our MI's are being reported.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	2	3	2									
Ytd	2	5	7									
Par	0	20	20									



Contributors of member incidents. This chart identifies those members who reported their incidents. It shows the number of incidents each of these members have reported relative to the total number of MI's received. The chart distinguishes between Groups and Companies merely to indicate the performance of the two membership categories. There are about twice as many operating units in the Groups than single Companies. So far this year each category has reported about the same number of incidents.

Know the Expert Panel

The **Expert Panel** comprises individuals who were nominated by members and approved by the Board. Such an individual must be associated with the explosives industry and possess expertise in specific fields. He must also be willing to make his expertise available to SAFEX members on a commercial basis which is agreed between the expert and the member. SAFEX does not get involved in the detailed arrangements but merely "connects" the Expert and the Member with the need.

To access the services of a SAFEX Expert, a client Member accurately defines the need it wishes the Expert to address. This requirement is captured in a Brief which is e-mailed or faxed to the Secretary General. The Member will be notified of the details of Experts that specialize in the fields of expertise designated by the client Member. It is then up to the Member to select an Expert and enter into an agreement directly with him.

Dr Pieter Halliday

PERSONAL

Position: Executive Director Global Technology
Company: AEL Mining Services
Location: Johannesburg, South Africa
Education: BSc, BSc Chem (Hons), MSc, PhD
Affiliations: Governor, SAFEX;
Board Member NIXT;
Board Member SA Society of Rheology;
Member ISEE, EFEE, IPS
Languages: English; Afrikaans

CAREER OUTLINE

With ICI Group:

- Global Technical Manager, Packaged Explosives
- Global Business Manager, Packaged Explosives

With AEL Mining Services:

- Research Officer
- Project Manager
- Explosives Research Manager;
- Technical Manager
- Executive Director Global Technology

EXPERTISE

- Explosives and Initiating Systems Technology
- Auditing
- Incident investigation
- Safety Management
- Quality Management
- Remediation

TYPICAL ASSIGNMENTS

- Development of emulsion explosives
- Pump safety systems for waterbased explosives
- Nitration chemistry for sensitisers
- Product development over whole range of commercial explosive products Building and commissioning of explosives plants.
- Risk assessments; Safety and Quality management
- Expert opinion on several explosives incidents
- Automation of detonator manufacture
- Spray drying of Pyrotechnics

QRA Corner

Welcome to a new instalment in the SAFEX Newsletter series called the QRA Corner. Each column will examine a particular aspect of state-of-the-art applications, large-scale testing, and algorithms associated with Quantitative Risk Analysis (QRA) models. Your authors will rotate between Lon Santis, Manager of Technical Services of the Institute of Makers of Explosives; John Tatom, Manager, Explosives Safety Group at APT Research, Inc; and Mike Swisdak, creator of the US Department of Defense' ESKIMORE large scale test program and currently a senior scientist at APT Research. Our first instalment in the last Newsletter comprised a series of questions and answers that often come up when the issue of QRA is first raised. This instalment touches on the large scale testing employed to enhance the algorithms used.

Large Scale Testing for QRA in the last decade

by

Michael Swisdak (Senior Scientist, APT Research Inc)

The year is 2002 and Version 2.0 of the U.S. Department of Defense (DoD) quantitative risk assessment software SAFER has just been released. The DoD's Risk Based Explosive Safety Criteria Team (RBESCT) has spent ten years and over four million *dollars* developing a state-of-the-art, semi-empirical quantitative risk assessment (QRA) model. The observations and experiments upon which the model is based come from the existing literature. Largely, this includes U.S. DoD as well as international testing on explosive safety and human response. Where data were lacking or incomplete, the RBESCT made conservative assumptions in the SAFER algorithms.

Seeing a need to fill in some of the gaps but also recognizing that obtaining all the data they wanted was impractical, the RBESCT asks its technical advisory group, the U.S. Department of Defense Explosive Safety Board (DDESB) Science Panel, for assistance. The Science Panel is asked to assess the maturity of the science behind the software and to propose a testing program that would address areas of conservatism introduced by a lack of established test data. In order to create a testing program that would fill in the gaps that most severely limited the development of algorithms (yet were feasible to address with testing), the Science Panel identified the following three most important issues:

- ISSUE 1: Secondary or donor (Potential Explosion Site, PES) debris generation and density versus distance,
- ISSUE 2: Target building (Exposed Site, ES) response to blast loading, and
- ISSUE 3: Target building (ES) protection against debris afforded to occupants.

Two series of tests were proposed to address these issues, with the **SciPan** program addressing ISSUE 1 and ISSUE 2, and the **SPIDER** program addressing ISSUE 3. Because of the manner in which these programs were structured, the results would benefit both the quantity-distance (QD) community and the risk assessment community. Planning for both the **SciPan** and **SPIDER** testing began immediately. Moving forward to 2012: the **SciPan** program is nearing completion while the **SPIDER** program is about halfway complete.

The **SciPan** program derives its name from an abbreviation for the DDESB Science Panel and is in no way affiliated with the city/island of Saipan in the Northern Marianas Islands. The SciPan test series is structured to examine the break-up and debris generation of reinforced concrete and masonry structures exposed to internal detonations of varying sizes. Where feasible, various types of structures would be exposed to the air overpressure produced by these detonations in order to ascertain their behavior under blast loading. **SciPan** 1 and **SciPan** 2 were conducted in 2003. **SciPan** 1 involved the detonation of 12,249 kg of flaked TNT inside the test structure and also examined the blast response of a nearby, large tilt-up concrete panel structures. **SciPan** 2 provided a blast-only environment for the large tilt-up reinforced concrete structure tested as an ES on **SciPan** 1 by detonating a 2,270 kg hemisphere of TNT external to the ES structure. **SciPan** 3 was conducted in 2005. It involved the detonation of 27,218 kg of flaked TNT inside the test structure and also studied the blast response of brick and concrete masonry structures exposed to the airblast produced by the detonation.

One of the major sources of uncertainty in the performance of risk-based

SciPan PES

SciPan 5 Charge

SciPan Debris Cataloguing

SPIDER 1 Impact Test

explosives safety analyses is the amount of protection that is provided by an exposed site. The **S**cience **P**anel **I**mpact **D**ata **E**valuation and **R**eview (**SPIDER**) program was designed to address this issue. Specifically, this program examines two key questions:

1. How are material type, mass, and velocity of debris used to predict perforation of and damage to specific roof and wall types?
2. What is the resultant hazard to occupants posed by fragment perforation and damage?

SPIDER 1, which looked at debris impact effects on typical roofing materials, was conducted in 2004.

Around 2005, with military operations intensifying in the Middle East, questions were being raised about the effects of detonations inside ISO containers. A third testing branch was designed and the first test on ISO containers (**ISO-1**) was conducted in May 2006. It involved the detonation of 1,054 kg of ANFO inside an ISO container located on the back of a truck.


ISO Container Detonation

Based on the initial success of these programs (**SciPan**, **SPIDER**, and **ISO)**, the DDESB asked the Science Panel to prepare a formal testing effort that would include those test series already underway as well as to propose additional work in other explosive safety areas. The program was formalized in February 2007 as a ten-year effort with testing proposed in the following areas:

- **SciPan,**
- **SPIDER,**
- **ISO** Container,
- Modeling of exposed structure behavior under blast and debris impact,
- General debris physics experiments, and
- Earth-covered magazine (ECM) debris

This effort was viewed as a continuation of an earlier DDESB testing program known as Project ESKIMO conducted between 1971 and 1985. ESKIMO was an acronym for **E**xplosive **S**afety **K**nowledge **IM**provement **O**peration. The goal of this program was to determine more accurately the minimum safe separation distance between earth covered magazines storing high explosives. This new program, designed to continue the successful ESKIMO work, is known as Project ESKIMORE (**E**xplosive **S**afety **K**nowledge **IM**provement **O**peration--**RE**dux).

Since its formalization in 2007, Project **ESKIMORE** testing has continued:

- **SciPan** 4 was conducted in August 2008. It examined the effects of a 1,000 kg detonation of flaked TNT inside the structure.
- **SciPan** 5 was conducted in June 2011. It examined the effects of a 2,995 kg detonation of flaked TNT inside the structure.
- **SPIDER** 2 was conducted in the summer of 2009. It examined the effects of impact on typical wall materials.
- **ISO**-2 was conducted in March 2007. It involved the detonation of 4,000 kg of ANFO inside an ISO container that was sitting on a truck.
- **ISO**-3 was conducted in March 2009. It involved the detonation of 1,054 kg of high explosive projectiles inside an ISO container that was sitting on the ground.
- **ISO**-4 was conducted in September 2010. It involved the detonation of 1,000 kg of Composition C-4 plastic explosive inside an ISO container sitting on the ground.
- **ISO**-4 Retest was conducted in December 2010. It again involved the detonation of 1,000 kg of Composition C-4 plastic explosive inside an ISO container sitting on the ground.

In addition to ESKIMORE, other allied nations have conducted and collaborated on large-scale explosives tests in the last 10 years. These include but are not limited to the United Kingdom, Belgium, Netherlands, Canada, and the KLOTZ group (a consortium of nations made up of the United States, Germany, Netherlands, Norway, Singapore, Sweden, Switzerland, and the United Kingdom).

Future issues of this column will discuss all these testing efforts in more detail.

Science at Work

This Feature contains articles with a technical bias illustrating how our industry is putting science to work in the interests of explosives health and safety. We want to recognise and encourage those who are involved in research and development as they continue improving our understanding of the behaviour of explosives. While explosives have been around for millennia there are still big gaps in our understanding of how and why they sometimes behave the way they do. As long as those gaps exist we are vulnerable. This Feature is also a forum for explosives scientists to advance scientific theories on why certain incidents occurred. This can further enhance our learning from those incidents. SAFEX wants to put science to work in order to prevent the harmful effects of explosives incidents.

A Review of Thermal Hazards in the Processing of Commercial Mining Explosives

by

Martin Braithwaite (Imperial College, London SW7 2AZ UK)

Introduction – Thermal Hazards & Energetic Media

By their very nature, energetic media are prone to react violently when overheated, leading to gas production, loss of containment, explosion and possibly detonation. In the processing of commercial mining explosives, even when the media is a nominally void free matrix, a departure from safe operating temperatures can lead to a serious accident. The development of ammonium nitrate based explosives (slurries and emulsions) have largely moved safety concerns away from localised and instantaneous impact, friction and electrostatic hazards to hazards more associated with exothermic chemical reactions caused by overheating or contamination. Safety questions raised will include:

- What is a safe operating envelope (pressure, temperature, flow, chemical formulation) ?
- Can process hazards be eliminated by plant design i.e. intrinsically safe?
- What and how many and at what degree of redundancy do safety devices need to be added ?
- What data are required in order to reach safety related decisions?

Hazard and Operability studies (HAZOP), quantitative risk analysis (QRA) and plant design will pose these and other questions.

There are two related scenarios for reaching an unsafe thermal state in an explosive plant. One concerns bulk overheating and cook-off and the other, localized hot spot initiation leading initially to deflagration – the former involves almost the entire inventory at the same time whereas the latter comprises of a burning front travelling at a finite rate through an initially undisturbed explosive.

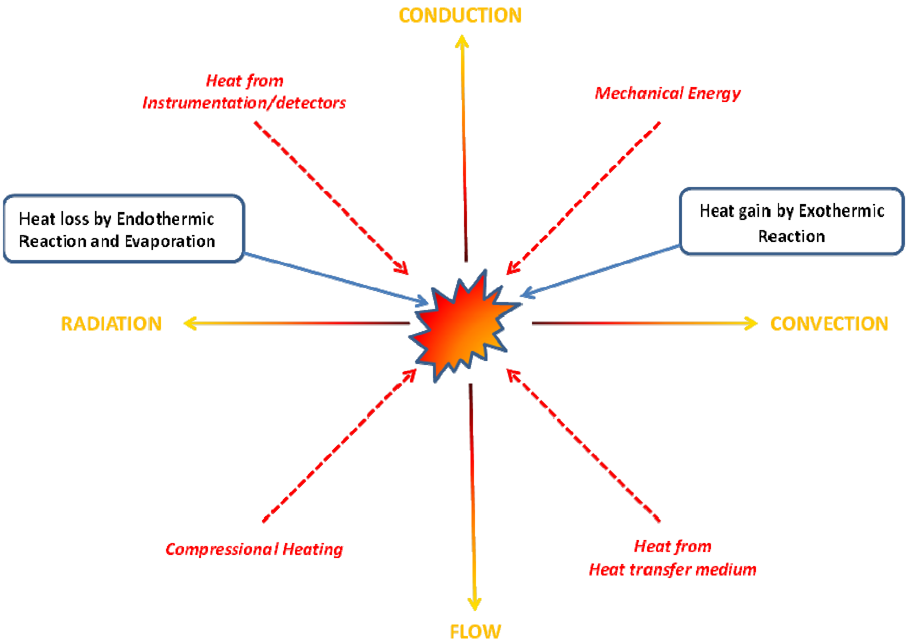


***Figure 1**: Heat loss and heat gain processes for an element of a reactive medium in a process plant unit*

The inventory temperature is an indicator of the degree of hazard in an explosives manufacturing unit. However, it is the rate of change of temperature with time that is the key to determining whether an inventory is safe.

a) The explosive formulation—reactivity, thermal capacity (specific/ latent heats), viscosity, density and thermal conductivity

b) the plant—Size of inventory, heat transfer characteristics, pressure, flow, power input and containment

In general terms, the rate of a single exothermic reaction increases exponentially with temperature where as thermal losses tend to be linear in temperature difference. This is frequently compounded by physical changes in the explosive (for instance water evaporation, void formation) affecting both its thermal inertia and sensitivity as well as more complex decomposition mechanisms.

Hazard and Operability Studies

Most chemical and explosives plants are subject to the standard set of six hazard and operability studies which cover all aspects from project inception to final post-commissioning checks. The first three of these studies are of relevance here. Hazard Study I is concerned with collating information about the process and product. This includes accident history, hazard data sheets covering test data and material compatibility issues. Invariably hazard test data are obtained or requested for undamaged product, as formulated and at ambient conditions. It is not common, in the explosives industry, to have data on intermediates or damaged product.

Hazard study II examines the explosives plant as designed and attempts to identify hazards on different plant units with the plant running as in the design envelope of operating conditions. It also determines whether a quantitative risk analysis for offsite safety is required. Hazard study III examines all the credible departures (flow, temperature, pressure, contamination, chemical formulation etc.) from normal operations (including start-up, shutdown and maintenance: domino effects to/ from adjacent plant). It is at this stage that most of the add-on security devices are decided. The study process is inevitably reliant on the experience and knowledge of the study team coupled with test data on undamaged explosive.

Quantitative thermal hazard test data, at conditions representative of those in process, will often be required as part of these hazard studies, both in establishing a safe operating envelope and in determining types and settings on security devices.

Exothermic reaction processes potentially leading to loss of containment

From a fine chemicals manufacturing perspective, cook-off (alternatively described as thermal explosion, reaction runaway) is a significant hazard when handling media capable of significant exothermic reaction i.e. that which could lead to overpressures, loss of containment or domino effect to other plant units. The cook-off scenario for a hypothetical simple Arrhenius exothermic reaction is illustrated in Figure 2. The heat loss to the environment is dependent on cooling processes, losing heat to the environment and therefore dependent on the scale (surface area/volume of the plant item) and fluid flow.

The rate of temperature rise in the explosive is governed by the heat released in the reaction less any dissipative process e.g. evaporation. For the case of a water-in-oil ammonium nitrate (AN) based emulsion Figure 2 would be more complex i.e. the balance would have to include:

- water loss as steam
- endothermic processes
- increasing pH
- complex exothermic reaction chemistry

Clearly, for this case, one safe (albeit conservative) operating temperature envelope would be that below the boiling point of water but greater than the fudge point of the supersaturated AN solution. For more sensitive explosives, such as those based on Nitroglycerine, concern would be more concentrated on a local initiation

Scale and quantification of thermal hazards – Possible Problems

Reliance on rapid thermal scanning tests for environment with reduced heat loss due to scale, insulation, etc. giving an overestimate of safe operating temperatures Inadequate fire prevention/ mitigation measures e.g. from bund fires, use of burning grounds for waste disposal.

Safe operating temperature

The lower limit is constrained by freezing, crystallization (fudge point), viscosity and materials of construction of the plant or equipment. The upper limit for bulk overheating can be conservatively set by adiabatic calorimetry but for an instantaneous event generating a hot spot (diameter 10-100µ) critical temperatures will be much higher due to much larger heat losses to surrounding media. Typical bulk limiting temperature will be ~ 450 K whereas the critical hot spot temperature will be ~ 700 K or greater.

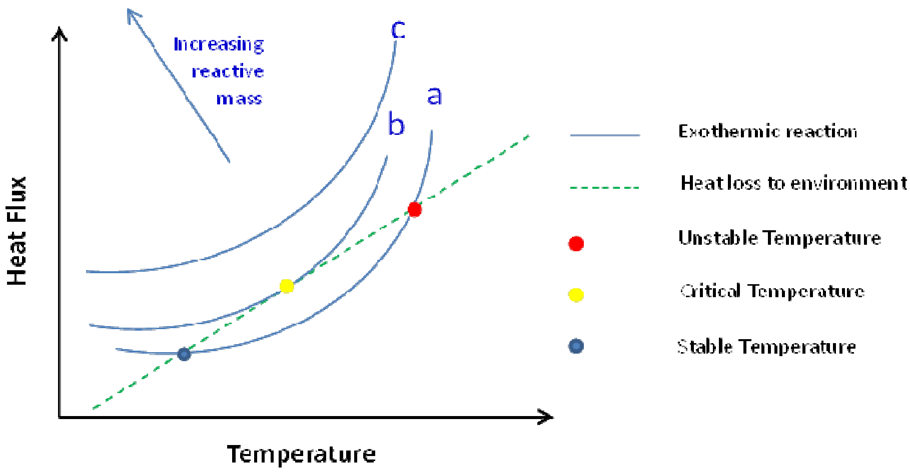


***Figure 2**: Plot of different exotherms for simple exothermic reaction (rate increasing exponentially with temperature) compared with typical (near linear) net loss to the environment. Plot c illustrates a case where the heat generated always exceeds the heat loss and explosion is inevitable. Plot b is the critical case where a limiting critical temperature for explosion is illustrated. Plot a shows a stable temperature i.e. a small deviation from this remains in a realm where net heat loss exceeds heat generation unless a much higher temperature has been reached as a result of other factors.*

producing a hot spot that subsequently leads to a deflagration and closely followed by a DDT process to a full detonation. Local initiation via hot spots can be caused by impact, friction, compression of fluid (or defect) containing fluid media or electrostatic discharge, often compounded by the presence of grit or foreign bodies. A more general related hot spot hazard, well known in propellant manufacture, is the compression of void containing fluids e.g. dieseling. This can be mitigated by variously avoiding voids, reducing void size and limiting maximum pressures and rates of pressure rise.

Thermal hazards also include rapid phase changes and resultant overpressure due to gas production and overpressure.

Thermal Hazard Testing

The primary aim of thermal hazard tests is to provide data to establish a safe operating envelope and also in assisting the choice, type and efficacy of safety devices. These are briefly reviewed here in three categories

i) Calorimetry

There are a plethora of different calorimetric methods (Differential Scanning Calorimetry) DSC, (Differential Thermal Analysis) DTA, Heat Flow Calorimetry, (Accelerating Rate Calorimetry) ARC). They differ in scale, allowed sample size, precision and mode of operation. DSC/DTA are scanning tests at the scale of a few mg of sample. In order to provide reliable data for processing energetic media the sample must be representative of that in process and the ratio of the thermal mass of the sample to that of the test container must be substantial i.e. such that the result is not dependent on the thermal characteristics of the test apparatus. Further, it should be noted that overall heat loss is scale dependent i.e. the process plant will provide a more adiabatic environment and the test method should reflect this.

Void compression in high pressure piston pump - Dieseling

Dieseling has been proposed as the primary cause of a fatal accident resulting from the explosion of a refined emulsion in a piston pump. Gas voids, introduced in the suction cycle, can be compressed to high temperature, possibly in the presence of organic volatiles. Solutions to this hazard include selection of a different pump, limiting maximum pressures and their rate of increase and alternative formulation (avoiding organic volatiles/ high viscosity).

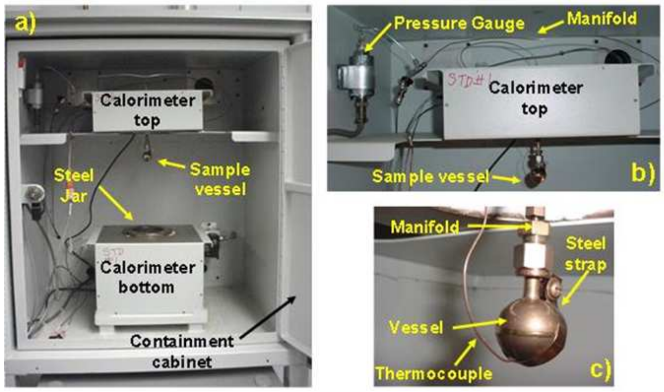


***Figure 3*: Accelerating Rate calorimetry with ~ 10 g closed sample vessel illustrated in (c). The adiabatic condition, from a predetermined starting temperature, is achieved electronically. Photograph courtesy of Natural Resources Canada (CERL)**

Unintended formulation change in process – Examples of deviations

- Change in pH, loss of water and reduction in density due to overheating
- Partial crystallization of supersaturated oxidized phase
- Inadequate mixing or emulsification of additives – Al, waxes

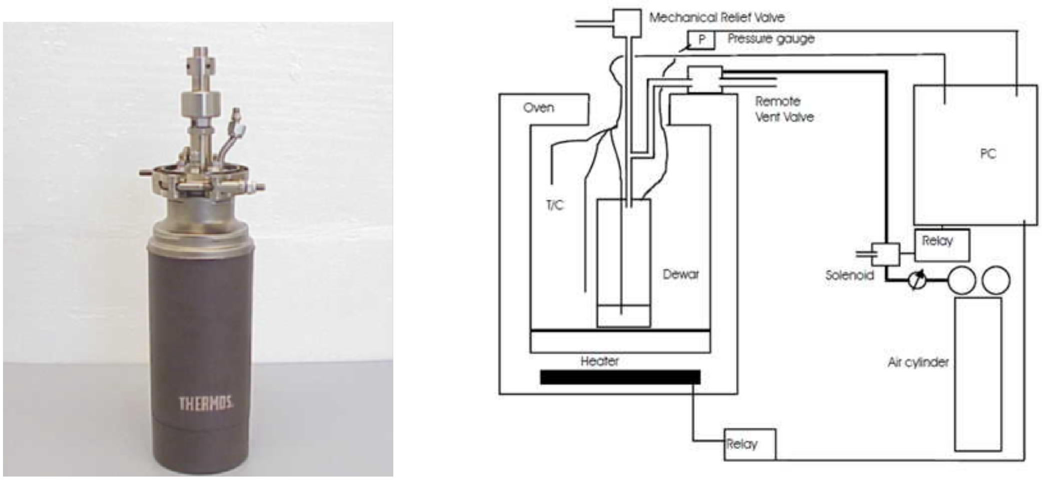


***Figure 4*:Adiabatic Dewar calorimetry with SS Dewar. Control and measurement system illustrated. Photograph courtesy of Natural Resources Canada (CERL)**

There is a further complication if the test results encompass a regime where there is loss of material by evaporation. Such cases require more careful comparison between the plant hazardous condition and the test result.

ii) Burning/ deflagration

Strand burners have been routinely used for the characterization of propellants, establishing both minimum deflagration pressures and pressure dependent burning velocities. In the context of safety in commercial explosives it is the minimum deflagration pressure (MDP) that is of interest. The test result (for a given explosive and temperature) provides an unambiguous measurement of this limiting pressure for stable deflagration. The MDP can be used for determining pressure relief/ bursting disk settings to relieve an incipient deflagration by lowering plant pressures to pressures lower than MDP quickly. The MDP can also be alternatively used for establishing maximum allowable plant pressures or for some formulations demonstrating that pressure relief is not a credible basis of safety.

The test essentially comprises a pressure vessel, temperature and pressure monitoring devices, pressure relief and secondary containment. It has the capability to establish unambiguous MDP data over a range of conditions and, in principle, deflagration velocities when these pressures are exceeded.

iii) Miscellaneous

There are a variety of other tests in common use not discussed here. In the author's opinion Koenen tube and vented pipe tests are of little use in the quantitative analysis of thermal hazards and means of controlling them – these tests measure several processes at once, do not simulate the plant hazard effectively and have undesirable artefacts.

Given that a high rate deflagration and also a thermal explosion will lead to loss of containment and severe local as well as potentially damaging off-site effects DDT and larger scale bonfire tests are not included here. Crude thermal scanning tests provide a useful precursor to a full ARC or Dewar study but results from these small scale tests are insufficient for quantitative use in hazard analysis.

It is for the plant personnel and process engineer to make use of thermal hazard test results. The data obtained from tests or published reports remain specific to the formulation tested at the prescribed conditions of the test. Incompatible materials and contaminants that can affect the chemical stability of the explosive have to be eliminated by design and operating procedure. If the operations are normally at more severe conditions than ambient, then the conditions of tests carried out should reflect this.

Change of intended emulsion formulation and pressure relief

Minimum deflagration pressures (MDP) determine whether pressure relief Is effective in quenching a deflagration in part of an emulsion plant operating at elevated pressure e.g. pumps (emulsification and transfer). Pressure relief or rupture disc settings can be chosen at pressures less than MDP with devices appropriately located. A change in formulation, for example, the use of a chemical sensitizer or low water concentration, reduces MDP dramatically and pressure relief will no longer be a safe basis of safety

Figure 5: Minimum Deflagration Pressure – Bomb and internal assembly to hold cylinder of test explosive. Photograph courtesy of Natural Resources Canada (CERL)

Contamination/ compatibility issues - Examples

- Use of a nitrite instead of a nitrate in the matrix oxidizer stage
- Use of copper in lines handling ammonium nitrate (copper tetramine nitrate)
- Use of organic lubricants and waxes on oxidizer lines
- Use of polymer based microspheres with different polymer type
- Contamination of organic insulation with oxidizing agents

Summary

The specification of a safe operating envelope for processing commercial explosives is often based on past experience and earlier hazard characterization studies. While this is usually satisfactory for normal operating conditions, the assurance of plant safety under some fault conditions, requiring additional securities, can require more detailed analysis and testing . This is required to ensure that pressure or temperature relief, quenching of reaction or plant trips are adequate. When further testing is required, care has to be taken in deciding on the condition of a representative sample of the explosive under test (physical and chemical) and its confinement. Extrapolating between the test and plant environments will require some engineering analysis. In studies on heterogeneous AN based explosives adiabatic calorimetry and deflagration studies are preferred as these approaches give the most reliable and conservative data under controlled conditions with sample sizes of order 100 gms.

Acknowledgement

The author is grateful to CERL, Ottawa and Dr Richard Turcotte for the use of photographs in Figures 3, 4 and 5. Further references are available which provide more detailed background to this article.

Effectiveness of Transparent Shields in Protecting Explosive Operations Personnel – Part I: Introduction and Experimental Arrangement

by

Harold W. Sandusky and Verence D. Moore

(Naval Surface Warfare Center Indian Head Division Silver Spring, MD 20903-5640)

Transparent shields for protecting personnel from the unintentional reaction of explosives, propellants and pyrotechnics are common in the manufacturing and laboratory environments. Their effectiveness was evaluated by the Naval Surface Warfare Center (NSWC), Indian Head Division in a report published in 1994. The work still seems relevant today and when a SAFEX Member brought it to our attention, we obtained permission from the NSWC to publish their report in our Newsletter. We are doing so in two parts: The first part, which appears below, introduces the work and describes the experimental arrangement. We intend publishing the results, discussion and conclusion as a second part in the next Newsletter.

INTRODUCTION

Transparent shields are used in some hands-on operations to protect personnel from blast, fragments, and heat associated with the accidental initiation of small amounts (typically <10g) of primary and secondary explosives, propellants, and pyrotechnics. Paragraph 8-3.1.4.a. of the Navy's explosive safety manual1 specifies that, "In the absence of reliable data, the adequacy of these operational shields, including thickness, size, fastening and location, shall be proved by actual test with a minimum safety factor of 25% above the maximum expected charge before their use is permitted in operations." Paragraph 7-6.4. of the same reference specifies that shields are to be tested in accordance with Reference 2. Such testing was performed at White Oak since there was no documented data from similar testing at White Oak and very limited data from other explosive operating facilities.

Military Standard 398 (Reference 2) specifies that the operator's head not receive more than a 2.3 psi peak positive incident pressure; that the upper torso be protected from incident and secondary fragments; and that the upper torso not be exposed to a thermal flux exceeding 0.62 $t^{-0.7423}$ cal/ cm^2 -s, where t is the exposure time in seconds. The effects of blast on personnel are summarized in Table 7-3 of Reference 1. Eardrum rupture occurs 1% of the time for an overpressure of 3.4 psi and 50% of the time at 16 psi. Lung rupture occurs at 10 psi for a pulse duration of 50 ms, and at 20-30 psi if the pulse duration is 3 ms. Thus, the maximum 2.3 psi overpressure allowed by reference 2 for an operator working behind a shield is below the threshold for disabling injury. The location of the operator's head is defined (Reference 2) to be 65" above the floor when standing and 31.5" above a chair seat when sitting. In addition to the blast pressure and heat flux measurements, still photographs of the shields are required before and after testing, and color cinematography at a rate of >400 frames per second is specified during the test.

Most tests were conducted to determine the protection offered by shields from detonating explosives, which would be the expected event from the accidental initiation of a primary explosive and would be the maximum credible event from any energetic material. Other tests were conducted to determine the protection that a shield offers from a pyrotechnic, a propellant, a cast explosive, and an explosive powder that burned, which is a likely event if the energetic material (other than a primary explosive) is unconfined and accidentally ignited.

One test was conducted to determine the maximum event that could occur in a loading press for a 12-gauge shotshell containing an explosive sample for the JANNAF shotgun/relative quickness (SG/RQ) test. Since no guidance for designing the currently existing shields was available, pressure transducers at locations other than those required (Reference 2) were incorporated into the tests with detonating charges to determine the path of the blast waves that reach an operator. Also, barriers of various sizes were substituted for shields, and two tests were conducted with no barrier to obtain free-field measurements.

EXPERIMENTAL ARRANGEMENT

There is a wide variety of shield designs used at White Oak, but the majority of the shields are basically plastic plates that are mounted by a bracket to the bench. If the width of the shield makes reaching around it difficult, there are usually cutouts for the arms. The shields/barriers that were tested are summarized in Table 1. A drawing of Brazil's polycarbonate (PC) shield, which was used in many of the tests, is shown in Figure 1. Groves' PC shield was the same width as Brazil's shield but 10" higher. This shield was modified to reduce the blast pressure to the operator as shown on the sketch in Figure 2 on next page. In Table 1, this shield is given the descriptor Wing2. Wing 1 is the same shield without the ¼" thick PC top, and Groves' shield is the ½" thick PC plate without the side extensions and top. The shield in Table 1 with the descriptor of Double had ½" strips of Celotex near the side edges to maintain the air gap between Brazil's and Groves' shields, which were taped together. In two tests there was no shield/barrier to obtain free-field measurements of air blast from detonating charges. These measurements were useful for obtaining wave velocity and pressure for comparison with those in shielded tests.

Table 1. Description of Shields

Descriptor in Table2	Dimensions+ W (in)	H (in)	T (in)	Mat'l*	D^ (in)	Comments#
None	-	-	-	-	20.75	Free-field measurements
Bazil	20	24	1/2	PC	29.0	18° tilt from operator, 4 1/4" wide x 7 3/4" high cutouts for arms
Groves	20	34	1/2	PC	28.2	8" high x 2" wide cutouts for arms
Double	20	34	1 1/2	PC	-	Bazil's shield mounted in front of Groves' shield with 1/2" air space between them and flush at the top
26x26	26	26	2 1/2	PMMA	-	3° tilt from operator
25x49	25	49	1/2	PC	37.2	
Wing1	33	34	1/2	PC	42.4	Groves' shield with side extensions of 1/4" PC angled 35° toward operator
Wing2	33	34	1/2	PC	42.4	Wing1 with 1/4" PC top
LabGard	15	29	1/8 PC+1/4 PMMA		26.5	Lab-Guard Model D, semi-circular PC shield with weighted base and PMMA liner

+ W = width, H = height, T = thickness

* PC = polycarbonate, PMMA = polymethylmethacrlylate

^ D = minimum distance from charge to head position of a sitting operator (distance around side of a shield)

\# Shields vertically mounted unless otherwise noted

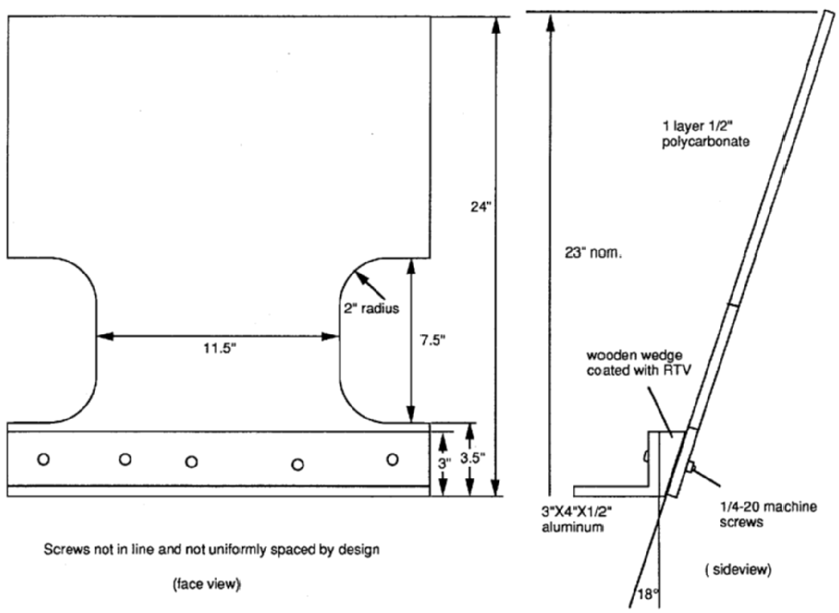


Figure 1. Bazil's Polycarbonate Shield.

The shields were mounted near the front edge of a 28" wide by 32" deep by 37" high table in a 10' x 16' x 8' high firing chamber. The table consisted of a steel angle frame with a 1" thick plywood top and a 1" thick plywood shelf at 15" above the floor. The table weighed <100 pounds and was not anchored to the floor. Following Test #18, 293.3 pounds of steel blocks were placed on the back edge of the table shelf. The location of the table was near the centre of the firing chamber, so that there was at least 5' between the charge and the walls. The tops of the charges were typically 54" below the ceiling of the firing chamber. The distances from the charge to the walls and ceiling were large compared to the distances to an operator; thus, no reflected blast waves from walls or ceilings interfered with the incident blast wave to the operator. Furthermore, those reflected waves had greatly attenuated over the distances they propagated before reaching an operator. Since tables and benches in a laboratory are often located against a wall, a 3/4" plywood barrier the width of the table and extending 42" high was fastened to the back of the table after Test #4 to simulate a wall (Figure 4 on p.15).

All shields, except a shield used in the chemistry laboratories, were mounted by two No. 404 C-clamps to the table. The Lab-Guard Model D-15-29PC shield, which is given the descriptor LabGard in Table 1, was mounted as it is in the chemistry laboratories. A 1/4" diameter aluminum rod was bent around the shield at a height of 13.5" above the table and each end was clamped to a horizontally-mounted ½" diameter rod, which simulated one rod of a lattice used for supporting glassware in the laboratory. The thumb screws on the clamps were finger tight to an average of 20 in-lb. In addition to the C-clamping of the other shields, the top of Wing2 was restrained by a 3/16" diameter, steel cable mounted to the back edge of the table top.

The detonating charges were PBXN-5 pellets of either ~2.6 g or ~11.5 g, except for two tests with 1.3 g cylinders of 1/4" thick Detasheet. Some of 2.6 g pellets, which were 0.50" diameter by 0.50" high, were fitted into either a 1/16" or 1/8" thick steel sleeve to generate fragments. All detonating charges were initiated by a Reynolds RP-80 detonator, whose 0.2 g of explosive is included in the following reporting of charge masses. The burning tests used a boron/ potassium nitrate (B/KNO3) ignition mix, Class A RDX explosive powder, PBXN-103 explosive, and a composite propellant (FS-25-C) consisting of ammonium perchlorate and aluminum in an inert binder. Burning was ignited by an ICI Americas Inc. (formerly Atlas Powder Co.) M-100 electric match. The electric match was insufficient to ignite the explosives, even when embedded in them. For both the explosives and the composite propellant, 1 g of B/KNO3 was used with the match as an ignition aid. A

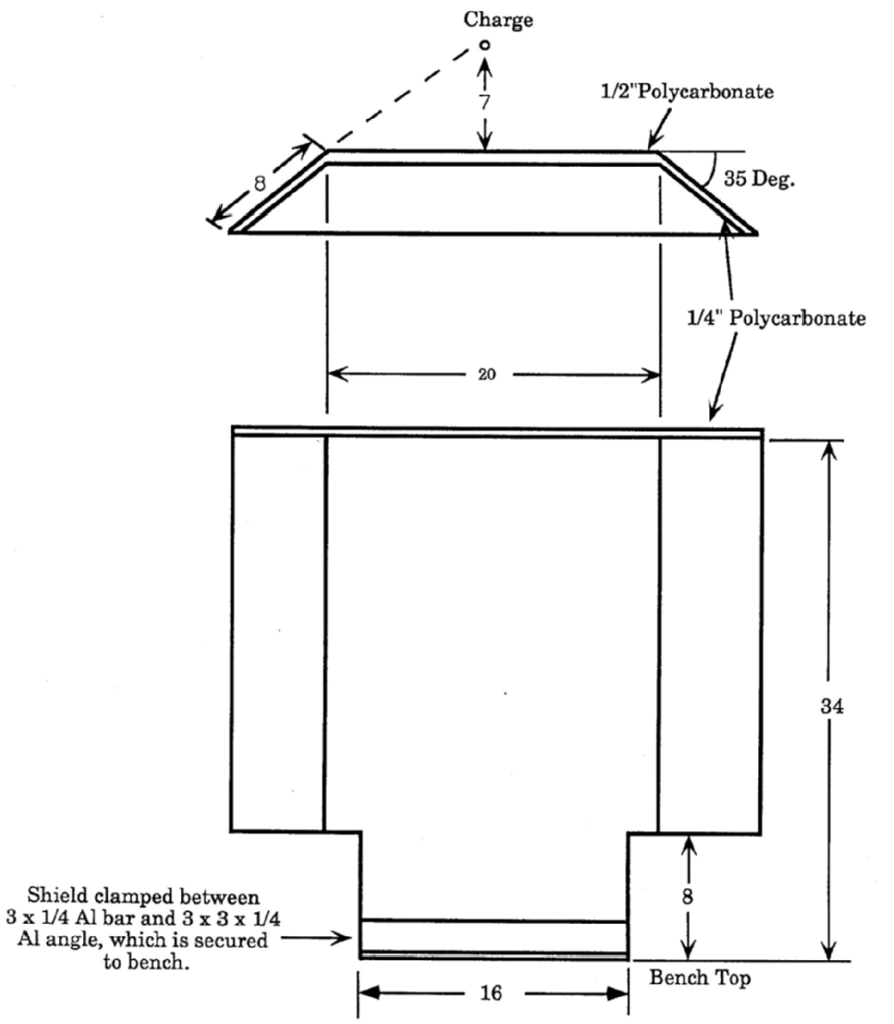


Figure 2. Polycarbonate Shield with Side Extensions and Top (Wing2)

match was also used to replace the percussion primer in the shotshell test. The all-brass, 3" long shotshell was loaded with a 2 g propelling charge of Olin Corp. WC 231 reloading powder and an 8 g sample of PBXN-103, the sample weight required for the SG/RQ test. A short ram that extended past the mouth of the shotshell was placed on the sample, and then a C-clamp between the base of the shell and the ram was used to axially confine the shotshell. This was an overtest of the confinement from the spring loaded ram used to seat the sample in the shotshell during loading. The charge axis was located 7 to 8" from the shield, except for a reduced 5.5" when testing the 2.5" thick polymethylmethacrylate (PMMA) shield in Test #14. These distances represent a comfortable reach for an operator, but varied to maintain a consistent horizontal distance of 11.5" from the charge axis to the senors corresponding to an operator's head. All detonating charges were on a 4" square stand that was typically 2.5" high (3.5" high in Test #11, 4" high in Tests #10,21,22). Elevating the charges from the table reduced the damage to the table top; and in many practical applications, the charge is somewhat elevated from the table. For the burning tests, a 4" x 4" x 3/8" steel plate was placed on the wooden table top at the same position from the shield as in the detonating tests. The B/KNO3 and RDX powders were put into a 50 mi plastic beaker that was placed on the steel plate. The height above the floor for the head of a standing operator was 65", as specified in Reference 2, and that for a sitting operator was 57". This height was based on several stool measurements plus the 31.5" specified above the stool seat.

The arrangement for the instrumentation for the first three tests in shown in Figure 3. Transducers G1-5 were Atlantic Research Corp. Model LC-33 pencil gauges for measuring side-on air blast; these gauges are no longer manufactured. Transducer G3 corresponds to the head position of a standing operator; and in subsequent tests, G5 was moved to 8" below G3 to correspond to the head position of a sitting operator. Transducer G2 corresponds to the head position of an observer that is standing at the right shoulder of the operator, and G 1 corresponds to the head position of a more distant observed In the following presentation of data, the reported measurements for an observer are from G2. G2 and G4 are the same distance from the charge as are G1 and G5. G4 and G5 were pointed directly at the charge for normal orientation to the blast wave; however, transducers behind the shield were horizontally oriented because the direction of the approaching blast wave was not known a priori.

In addition to the pressure transducers locations shown in Figure 3, the positions of two thermocouples are designated. T1 was mounted on the front side of the shield, while T2 was positioned near the head of a standing operator. Both were chromel/alumel thermocouples made from 0.002" wire, having a response time of probably >l ms in a convective atmosphere. These thermocouple signals were amplified to 10 mv/°C. After Test #5, T1 was removed to preserve it from being cut by fragments. After Test #16, a multiple sensor probe (MSP) was positioned midway between the head positions of a standing and sitting operator.

T2 was incorporated into the MSP along with a copper-constantan circular foil heat-flux gauge, also known as a Gardon gauge (Reference 3). Two Gardon gauges from Thermogage Inc. were used in the MSP. The gauge in Tests #17-21 had a 1 mm diameter foil and a corresponding response time of 100 ms, which would have been the state of technology at the time when the shield testing standard2 was written. The Gardon gauge in Test #22 had a 1/8 mm foil diameter and two orders of magnitude faster response time. Since much of the energy from detonating charges goes into compressional work on the surrounding environment, heat flux was expected to be significant only for the deflagration of pyrotechnics and the burning of secondary explosives and propellants, for which a 100 ms response time is appropriate.

The pressure instrumentation changed somewhat throughout the testing. After Test #3, G5 was moved to the head position of a sitting operator. G4 was moved to a position that was 8" to the left of G3 in Test #5 and in subsequent tests was lowered 8" to be to the left side of the head position of a sitting operator. The off-center locations of G4 helped to determine the path of the blast waves that reached an operator as well as showed the effect of not being positioned in the center of the shield. In another variation, G1 in Tests #15,16 was positioned under the transducers for the standing and sitting operator at the same height as the charge for detecting the blast wave transmitted through the shield and that which passed through the cutouts for arms. As will be discussed, the primary blast wave arrived at those transducers from around the shield, and only a weak wave was transmitted through the shield. Even though the blast wave did not propagate parallel to the axis

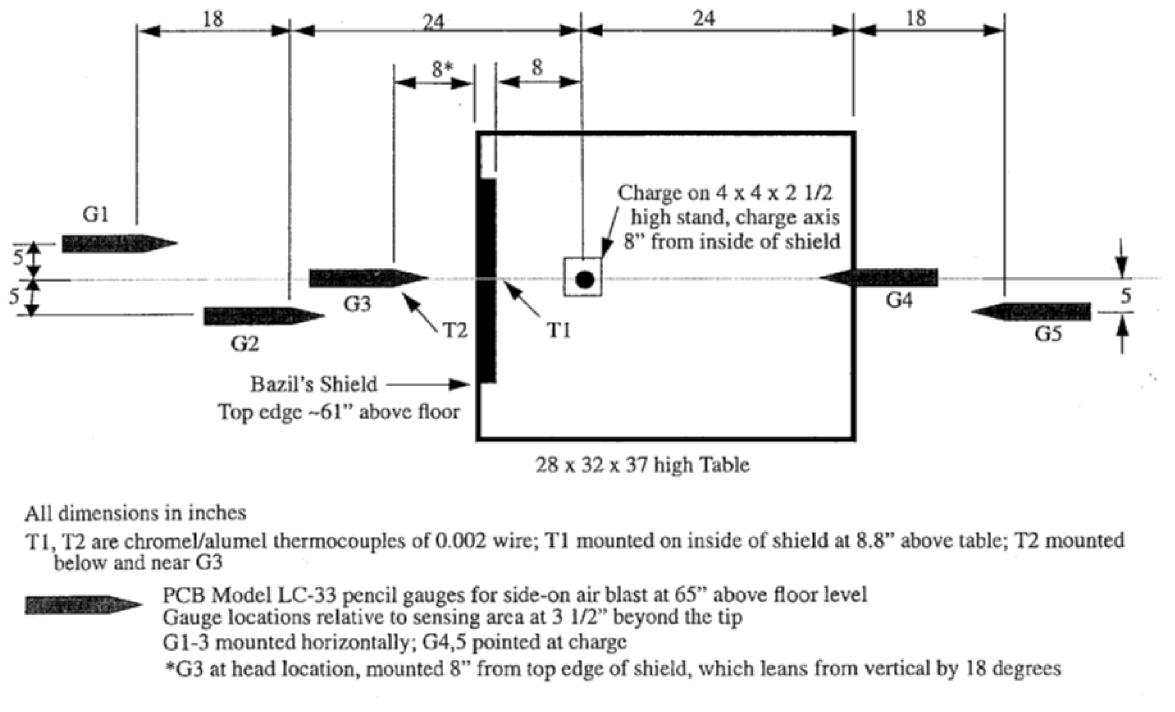


Figure 3. Firing Chamber Arrangement for Shield Tests #1-3

of those transducers, which is how they are intended to be used in measuring side-on overpressure, simultaneous wave arrival from several directions normal to the transducer axis was still a side-on loading. The blast wave measurements were verified by horizontally mounting another style of transducer (PCB 102A) in the MSP. This transducer would view waves coming from the sides and top of the shield as side-on measurements, thus providing a comparison to the response of the pencil gauges.

Figure 4 shows the arrangement of the instrumentation, which includes the MSP for the detonation of 1.3 g charges in front of Brazil's shield (Tests #17,18). Transducers G1-3 are in the same location as in Figure 3 on the previous page, while G4-5 have been moved behind the shield as discussed above. Whereas Figure 3 shows the distance from G3 to the top edge of the shield as 8" and the distance to the front of the shield to the charge axis as 8", the combined horizontal distance from G3 to the charge axis is only 11.5" as shown in Figure 4, because the shield leans at an angle of 180 from the operator (Figure 1).

The pressure transducer and thermocouple signals for all tests were recorded on magnetic tape, which had to be analyzed elsewhere. Since the data was generally not available until several days after the test, most signals were also simultaneously digitized on a LeCroy Model 8013A transient recorder after the Test #9. The LeCroy recorder was interfaced with a computer that provided reduced data immediately after the test. The heat-flux signals, because of their low sensitivity, were recorded on a Nicolet 2090 oscilloscope with a Model 201 plugin having a full-screen range of ±10 mv. Reported times are relative to the firing signal to the detonator, which would require only microseconds to initiate. Cinematography from one side of the shields was obtained with a Photo-Sonics, Inc. Model PL pin registered camera operating at 500 frames/second with a 0.5 ms shutter time. Kodak 7250 film (ASA 400, tungsten color balance) was used with the arrangement illuminated by two 1000 Watt quartz lamps. A video camera viewed the other side of the shield. Photographs of the mounted shields were taken before and after the tests.

The Experimental Results, Discussion and Conclusions sections of this paper will be presented in the next Newsletter.

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I. NAVSEA OP-5, Vol. 1, 5th Rev.; Ammunition and Explosives Ashore; Safety Regulations for Handling, Storing, Production, Renovation and Shipping
2. Military Standard 398; Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance
3. American Society for Testing and Materials Standard E511-73; Measurement of Heat Flux using a Copper-Constantan Circular Foil, Heat Flux Gage

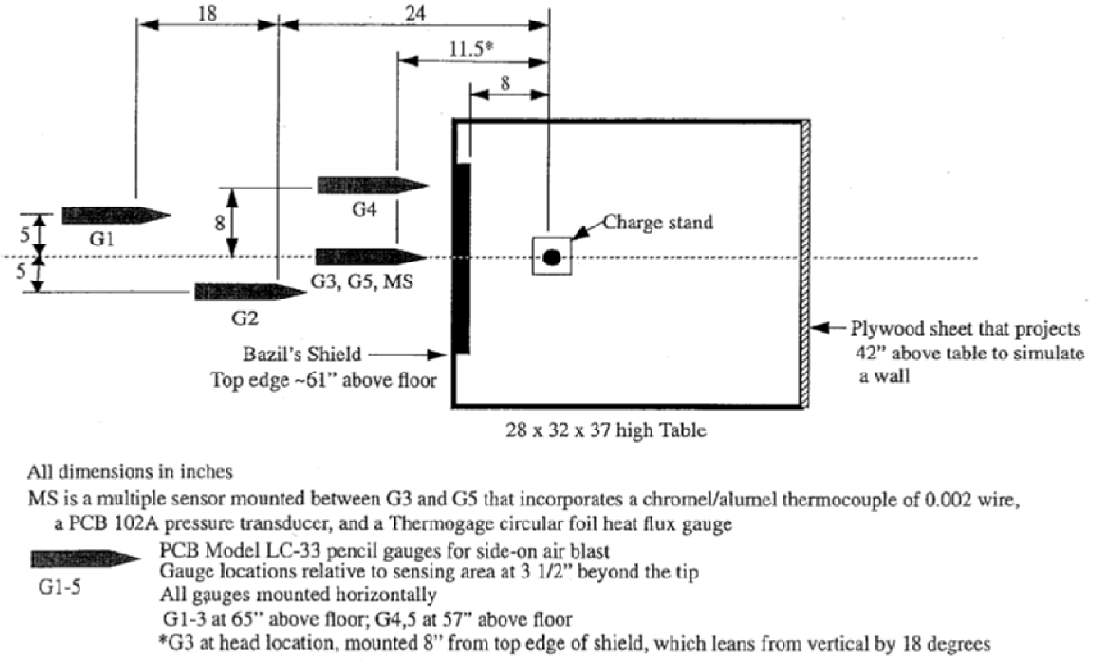

Figure 4. Firing Chamber Arrangement for Shield Tests #17 and #18

Explosives Eco-talk

The impact explosives and explosives manufacture has on the Environment falls squarely in the SAFEX domain. We are committed to publish the experiences members of the SAFEX community have in minimising explosives' environmental impact. While most of our explosives incidents are safety and health related, we want to learn more about our activities' environmental impact. This Feature aims to encourage readers to let us have contributions which create awareness of this facet of our operations as well as assist our industry to behave with environmental sensitivity and responsibility.

Remediation of TNT-Contaminated Water Using Pine Bark

by

O. Ashihmina, E. Nehrenheim, M. Odlare

(Mälardalen Safety Science Lab, School of Sustainable Development of Technology and Society, Mälardalen University, SE-721 23 Västerås, Sweden)

1. INTRODUCTION

Since 2,4,6-trinitrotoluene (TNT) has historically been the most extensively used explosive, it is the most common pollutant of water at manufacturing, processing, testing and demilitarization sites for energetic materials, where large volumes of contaminated wastewater are being produced daily. As TNT is toxic, potentially carcinogenic and mutagenic, the subject of efficient and cost-effective TNT-contaminated water treatment method development has attracted much attention within the last couple of decades. Methods for the separation of TNT from water can be divided into destruction and concentration methods (Marinovic et al., 2005).

The first group consists of incineration, catalytic and chemical oxidation and biodegradation. Biodegradation is the process, where bacteria get energy and nutrients by consuming chemicals, for example, TNT. Bacteria grow by breaking down TNT molecules into smaller compounds and water, i.e. they feed on TNT molecules. As long as the contaminant is present in the water, more bacteria are formed (see Figure 1). Since organic contaminants are made up mostly of carbon atoms, bacteria may be able to convert that ingredient into CO_2, water and nutrients. When this occurs, the ingredient does not pose a risk to the environment because CO_2, water and nutrients are safe. Such complete biodegradation, when a contaminant is eliminated from water or soil, is also called mineralization of a contaminant. However, when biodegradation is incomplete, molecules which are smaller than the original compound are formed. This process is less favourable than mineralization because these new molecules, or metabolites, should be intensively studied by their fate in

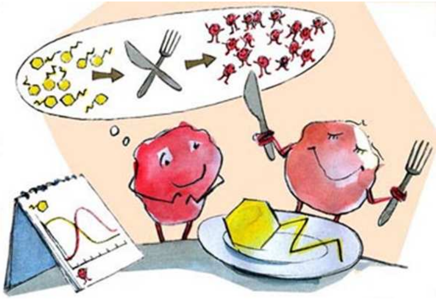

***Figure 1**: Scheme of biodegradation process* (*Drawing copied from http://www.scienceinthebox.com/*)

the environment before the process is implemented full-scale. This is the case of TNT, which is proved to be not susceptible to mineralization. TNT is considered generally recalcitrant to biodegradation that is why in order for the process to be efficient, usually additional amendments, which amplify the biotransformation of TNT, such as sugars, should be added to a bioreactor.

The second group includes adsorption of TNT on sorbents. Nowadays, the most commonly used sorbent for TNT removal from contaminated water is activated carbon. As the contaminated water flows through the activated carbon bed, molecules of the dissolved TNT concentrate on and adhere to its surface (see Figure 2). Adsorption occurs when the attractive forces at the carbon surface overcome the attractive forces of the liquid (see Figure 3).

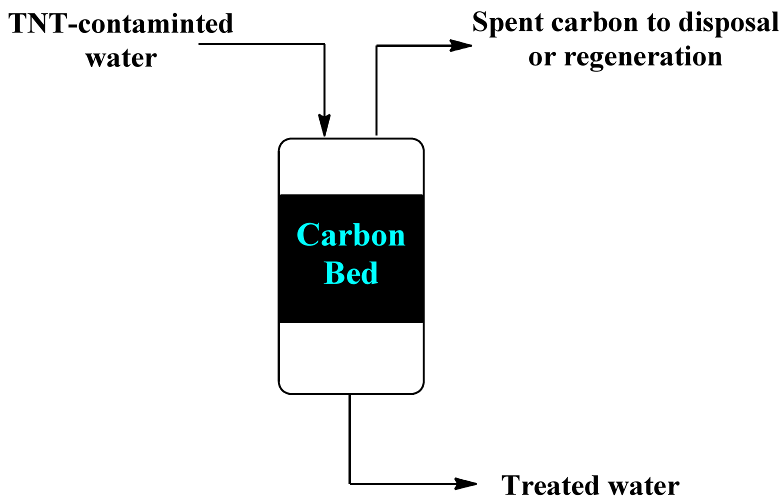

***Figure 2**: Diagram of activated carbon system for TNT-contaminated water treatment*

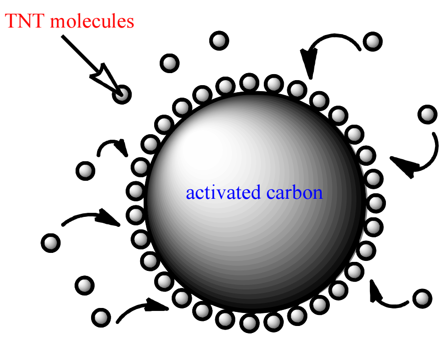

***Figure 3**: Scheme of adsorption process*

In choosing a suitable method for the treatment of the TNT-contaminated water, four main criteria may be identified; (1) environmental soundness, (2) efficiency, (3) low operation demands, (4) cost-effectiveness. These demands can be most completely met only by the adsorption method.

Today, active carbon is being used by demilitarization companies for adsorption of TNT and heavy metals in the process water (Nehrenheim et al., 2011). The disadvantages of its use

***Figure 4*: Pine Bark** *(Drawing copied from http://www.parkerbark.com/)*

***Figure 5*: Batches during the 7-day long experiment - batch A on the 1st day of the experiment; batch A on the 7th day; batch C on the 7th day**

are that the active carbon is a relatively expensive product and, even more significantly, it generates a waste that must be transported off site for destruction (see Figure 2 on previous page). It has been previously proposed that the substitution of the active carbon by a cheap organic sorbent, such as pine bark, can be a simultaneous solution to both problems posed by the use of the active carbon (Nehrenheim and Odlare, 2008). Pine bark (*Pinus Silvestris*) is a by-product, which originates from the forest industry (see Figure 4). Previous studies demonstrated promising results in application of this adsorbent in the treatment of wastewater, contaminated with heavy metals and chlorinated pesticides (Apostol & Gavrilescu, 2009; Ratola et al., 2003).

The general objective of the present study was to assess two ecologically sound and cost-effective techniques; adsorption and biological degradation for remediation of TNT-contaminated water.

2. EXPERIMENTAL SECTION

The study was set up as a batch experiment where all experimental batches were divided into three groups: in one group biodegradation method was applied for the treatment of TNT-contaminated water (batch A), in the second group – adsorption (batch B), in the third – both methods together (batch C) (for abbreviations, see Table 1).

- To the batch A were added: 1. Water, contaminated with TNT; 2. Inoculum, i.e. concentrate of bacteria, that is introduced into the system in order to promote their subsequent reproduction and growth; 3. Nutrients, or essential elements for bacterial species to grow, such as nitrogen, phosphorus, sodium, calcium (specifically, M9 minimal salt medium); 4. Glucose in order to amplify the degradation of TNT
- To the batch B were added: 1. Water, contaminated with TNT; 2. Pine bark
- To the batch C were added: the same ingredients as in the batch A, plus pine bark (see Table 1)

The bottles were incubated on a shaker for seven days at 28°C (the optimum growth temperature for bacteria). The efficiency of biodegradation was evaluated by comparing the disappearance of TNT in the experimental batches to that in sterile controls.

2.1 Chemical analysis

The samples were analyzed for TNT and quantified by using high-performance liquid chromatography (HPLC). The measuring was performed on the first day (Day0), the third day (Day3) and the seventh day (Day7) of the experiment.

3. RESULTS AND DISCUSSION

In the batches A, B and C 96%, 100% and 100% of TNT respectively, had been degraded by the third day of the experiment, compared to the control (see Figure 5 above and Figure 6 on the next page). Noteworthy is that only the batches containing glucose (A and C) were subjected to the significant decrease in pH by the third day compared to the

***Table 1*: Contents of the experimental batches**

Batch	Contents of the batch	Method
A	TNT + Inoculum + Nutrients + Glucose	Biodegradation
B	TNT+ Pine Bark	Adsorption
C	TNT+ Inoculum + Nutrients + Glucose + Pine Bark	Biodegradation + Adsorption
Control1	TNT	

first day (see Figure 7), which confirms that glucose enhances the TNT biodegradation process (Boopathy et al., 1998; In et al., 2008; Muter et al., 2008). Daun et al. (1998) demonstrated complete conversion of TNT within only 13 h. However, apart from this study their experiment was performed in bioreactors, which ensured pH maintenance at 7.0 and an hourly feeding of the degradation medium with glucose.

In the batch B, where the adsorption process was tested, one of the possible mechanisms behind the complete removal of the compound from the contaminated water could be a physicochemical interaction between TNT and pine bark. For the batch C, where the combination of the two methods was investigated, other mechanisms could be involved in removal of TNT from the media, namely, biodegradation of TNT and subsequent immobilization of the TNT metabolites on pine bark by the formation of relatively firm chemical covalent bonds. This could be caused by condensed tannins (often called "phenolic acids"), which are the major component of the hydrophilic fraction of soluble constituents of pine bark (Sjostrom, 2003) and it is well known that phenolic acids may react with amino-groups producing amide bonds, which are resistant to hydrolysis. Knicker (2003) reported formation of amide bonds during interaction of TNT transformation products and humifying organic matter. It could also be that the microbial community of pine bark degrades TNT, since the concentration of TNT extracted from pine bark on the seventh day of the experiment is less than on the third day (see Figure 8) Batches B and C. For the batch B: 32.54 mg/L of TNT were extracted from pine bark on the third day of the experiment, 6.53 mg/L on the seventh day; for the batch C: 8.43 and 1.23 mg/L of TNT were extracted on the third and seventh day respectively).

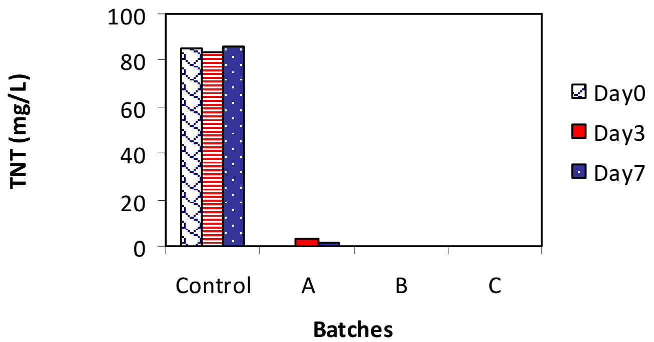

***Figure 6*: Concentrations of TNT on the first, third and the seventh day of the experiment.**

(For abbreviations, see Table 1.)

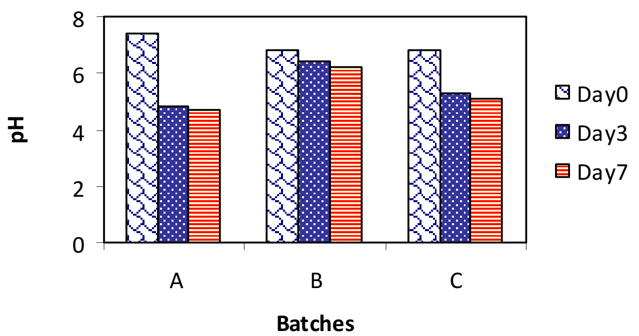

***Figure 7*: pH of the batches on the first, third and seventh day of the experiment.**

(For abbreviations, see Table 1.)

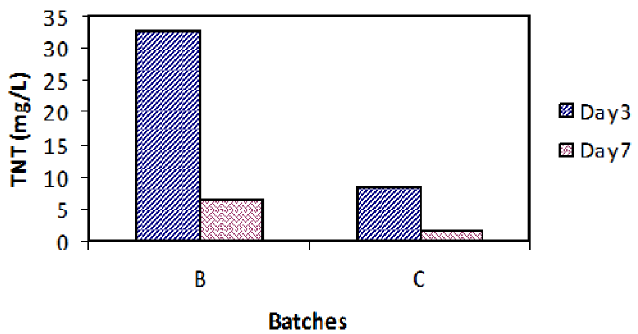

***Figure 8*: Concentrations of TNT extracted from pine bark on the third and the seventh day of the experiment.**

(For abbreviations, see Table 1.)

The pH in the treatments containing pine bark was about 6.8 (see Figure 7) which was somewhat lower than in the other treatments (about 7.2-7.4). These results are in agreement with Bras et al. (2005), who stated that pine bark surface is acidic and acts as a buffer in the pH range from 4 to 10.

4. CONCLUSIONS

In the study three methods were tested for TNT removal from the contaminated water - biodegradation, adsorption and the combination of the two methods. The combination of adsorption and degradation techniques is likely to be a better method for TNT remediation from contaminated water than each method on its own because the TNT metabolites, which are formed in the biodegradation process, can form relatively strong bonds with the pine bark particles and therefore be irreversibly immobilized. Still in the future studies it is important to show that the immobilization of the compounds on the pine bark surface is irreversible. Pine bark enhances removal of TNT from polluted water by participating in TNT degradation and working as an adsorption media. Generally, it may be concluded that pine bark is a good and cheap alternative for removal of TNT from contaminated water.

5. ACKNOWLEDGEMENTS

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From the Boardroom

The SAFEX Board of Governors meets routinely at the beginning of every year to discuss the health of the Association and the way forward. The SAFEX Strategy and its implementation by way of the services SAFEX provides are standing items on the Agenda. Other standing items include Governance of the Association; SAFEX Events such as Congresses, Seminars, etc.; and the Secretariat. The most recent Board meeting took place in Nashville, Tennessee on 12 February this year. Besides the review of the last SAFEX Congress, the Meeting started planning for the next Congress. The *SAFEXplosives Management* Course also received considerable attention.

Board approves upgrade of the SAFEX Website

Our website is almost 10 years old and we have long been aware it needs to be upgraded. The technology of the current site is outdated and incompatible with many of the new operating systems and software. In addition we should also address the "look and feel" of the website as part of the Upgrade. One of the key aspects we need to consider is the Database and its search capability. It has been suggested that the search method used by the EIDAS Database on the HSE's Website is more user-friendly and should be adopted.

As we did not want to embark upon a project to upgrade the Website until after the most recent Congress, the Board has now agreed to proceed with the Upgrade. It asked that the look and feel of the Website should appeal to the younger generation and also accommodate social media such as Facebook and Twitter.

Dates and Host City for XVIII SAFEX Congress in 2014 identified

The SAFEX Board agreed to hold the next SAFEX Congress in 2014 in Warsaw, Poland from 19 to 24 May 2014. These dates are a little earlier than usual to allow for the major public holidays in the European Union later in May of that year. Nitroerg SA, one of our Company Members, is located in Poland and kindly agreed to act as "host company" by assisting us with the arrangements. The Congress organisers is looking at various hotels with the help of Nitroerg representatives with a view to identifying a suitable venue for the Congress

First *SAFEXplosives Management* Module Trial

Noel Hsu and Jackie Akhavan gave a presentation on the proposed *SAFEXplosives Management* Course at the recent Congress in Istanbul. 22 delegates responded to the simple survey that was conducted to help gauge support for such a Course. The survey indicated strong support for the Course with a significant preference for the E-learning Format. The Board recognised that the number of responses was small but concluded it should take the first steps to develop the Course in the E-Learning Format

It was agreed that the Basis of Safety (BOS) module will be a good one on which to cut our teeth given that it was presented at the Congress. Andy Begg will be the Subject Matter Expert (SME) who will collaborate with Cranfield University to develop the BOS Pilot Module. Cranfield University kindly agreed to host the Pilot Module on their website (Virtual Learning Environment) for a 2 month trial once the Beta Version of the Module is complete. The Module will only be accessible to individuals authorised by SAFEX. Cranfield University will manage the e-helpdesk, set-up user accounts and enrol new students.

If everything goes according to plan, the Pilot BOS Module should be ready for trial in May/June. The Secretariat wants to hear from any member companies who are keen to assist with the trial of the Pilot Module. Please contact us at secretariat@safex-international.org

Incident Statistics Network Launch in April

Twenty three SAFEX members indicated an interest in sharing accident rates and similar statistics in the poll that was conducted early this year. The thinking behind such an Incident Statistics Network is to:

- Provide a benchmark of safety performance for member companies
- Identify where good practices may exist
- Obtain a real indication of progress in our industry and segments of it.

The Board approved the establishment of an Incident Statistics Network and noted that the members of the Network will agree the type of statistics and the frequency at which those will be collected. The Network can also decide how it wants to segment the information received e.g. company size; region; sector – military or civil; etc. The "condition" for joining the Network and obtaining the information will be active participation in providing the agreed data. Terry Bridgewater (Chemring Group) is a Governor and offered to lead the Network with support from the Secretariat. The plan is to provide interested members with a proposal for their comment and suggestions in April. This will be the first step in agreeing the nature of the statistics required and the frequency at which they should be reported

Non-participation in the Network will not affect the normal services SAFEX provides such as the distribution of Incident Notices and Investigation Reports.

Members who are interested in participating in the Network but have not yet submitted their names should contact the Secretariat at secretariat@safex-international.org

IExpE grants Company Membership to SAFEX

The recent General Meeting of Members in Istanbul decided to admit the Institute of Explosives Engineers (IExpE) as a Corporate Associate Member of SAFEX. As a reciprocal measure the Council of the Institute of Explosives Engineers granted Company Membership of the Institute to SAFEX in a letter dated 23 December 2011. "In addition the Council of the IExpE agrees that SAFEX may use the Institute logo on its website but that no other individual or corporate members of SAFEX may use the Institute logo unless that right has been granted to them separately by the IExpE. The IExpE would also ask SAFEX to encourage any of its members who qualify for membership to join the Institute of Explosives Engineers. We hope that this joint membership will further support the furtherance of safe working practices in the explosives industries

The Board gratefully accepted the privilege of IExpE Company Membership in the belief that it will further enhance our collaborative efforts to improve the health, safety and environmental performance of the explosives industry worldwide

Board recognises Newsletter contributors

At its meeting the Board acknowledged the time and effort required to produce contributions for the regular Newsletter features. It noted that with the departure of Phil Lightfoot from CERL, a new feature called *Science at Work* has been introduced with the help of members and associates. Other new features include *Pondering the Profession* and *Quantitative Risk Assessment (QRA) Corner*. Ben Barrett is also unable to continue his regular articles for *Our Regulatory World*. However, SAFEX hopes to interest our regulators to contribute to this feature.

Contributors to these and other features all stand in full-time employment and write these articles because they love their subject and are committed to SAFEX and the explosives industry. The Governors thanked all those who contribute regularly and in particular Prof Martin Braithwaite (Imperial College), Lon Santis (IME), John Tatom and Mike Swisdak (APT Research), Hans Wallin (KCEM) and Tony Rowe (AEL Mining Services).

Pondering the Profession

This column is devoted to our 'Safety Professionals' in recognition of the crucial role they play in the explosive industry's health, safety and environmental efforts. It is intended as a forum in which we can talk about the Profession. Our aim is that this column will be read by everybody but that our 'Safety Professionals' will make it their own.

SAFEX has a high regard for the role of the Safety Professional in our industry and wants to enhance their effectiveness and standing. We therefore urge Safety Professionals to let us have their contributions for this column. Unfortunately, we did not receive any contributions for this edition of the Newsletter. However, we hope to feature it again in the next Newsletter.

Safety Snippets

Open Invitation to all Newsletter Readers

The 5th international Conference on Explosive Education and Certification of Skills

12 to 14 June 2012, Karlskoga, Sweden

EU Excert — Certifying Expertise in European Explosives Sector

The EuExcert Association, Business & Science Arena in Karlskoga, KCEM and Karlskoga Municipality are pleased to invite you to participate in the 5th International Conference on Explosive Education and Certification of Skills, to be held in Karlskoga, at Hotel Bofors Stallet, on 12th –14th of June 2011.

KARLSKOGA KOMMUN

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 Military and Civil areas.

Registration Fee for the 3 days is EUR 350 which includes Conference proceedings and Conference dinner on the 12th of June as well as the social programme on the 14th of June. Registration form are available on the conference website www.kcem.se . The Conference Program is outlined below and any questions can be directed to Dr. Hanne Randle, Business & Science Arena, Karlskoga Sweden at hanne.randle@karlskoga.se

12th of June

09.00 - 10.00 Registration and coffee
10.00 - 10.45 Welcome and opening
10.45 - 11.30 Key Note speaker
11.30 - 12.00 Paper presentations
12.00 - 13.30 Lunch
13.30 - 14.15 Paper presentations
14.15 -15.45 Coffee break
15.45 -17.00 Paper presentations
19.00 - Conference dinner

13th of June

09.00 - 10.30 Paper presentations
10.30 - 11.00 Coffee break
11.00 - 12.15 Paper presentations
12.15 - 13.30 Lunch
13.30 - 14.45 Paper presentations
14.45 - 15.15 Coffee break
15.15 - 16.00 Conference evaluation

14th of June - Social program

09.00 - Study visit at Alfred Nobel museum and the Björkborn Manor http://nobelmuseetikarlskoga.se/index.php/home
Lunch
13.00 - Study visit at Bofors Test Center http://www.testcenter.se/index.php/welcome-to-bofors-test-centers-website

Inbox @ SAFEX-International.org

From time to time we receive e-mails from members of the SAFEX community on a variety of issues. It is important we share such experiences and insights and if necessary debate them. Our quarterly Newsletter may just be the forum for doing so.
We therefore invite ALL readers to drop us a line at secretariat@safex-international.org if they want to raise an explosives health, safety or environmental issue or comment on any of the opinions expressed by our correspondents.

Storing propellants is no simple matter

The incident that occurred on 11 July 2011 at the Evangelos Florakis Naval Base, Mari, Cyprus was widely reported in the media last year. The explosion occurred when a variety of propellant powders stored at the Base ignited spontaneously and exploded killing 13 people and injuring 62 others. It also caused extensive damage to a nearby power station, houses and vehicles. SAFEX was unable to obtain any good information at the time. Subsequently the SAFEX Contact of a member company collated the information from official reports that were issued after the investigation.

The Incident Notice that was issued prompted Maurice Bourgeois (GD-OTS Canada) to make the following observations: Storing propellant outside, exposed to the sun is certainly a bad practice and is the probable cause of this accident (overheat of the propellant). There is also another issue at stake. Propellants have chemical stabilizers which degrade with time. Obviously bad storage conditions accelerate the degradation conducive to spontaneous ignition. Even under good storage condition, there should be a quality control test to check the remaining concentration of stabilizer every five or ten years and even more frequently under adverse storage conditions. It is regrettable to be reminded in this way of our obligation to perform these tests systematically for long term storage of propellant.

This incident also prompted Alex Mandl (Maxam Australia) to comment as follows: It occurs to me from your notification that there are a few things needing to be established. If they were simple gun propellants stored as UN Class 1.3 and not subject to confinement via mass storage, the likelihood of such a violent explosion would have been relatively minimal. You could probably argue that what was seen was a transition from burning to something approaching a true detonation. There are a number of studies showing TNT equivalence of near 100% for naval propellants used in large calibre gun systems, typically double base multi perforated grain propellants.

I agree that the storage described was extremely unwise and contravened most principles of the storage of explosives, remembering that Class 1.3 is still a subset of Class 1. I will be interested to see any report from the accident and especially any modelling that was done. Propellants are a significant issue and the higher the energy, the higher the potential hazard – something which the fireworks industry is keenly aware of nowadays.

Pallets an important packaging component

SAFEX recently issued an Advisory received as a Safety Alert from the Explosives Inspectorate of Queensland, Australia. It refers to plywood pallets on which stacked cartons of boosters were imported from overseas. When the loaded pallets were handled with a forklift in the normal way, one pallet broke up around the forklift tines causing the cartons of boosters to collapse. The pallets were not strong enough and of very poor quality.

Maurice Bourgeois (GD-OTS Canada) found the Advisory very relevant and commented: This is an interesting topic. Regulators in all countries focus their attention on the containment packaging requiring drop tests etc. The pallets are not controlled and it is up to the explosives manufacturer to attach the authorized explosives containers on a pallet of their choice. We have had issues with improper pallets for various products more particularly with Blackpowder manufacturers. Blackpowder used to be shipped in steel kegs which offered some protection but created more confinement. Now it is shipped in cardboard boxes. The pallets are of very poor quality. The market for fireworks blackpowder is very competitive and hence manufacturers tend to minimise costs. The pallets are too small so the boxes hang over the edge of the pallet. With humidity, the cardboard boxes sag over the edge hence creating a pinch point when the forklift truck tines are inserted to pick up the pallet. Sometimes the boxes shift during transport creating an increased overhang. At other times cheap planks or woodchip boards break exposing nails that can perforate the cardboard boxes. We had to ask the blackpowder supplier for side wood boards to be installed to prevent load shifting and box overhang. But I think the regulators should pay as much attention to the quality of the pallets and strapping methods as they do to packaging (authorization of containment packaging). Poor palletizing and poor bracing (dunnage) can create major accidents during handling and transport operations.

Tony's Tale-piece

A tailpiece is something that appears at the end of a publication. I guess it is derived from the tail of an animal which is (normally) fixed to "the end" of it. However, we refer to this feature as a "Tale-piece". It is not a spelling mistake but a different tale. This "tale" is about telling stories. While it appears at the end of our Newsletter, it is also meant to tell a story hence the play on words. Let me tell you what "Tony's Tale-piece" is about.

Tony Rowe from AEL Mining Services has kindly agreed to provide a regular feature based on truths he has discovered over many years in his work with explosives. He has a unique style of writing (perhaps "telling stories" may be a better way to describe it) which we hope gets a well-known message across in a new way. This Feature is there to remind readers of some explosive(s) truths in a different way!

These Magazines are not for Reading

by

Tony Rowe

(AEL Mining Services)

Many cultures have cautionary tales. Aesop's Fables are probably the American and Western European versions of these simple stories of greed and retribution. Here is one from the Far East. It goes something like this:

A long, long time ago in a land far, far away there lived a man. He was a greedy man, vain and arrogant. His name was Kwen.

Kwen was solely responsible for controlling the collection of tax monies for the Emperor, but his salary, large though it was could not cater for Kwen's extraordinary needs. He had a number of vices and his tastes for the exquisite were without limit. The best wines, the most beautiful women, the finest homes and fastest racehorses; he desired them all. Slowly and with infinite patience he started to divert tax money to his own account. Nobody noticed and he was soon spending the money almost as fast as he could acquire it. He needed more and so he took more. His acquisitions made people jealous and they began to question the source of his wealth. An audit of Kwen's accounts was undertaken. He was exposed and it was not long before word of his manipulations reached the Emperor. The Emperor called Kwen before him and asked many questions. Kwen lied willfully; blaming everybody but himself. The Emperor listened at length and then passed this infamous judgment. "Banknotes are merely paper, but they carry an Emperor's promise. You have betrayed both my trust and that of your office and so, because you love money more than life

itself I decree that you be walled in within a cell built from solid stone. No food or drink shall be provided to you, but each and every day at the hour of 10:00 in the forenoon a piece of paper the same size as our country's largest denomination banknote shall be brought forth. It shall be inscribed with the following words: Food and Water. The paper shall then be pushed through a slot left for this purpose in the wall of your cell. You shall live as long as your love of money can keep you alive."

Sounds harsh, but in the explosives industry punishments for mistakes and transgressions can be equally swift and just as unpleasant.

When I was still a relatively young man, a very wise person provided me with some basic advice around the use

of explosives. Those words became my rod and my staff. They kept me safe then and have continued to guide me ever since. I will from time to time share his wise words with you. They may help keep you safe too.

On the subject of Explosive Magazines my mentor spoke these words:

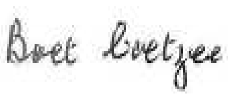
- Never rush when handling explosives, rather keep a cool head and a clear mind. Haste should be scrupulously avoided.
- Store explosives only within a suitably licensed, dry, cool, clean and well ventilated building.
- Keep the magazine door locked at all times when not actually putting explosives in or taking explosives out.
- Post the magazine rules clearly on the door.
- Keep accurate records of what is in each magazine
- Instructions should be kept up to date and always be strictly followed.
- Segregate the storage. Store different types of explosives separately from one another.
- Blasting explosives, boosters and detonating cord must be stored separately from initiators such as detonators (blasting caps).
- Do not store any container or box inside a magazine that is open or doesn't have a lid.
- The opening of cases of explosives inside a magazine is strictly forbidden.

- Cases of explosives should never be stored on the floor, but rather on suitable wooden shelving placed there specifically for the purpose.
- Magazine floors should at all times be kept clean and free from loose explosives, grit or sand.
- Cases should not be stacked too high and with the manufacturers label and Date of Manufacture turned to the front. This is for stock rotation purposes so that the oldest stock can be used first.
- Flammable solvents, oily waste, matches, metal tools, smoking materials, petrol, etc. are CONTRABAND and as such strictly forbidden. These materials should never be brought near or into a magazine containing explosives.
- No source of light using any form of naked flame such as candles, oil lanterns or carbide lamps shall ever to be allowed near or be brought into a magazine containing explosives.
- To prevent the spread of fire, the ground around any explosives magazine should be kept clear of all loose brushwood, twigs, dry grass, dead leaves or other combustible debris.
- Always wash your hands after handling explosives, especially TNT or boosters.
- Explosives must not be taken into any forge or blacksmiths shop due to the dangers of a spark or hot iron from the forge causing an ignition and subsequent explosion. In today's world read garage, workshop or a panel beaters shop.
- Never dispose of old or unwanted explosives by either burying them or tossing them from a moving vehicle.
- Never, ever to allow explosives to fall into the hands of children or young men having no explosive related skills or experience.
- Rough handling or the throwing or sliding of cases or packets containing explosives shall be strongly discouraged.
- Don't take blasting machines, shot exploders or electronic shock tube firing devices into any explosives magazine.

In my tutor's days, detonators and safety fuse were supplied separately and had to be assembled, by hand, before use. Sometimes the assembly process failed. When it did he would usually say something like this: "Damaged or rejected detonators, may be contaminated with loose powder. Such items should be dealt with only in small quantities. Re-handling should be avoided as much as possible."

It's 2012 but this is still good advice. Magazines are not only for reading. In the explosives world they become a bomb if not treated with the respect they deserve .

You know it makes sense.



Boet Coetzee
Secretary General, SAFEX International
Tel: + 1 919 342 5848
Tel/Fax: + 27 21 854 4962
e-mail: secretariat@safex-international.org

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REGISTERED OFFICE

SAFEX International
c/o Modoux Services Sárl
Route du Village 13
CH – 1807 BLONAY. Switzerland
Web: www.safex-international.org