
## FROM THE SECRETARY GENERALS'S DESK

## CONTENTS



How time flies, we are already halfway through 2015! For the industry thus far ,from a Safety perspective a good year, as no serious explosives related incidents were reported. Below are the Incident Notices issued since the last Newsletter:

IN06-15 – Lead Azide Chimney Explosion

IN07-15 – Shock Tube Extrusion Detonation

IN08-15 – Lead Azide Detonation

IN09-15 – Unplanned Blast Hole Detonation.

IN10-15– Burning Ground Explosion

IN11-15– Detonating Cord Destruction Incident

In this Newsletter the Safety Statistics of the members participating in this study are attached .Terry Bridgewater one of the SAFEX Governors ,collects and collates this data on an annual basis – I would like to encourage more members to participate , as this information is a very important lagging indicator for use by the safety specialists. The industry we operate in is very unforgiving and monitoring statistics as well as reporting of incidents gives an indication of the health of the current safety situation and culture globally .This hopefully will assist member companies to stay alert and ensure the highest safety standards are set and adhered to.

In view of recent AN fires Ron Peddie an Expert Panel Member supplied a document on a meeting held in 1983 by Professor Bauer to discuss the explosion hazards of AN . This historical note is still very pertinent and should be viewed as open for discussion by the industry.

The recent IGUS /CIE Conference was held in Santiago under Ken Price's able leadership. Safety Experts ,Technical Experts and Legislators from across the globe shared and discussed incidents ,technical results and legislative implications in a very open and honest environment .The next conference is planned for 2016 in Switzerland.

The IME spring meeting was held in Arizona USA at the end of May and SAFEX as an Associate Member was in attendance .Discussions focussed mainly around new directions in legislation ,training and safety .A presentation was given by SAFEX on Truck Incidents and the establishment of an International Work Group to address this issue . A lot of common interest

**NEXT CONGRESS 15-20 May 2017 in Helsinki ,Finland**

was generated with this subject. Discussions also took place with IME members around the eLearning initiative that SAFEX embarked on starting with the Basis of Safety Module.

Referring to the latter an **urgent reminder** to our members that the **Basis of Safety Module** is now available to members on the **eLearning Portal** at the cost of €100 per individual (non members € 250).Please use this tool as it provides critical safety training for explosives practioners.

Just yet another reminder that the next **SAFEX Congress will be held in Helsinki , Finland from 15 till 20 May 2017** . I urge members to diarise this event and request **especially the CEO's and relevant Senior Executives** to make the effort to attend .A special session will be planned to get your views, inter alia ,on where SAFEX should focus and strategically move over the next few years – This will be an invaluable interaction and will require your commitment!

## THE SAFEX STATSTICS NETWORK
## By Terry Bridgewater

### BACKGROUND

At the SAFEX Board of Governors meeting in February 2012 a proposal was discussed to look at less serious incident data relating to general occupational incidents. Often weaknesses here can be a precursor to more serious incidents and the data might also allow us to see good practice and provide a network for sharing.

It might also allow the participants to benchmark against each other and with other related industries and to monitor progress over time. Additionally, if we see one company who report very low incident rates then we can ask them for information about their success.

It was agreed to establish an 'Incident Statistics Network' to collect data from willing participants subject to a set of rules that were agreed by the group.

Most importantly, only those participants who provide the agreed data receive the consolidated information. SAFEX Members are free to join the network at any time if they are willing to provide the required information and participants are free to withdraw from the network at any time.

The focus is on occupational safety data rather than process safety data and the group has discussed extending the scope to include near misses (or near events) but to date it has not been possible to identify a robust measure for process safety near misses.

We have now collected two and a half years of data and this paper summarises the results and findings and compares the SAFEX community performance with other industries. In accordance with the original rules of the programme, the participants receive the full data set with details of each member but others, including the Board, only see the overall summary.

### RESULTS FOR 2014

The companies participating in the programme are:

- Arabian Explosives;
- Austin International;
- Chemring Group;
- Davey Bickford;
- EPC Group;
- Incitec Pivot (Dyno Nobel);
- Kayaku;
- Rheinmetall;
- Titanobel (new in 2014).

Three fatalities were reported by the participants in 2014; one at Chemring and two at Rheinmetall.

The participant companies supplying data employ a total of 15,808 people and there were 86 lost time incidents in 2014. This gives a rate of 0.54 incidents per 100 employees. This compares with a rate of 0.45 in 2012 and 0.42 in 2013 indicating a slight deterioration.
Incident rates are calculated using the US OSHA formula.
The data has been compared against the industrial injury and illness data collected and published by the US Bureau of Labor Statistics. They collect up to 80,000 submissions from companies all over the US and compile them under standard industry codes (SIC). Comparable or complimentary industry sector performance for 2013 is included in the following table:

| Sector | LTI |
|---|---|
| Chemical manufacturing | 0.50 |
| Explosives manufacturing | 0.30 |
| Small arms ammunition manufacturing | 1.10 |
| Ammunition (except small arms) | 0.30 |
| Oil and gas extraction | 0.50 |
| Coal mining | 2.20 |
| Metal ore mining | 0.90 |
| Non-metallic mineral mining and quarrying | 0.70 |
| General freight trucking | 2.30 |
| Electrical power generation, transmission and distribution | 0.50 |
| Natural gas distribution | 0.90 |
| Guided missile and space vehicle parts | 0.20 |
| Machine shops | 1.20 |
| Electrical equipment, appliance and component manufacturing | 0.60 |
| Hazardous waste treatment and disposal | 0.60 |
| Aircraft engine and engine parts manufacturing | 0.40 |
| Engine, turbine and power transmission equipment manufacturing | 0.70 |

***Ref: Incidence rates of nonfatal occupational injuries and illnesses by industry and case types, 2013 available from:*** *http://www.bls.gov/iif/#tables*

This suggests that the SAFEX participants are generally within the broad range of industrial performance and perhaps a little better than some.

Lost time incident types in 2014 were similar to previous years:

| Quantity of lost time injuries resulting from: | Total |
|---|---|
| Energetic event | 6 |
| Slip, trip or fall | 19 |
| Strain or sprain | 21 |
| Repetitive strain | 3 |
| Laceration / graze / puncture wound | 7 |
| Crush | 9 |
| Struck against object | 3 |
| Struck by object | 10 |
| Chemical burn or adverse response to a substance | 1 |
| Stress | 3 |
| Burn | 2 |
| Other | 2 |
| **Total number of lost time injuries** | **57** |

We are always looking for other participants to join the network and to share their data.

Terry Bridgewater, Director of Safety for the Chemring Group convenes the Network and issues reports.

If you are interested in further information or wish to participate please contact Terry (terryb@chemring.co.uk) or the SAFEX General Secretary (secretariat@safex-international.org).

## AN IMPORTANT COMMENT FROM OUR EXPERT PANEL MEMBER—HORST MARZ— ON THE ARTICLE TITLED:

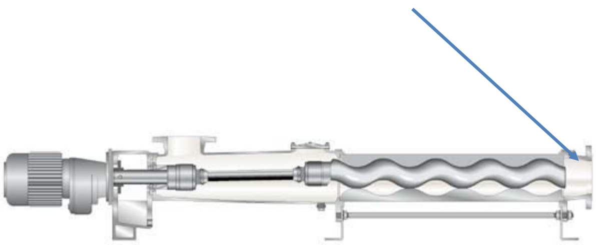
### The Bowtie Risk Assessment Method

### (Published in Newsletter No.52)

**In the following note he clarifies a comment on the actual application and usefulness of a Thermo Plug when correctly applied .**

A thermo fuse or better called a "Thermo Plug" will NOT be able to protect a PC pump against the hazards of dry pumping because in a dry pumping event there is no heat transfer between plug and emulsion taking place which could melt the plug and initiate a stoppage of the pump. The best safety devices to prevent this event are thermocouples placed in the stator and flow switches.

A "Thermo Plug" is a reliable safety device for progressive cavity pumps to guard against deadhead pumping. It is placed in front of the stator outlet face and blocks a 16 mm passage through which hot emulsion is ejected to the outside once this plug is molten. The plug melts through heat transfer from a small flow of overheated emulsion which oscillates between the two stator chambers during a deadhead condition.




Progressive Cavity Pump

We thank both Horst Marz and Mike Taylor for their comments and follow-up on this issue.

## UNDER LOCK AND KEY

**This is the penultimate in a series of articles by JIEDAC on Explosives and Precursor Security**

**Presented by Ravi Chauchan**

**Countering the IED Threat: The Government Approach**

**Introduction**

Previous articles by the UK Ministry of Defence (MOD) Joint Improvised Explosive Device Analysis Centre (JIEDAC[1]) discussed the history, evolution and technologies of the Improvised Explosive Device (IED) threat, which have led to the IED becoming a significant weapon of choice by terrorist groups worldwide. This article discusses how governments are postured to counter the IED threat and gives examples of how they work together through global organisations, focusing on the counter proliferation of explosives materials.

The widespread use of IEDs is an enduring global threat for everyone, not just military personnel. It has a profound effect on governments as well as civilians. IEDs have the capacity to injure and kill and also demoralise the indigenous population, who perceive there to be insecurity in their country; potentially creating a lack of confidence and trust between them and their government.

IEDs vary in complexity according to the target, resources available and skill of the manufacturer. They can be constructed from components that are plentiful, inexpensive and in everyday use, or of complex electronic design. Therefore Counter-IED (C-IED) forces need to keep ahead of adversaries in order to combat an ever evolving threat by developing robust C-IED policies. An example of this is the C-IED strategy adopted by the North Atlantic Treaty Organisation (NATO).

**The NATO C-IED Strategy**

The NATO approach is built around 3 mutually supporting and complimentary pillars; defeat the device, prepare the force and attack the network, underpinned by a base of effective understanding and intelligence.

**Understanding the problem and the adversary**

The aim of the NATO C-IED approach is to defeat an adversary's IED system. An IED system is defined as "a system that consists of personnel, resources and activities and the links between them, needed to resource, plan, execute and exploit an IED event." [2]

[1] JIEDAC is to be become the Attack the Network Capability within the UK Ministry Of Defence Operations Directorate

[2] Ministry of Defence Joint Doctrine Publication 3-65 (AJP-3.15 (A)) Countering-Improvised Explosive Devices – NATO Unclassified – [Accessed 12 February 2015]

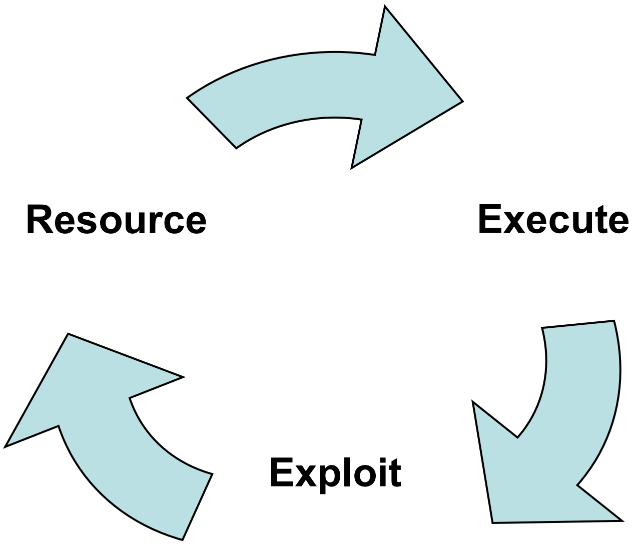



*Figure 1*

- **Resource and Plan**. Activities include securing technical and financial support, recruitment and training of personnel and provision of materiel to be used in IED construction. Research and development may also be performed to design new types of IEDs to combat any emerging counter measures.

- **Execute**. Once an adversary has selected a target, a more detailed plan will be formulated. The IED will then be placed in the target area and the optimum moment chosen for detonation, to maximise the destructive effect and avoid capture.

- **Exploit**. Adversaries will often choose to exploit the successes and activities usually consist of the following 2 strands:

  - **Assessment**. An adversary assesses the effectiveness of an IED event and analyses their achievement against their target. This allows technical modification and development at the manufacturing stage.

  - **Promote Success**. IED events are normally important elements of the adversary's information plan. Details of events and images will be released to target audiences and the facts may be embellished to promote success.[3]

As with any issue, a good understanding of the problem is key for developing a solution. Understanding within the context of C-IED extends to beyond just understanding the adversary to understanding the wider environment, including the social, cultural, economic and political drivers of those affected by the system. C-IED forces will seek to develop effective intelligence to support their understanding. This may come from a wide variety of sources, including surveillance, imagery, technical and human intelligence. Technical intelligence covers a wide area, but of particular interest in the C-IED context, is the exploitation of IED stores, defused devices and sites of detonation. This can provide security forces with additional information on the construction of IEDs, sources of their precursors.

[3]Ministry of Defence Joint Doctrine Publication 3-65 (AJP-3.15(A)) Countering-Improvised Explosive Devices – NATO Unclassified – [Accessed 12 February 2015]

**The 3 Pillars**

**1.Defeat the Device**

Defeat the Device activities tend to be defensive in nature; aimed at defeating IEDs that have already been emplaced in order to prevent the loss of life and allow freedom to move within an area. Defeat the Device can involve the use of search, disposal, neutralisation and disruption tools and techniques.

There are a number of levels of search, from basic to advanced, with increasing levels of assurance and utility in an array of threat levels. These may involve the use of specialist equipments, such as working dogs and detection devices.

Once a device has been located, there may be a requirement to remove or dispose of it so as to remove the threat. This is done by trained personnel with capabilities increasing as a result of the level of training and equipment. The use of more advanced techniques by specialist teams reduces risk and enhances the evidential value that can be used to feed the understanding of the threat.

**2.Prepare the Force**

Where there is a high IED threat, forces must be appropriately trained, manned and equipped in all aspects of operations to carry out C-IED activities effectively. Forces must be organised and able to work alongside other allies and partners. They must act on intelligence and understand the adversaries' operational methodology. On many occasions, prepare the force activities will often extend to providing training for the host nation and other government agencies and departments.

For example, UK government agencies and departments, alongside allied global counterparts, have collaborated and build partner capacity in of law enforcement personnel and industry, when countries that have requested assistance in defeating the IED problem. Schemes have included:

- Training and equipping customs teams to prevent illicit trade in precursor chemicals;
- Training industry to set up end user "know your customer schemes"; and
- Training and equipping exploitation teams.

### 3. Attack the Network (AtN)

Attack the Network activities consist of proactive activities to disrupt the wider IED system, including, but not limited to, the supply of IED components, finance, leadership, personnel and expertise. It is not just one activity that achieves success but a combination of activities across different timescales from cross-governmental and global non-governmental organisations, as well as industry.

For example, the most effective action may not be to prosecute leadership, because, in the short term, they can easily be replaced. A greater and longer lasting impact could be achieved by targeting broader aspects of the network, such as disrupting the adversaries' ability to acquire precursor chemicals, or commercial grade explosive components.

To assist in our mutual aim of attacking the network, governments and their global counterparts have collaborated to improve security in the supply chains of explosives materials; these have been conducted in a number of forums such as:

- **Specific Government Engagements.** Engagements have been conducted by the UK Government to help improve security legislation from the lessons learnt through many years of countering IEDs. The UK and other international partners have provided training to a wide range of stakeholders in all aspects of the defeat the device, prepare the force and attack the network pillars. This has extended beyond military C-IED forces, to include legislative enforcement agencies, local law enforcement and security forces.
- **The World Customs Organisation (WCO)**. In 2012, the WCO, in collaboration with INTERPOL and the United Nations Office on Drugs and Crime, set up Programme Global Shield (PGS). This initiative is supported by over 90 governments globally and their enforcement / customs organisations; including those of the UK. The objectives of PGS include the security of legitimate global supply chains and protection of the population; prevention of the smuggling of drugs and other restricted items; the illicit diversion of precursor chemicals that could be used in the construction of IEDs; raising awareness of global threats; and engagement with industry to establish and promote best practices. There are currently 14 listed precursor chemicals whose shipments are monitored. This list is currently under expansion to include other IED components, including blasting caps. Information and intelligence is shared by global customs organisations, to assist in the prevention of incidents that pose a threat to security. This is done via a global computer database, which records real time details of shipments and seizures of goods. Through training of customs staff on detection and handling of precursor materials, they are better equipped to identify and seize illicit shipments and communicate details of investigations to other global members. PGS has proved effective in reducing the quantity of illicit components
- **The Istanbul Process**. In 2011, the Istanbul Process, also known as the Heart of Asia Initiative, was founded with the intention of creating a peaceful and stable Afghanistan as well as a secure and prosperous region. The Istanbul process consists of 14 member countries4 who hold regular meetings from country leadership to technical working group level. The Istanbul Process members have been offered support from other countries and non-government organisations from across the globe in order to have implemented a number of confidence building measures to ensure they reach their goal. The role of the supporting countries is to complement and assist with the confidence building measures. Supporting activities have included: sharing information and expertise; the provision of technical and even monetary assistance; training and development to assist with counter-terrorism activities; and support with developing commerce and industry opportunities in the region. The UK is a supporter country of the IP initiative. It has pledged support to various issues, one of which has been restricting the use of precursor chemicals and commercial grade explosives in IEDs. A unified approach to building confidence and stability will increase prosperity and security across the region and globally, which will assist in the C-IED mission.
- **Chief Inspector of Explosives (CIE) Conferences.** The CIE forum provides an environment where explosive legislators and enforcement agencies are able to discuss any problems and lever solutions from the international perspective and share best practise from legislation and industry. JIEDAC and its international partners have turned to this forum to see how the C-IED strategies can learn from the CIE and support the CIE in their endeavours to improve safety and security.

**Conclusion**

In conclusion, to overcome the IED problem, NATO countries and their global government, industry and law enforcement partners, need to understand the adversary and the whole of the IED system for C-IED measures to be effective.

The approach of the 3 pillars of defeat the device, prepare the force and attack the networks working together can start to turn the tide in combating an ever growing IED threat. Countries and governments working together, internally and externally across different action arms from military to law enforcement and policy makers, can achieve a greater impact than individually in defeating the IED threat.

The final article will extend on this principle of unity of effort to look at how governments can and have worked with industry to impact on the IED threat.

[4] Afghanistan, Azerbaijan, China, India, Iran, Kazakhstan, the Kyrgyz Republic, Pakistan, the Russian Federation, Saudi Arabia, the Republic of Tajikistan, Turkey, Turkmenistan, and the United Arab Emirates

## AMMONIUM NITRATE BEHAVIOUR IN A FIRE

### Presented by Ron Peddie

Recently, there have been 2 events in which an explosion has occurred following a fire involving Ammonium Nitrate:

- At a fertilizer facility in West Texas (2014) and
- An AN transport vehicle near Angellala Creek in Queensland (2015).

Each time there was a fire involving ammonium nitrate followed by an explosion,the question arises: “How much do we know about the behaviour of AN in such a situation?”

We know most of the processes that can take place in a fire involving ammonium nitrate , due in part to a study carried out by Professor Bauer and his co-workers at the University of Kingston in Ontario between 1978 and 1992. This group produced 11 reports and a summary report (Shah 2009). This is the most detailed survey of the properties of ammonium nitrate yet produced. This work together with the earlier work at the US Bureau of mines forms the main basis of our understanding of the behaviour of ammonium nitrate in a fire.

The studies show that when ammonium nitrate is involved in a fire it first melts, since its melting point is 170°C. The melt decomposes as the fire progresses, at above about 200°C the pH drops and bubbles start to form (Bauer A 1979). At about 220°C, the density drops as a result of the evolving gases and the solution becomes sensitive. This sensitivity increases as the temperature of the solution rises. However, interestingly no one has ever been able to detonate molten ammonium nitrate purely by fire or heat input. As it reaches higher temperatures where one might think it would detonate spontaneously, the whole reacting mass decomposes and becomes gaseous. It has been observed that ammonium nitrate never detonates purely because of fire. There appears to be another factor which is required and one that has not yet been proved experimentally.

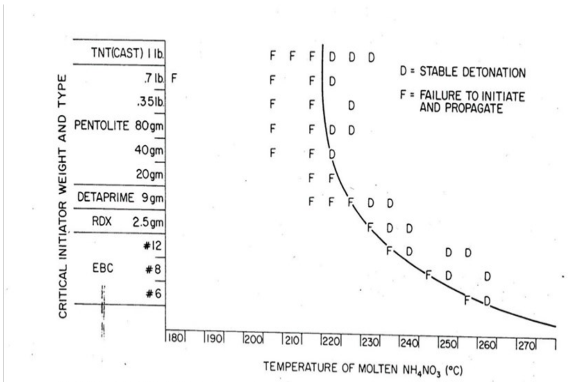



FIGURE 26 CRITICAL INITIATOR WEIGHTS AND TYPES FOR MOLTEN $NH_4$ $NO_3$ AS A FUNCTION OF TEMPERATURE.

*Figure 1 Initiation of molten ammonium nitrate (Bauer A 1979)*

**References**

Bauer A, A KIng. 1979. *Crtitical initiation paramters for molten Ammonium Nitrate.* Kingston: Canadian Fertlizer Institue.

Shah, Kish. 2009. "Summary of the work at Queens University by Bauer King & Heater." *ANNA ( AMMONIUM NITRATE AND NITRIC ACID).* Little Rock AR: ANNA.

We found this discussion document written as the minutes of a meeting held with Professor Bauer in London in 1983, which discusses some of these issues. This document has not been previously published.

> ***“It was clearer than ever and could not be too strongly emphasised that the most important contribution, which could be made to ammonium nitrate safety, was to avoid fires”***

Dr A C Docherty Secretary of the meeting with Professor Bauer 1983

**REPORT OF FMA MEETING WITH PROFESSOR BAUER OF QUEEN’S UNIVERSITY KINGSTON, CANADA**

**INTRODUCTION**

Professor Bauer is a leading world authority on the explosion hazards of ammonium nitrate and the FMA (Fertiliser Manufactures Association of the UK) invited him to London to describe his most recent work on this subject.

Council set up a small committee to make the arrangements as follows:

Mr P A Squire (Chairman)

Dr KS Barclay (Norsk-Hydro – Fisons)

Mr JM Kidd (ICI)

Mr HSS Few

Dr A C Docherty (Secretary)

The meeting took place on Thursday 6 January 1983 .It is seen that representatives from Western Europe were invited and Dr B J Thompson of the UK Health and Safety Executive because of interest in this topic.

In the event, neither D A Pittam nor F Socci were able to be present.

It was decided that Professor Bauer should see one of the UK Fertiliser Plants so that he might comment on UK practice if he wished to do so and Dr K S Barclay therefore arranged for a visit to Norsk-Hydro-Fisons at Avonmouth on the previous day, Wednesday 5 January 1983.

**PRESENTATION BY PROFESSOR BAUER (09.05 – 10.30)**

Professor Bauer first thanked the FMA for their invitation and then went on to explain that the work which he was to describe began 4 ½ years ago when a draft EEC directive concerning ammonium nitrate fertiliser came to the notice of himself and others in Canada. This directive was designed to distinguish "Straight ammonium nitrate fertiliser of high nitrogen content from varieties of ammonium nitrate used in the manufacture of products used in explosives".

Within Europe, ammonium nitrate fertilisers are commonly of low porosity but in Canada they are of higher porosity to the extent that some would not comply with this EEC directive. Although the draft EEC directive was applicable only within the EEC, nevertheless it was apparent that it might have some influence in a wider context. He commented also upon the thermal cycling procedure which is part of the porosity test. It was certainly inappropriate in Canada where storage and transport of ammonium nitrate in bulk was usual. In such a case, only the outer ½-inch or so of a heap ever changes significantly with temperature. It was of course true that thermal cycling did make the fertiliser more porous but this was a surface effect only and he did not consider it important.

The EEC directive also had provision for a detonation test in a 4 inch internal diameter steel pipe with 500 grams of dynamite proposed as a booster, and although Professor Bauer did not deny the need for a detonation test to identify potential explosives he thought that the test was far too severe. In the US the test for susceptibility to detonation was to use a 3 inch internal diameter steel pipe with 46 grams of cast pentolite as booster and currently the UN specifies a 2 inch (50mm) diameter pipe with a 160 gr RDX or pentolite booster using a No.8 cap. This is the smallest cap currently available commercially and the logic was that if these small boosters caused detonation then classification as an explosive was justified. To move to a 4-inch pipe with 500 grams of dynamite was gross overkill. He also criticised the choice of dynamite as a booster because of the variable results that could be obtained by its use. Cast pentolite or a standard No.8 cap were much more consistent in performance as boosters.

He was not greatly concerned about the upper limits in the EEC directive although, as he would show later, it was probably more important to set limits which would be safe for ammonium nitrate in the molten state than to be concerned about the solid which, when compared with explosives, was really a very stable material.

Having explained that the draft EEC directive was the trigger for the work. Professor Bauer said that they then carried out an extensive review of the literature relating to the involvement of ammonium nitrate in explosives and, setting aside incidents in which detonation by conventional explosives was a possible cause, came to the conclusion that it was far more important to consider what might happen to ammonium nitrate in a fire situation than to be concerned about the possibility of detonation of the solid. Nevertheless part of their assignment had been to assess the detonability of the solid and therefore they had increased the pile of fertiliser to be tested and increased the size of the explosive charge to detonate it and had found that with a 8 ton pile of bags in a hemispherical configuration of one to two meters in diameter with a 50lbs cast block of TNT at the centre as a booster, even the most dense prills tested could be made to detonate. This work had however shown also that less dense prills were easier to detonate but the boosters used were still large compared with those used to detonate conventional explosives.

Professor Bauer having indicated that he would welcome comments at any stage; several participants made the following points:

1. The thermal cycling procedure was criticised especially with regard to ammonium nitrate in bulk. Did this criticism equally to ammonium nitrate in bags? Professor Bauer thought that it did.
2. Criticism of the porosity test perhaps overlooked the fact that this test was of value in that it was an indication of the hardness of the prill and its resistance to crushing in transport. Professor Bauer had no criticism of the test as a test. It was the need for it that he questioned.
3. The EEC directive was simply intended to distinguish fertiliser grade from explosive grade and there did not seem to be any dispute as to the fact that the more porous material was more sensitive to detonation and was thus potentially less safe in use. Professor Bauer thought that even the porous explosive grade was not

dangerous until mixed with fuel oil to give "ANFO" which was the actual explosive.

4. There was perhaps some merit in distinguishing between fertiliser and explosive grades since much closer control was possible in a mining situation than on a farm. Professor Bauer said that on the other hand mining was often in remote locations where supervision was minimal and to get it there might require, ship, rail and finally road transport with transfer at each stage.

It was established that no European ammonium nitrate had been tested in this work and the point was made that in more densely populated Europe perhaps more stringent control of ammonium nitrate was desirable. Professor Bauer did not disagree he simply thought that the proposed test was too severe.

**Professor Bauer then described his work on molten ammonium nitrate.**

This had demonstrated:

1. No detonation of the melt was possible until a temperature of about 220 °Cwas reached.
2. The critical impact pressure required to detonate the melt decreased rapidly from about 125 kilobars at 230°C to only 6 kilobars at 260°C.
3. Over the range of 230°C to 260°C gas evolution in the liquid increased rapidly and at 260C it appeared to "boil" violently.
4. The effect of this gas evolution was to reduce significantly the density of the liquid.
5. It was believed that it was the density rather than the temperature, which was the significant factor in increasing the sensitivity to detonation over the range 230-260.°C

This was confirmed by tests simulating at 190°C the density of molten ammonium nitrate at 260°C by suspending "micro balloons" in the liquid (hollow glass spheres of nominal diameter 90 microns and nominal density 0.1 gms per cubic centimetre).
It was believed that it was not the lower density, which was the real cause of the increased sensitivity to detonation, but the gas bubbles, which gave rise to the lower density. When subject to a shock these bubbles contracted adiabatically with a consequent increase in temperature which could amount to several thousand degrees centigrade. In explosives practice this was a well-known phenomenon and it had been shown on the one hand that if nitro glycerine was completely degassed it was virtually insensitive to detonation and on the other hand gas bubbles were often deliberately added to slurry explosives to increase their sensitivity to detonation. In this later connection it had been found that although lowering the density of a slurry explosive by adding gassing agents did increase its sensitivity to detonation up to a point, there was a limit to this process and beyond this point additional gassing started to reduce the sensitivity again; the same would be expected to be true to pure ammonium nitrate but this had not been checked.

A question was asked as to whether the nature of the gas in the bubbles made any difference. It was concluded that since the temperatures reached by adiabatic compression were very high it would not make any difference if the bubbles were steam (normally regarded as condensable on compression) or a "permanent" gas such as nitrogen or oxygen.

**PRESENTATION BY PROFESSOR BAUER CONTINUED (11.00 – 12.15)**

Professor Bauer was asked to comment upon the effects of impurities on the explosion behaviour of ammonium nitrate, and dealing first with chlorine he said that as far as the solid was concerned he did not expect chlorine to affect its sensitivity to detonation. In fact in coal mining it was customary to deliberately mix chlorides with explosives to desensitise the explosive. However, in the case of molten ammonium nitrate there was no doubt that chlorides accelerated decomposition and therefore were undesirable.

With regard to other impurities, the situation was similar and it was the molten stage, which was of greater concern. Some surface coatings for example tended to make the molten material froth and this was undesirable.

In reply to a question concerning solid diluents such as chalk or phosphates which were known to decrease sensitivity of solid ammonium nitrate to detonation, Professor Bauer said that solid diluents did increase the internal surface area but did not give rise to gas bubbles and hence did not give rise to hot spots on detonation.

Professor Bauer went on to describe his most recent work using projectiles in an attempt to detonate molten ammonium nitrate and some fertiliser solutions. A custom-built cannon firing a cylindrical aluminium projectile 150 mm diameter and 150 mm long (weight 7.2 kgs) was used in this work. The projectile travelled at up to about 400 meters per second and the solutions were contained in Pyrex glass containers of wall thickness 3mm. The containers were 180 mm diameter and 0.6 mm long and the projectile was fired at 180 mm diameter end. As far as the fertiliser solutions were concerned, none was capable of being initiated to detonation by the projectile impact tests. It was however possible on one occasion to detonate 100% ammonium nitrate at 260C°C where the density was 0.8 grams per cubic centimetre with an impact velocity as low as 190 metres per second. The presence of small amounts of water however had a great desensitising effect and no detonations were obtained on a 95/5 AN/water mixture at density close to 0.8 grams per cubic centimetre even at maximum cannon velocity approaching 400 metres per second, but despite the fact that such a mixture would be readily detonated by a small electric blasting cap.

Professor Bauer then described work on adding a wide variety of materials to molten ammonium nitrate in an attempt to produce detonations. These all failed to detonate. He also described rapid heating tests on ammonium nitrate in glass flasks with powdered metals such as lead, chromium, zinc and copper. None of these resulted in a detonation. Next, he described cook-off tests in which ammonium nitrate was heated rapidly in close confinement in a steel pipe with only a ½-inch diameter vent. Only in the case of added copper powder did this test lead to a detonation and this was consistent with earlier work in which tetramine cupric nitrate – readily formed in molten ammonium nitrate – exploded when heated to 331°C. Professor Bauer believed that the presence of this compound in a pool fire with molten ammonium nitrate represented a very hazardous situation.

**QUESTIONS TO PROFESSOR BAUER (14.00 – 15.15)**

1. If a liquid pool were to detonate could it set off an adjacent solid? It was thought that if 70 lbs of liquid were to detonate it might.

2. Might an exploding fuel tank detonate molten or solid ammonium nitrate? This was not thought to be likely.

3. Mention had been made of sensitising additions. Had any work been done with stabilising additives? No such work had been done.

4. What were the relative merits from a hazard point of view of bulk or bagged storage? Professor Bauer preferred bulk to keep organic material out of the system. He did not think that contamination was a problem. He could not comment on a maximum recommended amount to store in bags.

5. What about pumping hazards? It was recommended that adequate head be provided to avoid cavitation (in concentrated ammonium nitrate solutions) which could lead to sensitisation. On the other hand, ammonisation in neutralisers at 170°C would cause no problem.

6. What about wax coated materials? It was thought to be a step forward that manufacture of these products had now ceased.

7. What about future work? The question of copper required further investigation and it was also desirable to repeat some of the projectile work with the molten material under stronger confinement.

8. Criticism was made of the reference to the Oppau explosion in published work and Professor Bauer said he might have stated the Oppau situation badly (?). In defence of EEC detonation test it was believed that if the test had been available and had been applied at the time it might have avoided the Oppau disaster.

9. Professor Bauer said that the US code had a burn-off test as well as a blasting cap test.

10. Would it be possible for exploding molten material to set off a large store of 10,000 tonne for example? Professor Bauer said that this should be amenable to calculation and he would look into it.

11. Bagged products were commonly stored in 300 tones stacks separated by corridors, mainly for access by forklift trucks. Would these corridors act as explosion breakers? Again, Professor Bauer thought that this also should be amenable to calculation.

12. What about bulk stocks in Canada? Professor Bauer thought that a substantial explosive charge would be necessary to detonate any bulk store.

**PRESENTATION BY DR K S BARCLAY AND DISCUSSION (15.45 – 16.00)**

Dr Barclay explained current practice in the UK remarking that many of the points, which he had in mind to mention, had already emerged in the recent discussions, 300 tons stacks with corridors for example.

In response, Professor Bauer said that he really preferred ammonium nitrate to be handled in bulk with dedicated wagons, as was commonly the practice in Canada. For bags, he thought that to insist on dedicated wagons was not practical.

With regard to manufacture, he foresaw no real problems as long as care was taken to keep up the density of liquid materials pumped round the plant. It might be a good idea to have the density monitored at critical locations.

the density of liquid materials pumped round the plant. It might be a good idea to have the density monitored at critical locations.

Tanks were quite sturdily built and they would provide a significant barrier to the transmission of impact to the contents. The situation was quite different from molten material in 3mm glass vessels.

With regard to separation distances of ammonium nitrate storage from public areas, apparently only a reasonable separation was suggested. There had been some work done on this aspect in the US.

**CHAIRMAN'S CONCLUDING REMARKS (16.15)**

Mr Squire said that it had been an interesting and useful day for all of us. We had learned a lot and the discussion had helped us all to crystallise our views on this important topic. It had been valuable to have our European colleagues present for we all shared a common objective namely that we all wanted to conduct our operations in the safest possible way and did not wish to be lulled into a false sense of security and relax our standards. It was clearer than ever and could not be too strongly emphasised that the most important contribution, which could be made to ammonium nitrate safety, was to avoid fires.

Notes taken by Dr. DA Docherty

## NO 10 in the SAFEX SERIES OF ARTICLES on Improving Explosives Competence

Denise Clarke

***Improving explosives competence***
*All explosives manufacturers recognize the importance of training and developing people who work in and are responsible for explosives operations. SAFEX recently responded to a perceived need to develop leaders of explosives operations by embarking on the development of the SAFEX Explosives Management Course in an e-learning format. We are not alone in trying to support SAFEX members in their quest for improved workplace competence. SAFEX is willing to partner with anyone or use any technology that can contribute to the competence of people working with explosives and thereby make our workplaces safer. In this Newsletter feature we propose presenting a series of articles that explain the UK's National Occupational Standards (NOS) in Explosive Substances and Articles (ESA). In the coming editions of the Newsletter, each article will examine a different aspect of the ESA standards and explain how they can be used for a range of purposes.*

**Title: Explosives apprenticeships in the UK**

In this article, we look at the use of the Explosive Substances and Articles National Occupational Standards (ESA NOS) within apprenticeship programmes. The purpose of an apprenticeship is to provide a supply of trained young people to an industry by offering structured, high quality learning and transferable skills and knowledge. A key feature of apprenticeships is the collaboration of employers, colleges and professional institutions.

**A very short history of apprenticeships in the UK**

Apprenticeships have existed in the UK since the Middle Ages, later becoming more tightly regulated in the sixteenth century and requiring apprenticeships to last for seven years. In 1802, this was reduced; the requirement for reading, writing and arithmetic was introduced and the working day was limited (to twelve hours!)

Since 1964, successive governments have introduced many changes to the design and management of apprenticeships, particularly since the 1990s, each designed to improve the quality and scope of apprenticeships.

In 2012, the government-commissioned report by Doug Richard was published. Richard called on the government to improve the quality of apprenticeships and make them more focused on the needs of employers. His recommendations included:

- redefining apprenticeships: they should be targeted only at those who are new to a job or role that requires sustained and substantial training;
- focusing on the outcome of an apprenticeship - what the apprentice can do when they complete their training - and freeing up the process by which they get there. Trusted, independent assessment was seen as key to this;
- recognized industry standards should form the basis of every apprenticeship;
- all apprentices should reach a good level in English and Maths before they can complete their apprenticeship;
- government funding must create the right incentives for apprenticeship training. The purchasing power for investing in apprenticeship training should lie with the employer;
- greater diversity and innovation in training - with employers and government safeguarding quality.

Industries in the UK are currently working to meet these requirements and are in various stages of development: some have already redesigned apprenticeship programmes that meet these new criteria and others have yet to start.

**Development of explosives apprenticeships**

In 2013, the UK's explosives apprenticeship was published. It comprised a UK Level 2 Intermediate Level Apprenticeship in Explosives (with three pathways: in Explosives Operations, Explosives Storage and Maintenance and in Munition Clearance) and a UK Level 3 Advanced Level Apprenticeship in Explosives (with two pathways: in Explosives Supervision and Defence Range Safety Supervision). All the pathways were designed to provide apprentices with a broad and deep understanding of explosives within these functional areas so that, on completion of the programme, they would be able to fulfil their employers' requirements in a range of functions, thus enhancing the versatility and flexibility of the workforce.

The timing of the publication of the Richard Review report was unfortunate for the UK explosives industry. The industry had only just completed the development of its apprenticeship framework when the Richard Review report was published. This therefore means that the apprenticeship needs to be redesigned and the industry is in the very early stages of planning its response.

**The drivers to implementing apprenticeships**

We talked to several organizations that deliver apprenticeship frameworks: Defence Munitions (DM Gosport); QinetiQ and Deflog VQ Trust which delivers the Explosives Storage and Maintenance on behalf of the Royal Logistic Corps of the British Army.

DM Gosport has a long history of apprenticeships which were introduced to develop the skills of young people to enable them to meet the challenges of defence logistics. DM Gosport's apprentices complete a three-year Advanced Apprenticeship (i.e. UK level 3) in Mechanical Engineering. Approximately half go on to process live weapons and additional explosives-specific training for that is given. Essentially, DM Gosport sees the apprenticeship as a long term investment in the development of young people who, it is hoped, will build their careers in this field. As ex-apprentices themselves, Richard Morgan (Head of Establishment) and Kevin Haydock (Apprentice Training Manager) prove the success of this approach. The scheme was rated as outstanding by Ofsted [1] during its last inspection. Both agreed that the apprenticeship structure offers value for money in that the programme includes not only the delivery of training and the attainment of relevant qualifications but also building life skills including team working.

All QinetiQ's apprenticeships are aimed at delivering what the business needs, which, in terms of apprenticeships, are highly specialized. QinetiQ has therefore undertaken development work to ensure the best fit between the apprenticeship and business requirements.

QinetiQ will pilot a new framework at its own Apprentice School: the L2 Apprenticeship in Electro-Mechanical-Explosives followed by the L3 Advanced Apprenticeship of the same name. Apprentices will complete the existing City & Guilds Electrical and Electronic framework which will provide them with the required engineering and hand skills that they will need. They will then progress onto the explosives component which will result in the attainment of the HSQ L2 Diploma in Explosives Operations, followed by the HSQ L3 Diploma in Explosives Supervision.

The British Army's aspiration is for all its trade groups to have an apprenticeship. This will not only deliver the required military training but will also aid the recruitment and retention process by ensuring that military personnel gain civilian-recognized qualifications that will be of value to them in their careers post military service.

[1] Office for Standards in Education, Children's Services and Skills

**Structure of apprenticeships**

Because apprenticeships are designed to give a broad grounding that will benefit completers for the rest of their career, apprenticeships often have a similar structure (albeit with variations).

All apprentice providers offer a very similar pattern of learning:

- A combination of on and off the job training;
- Personal, Learning and Thinking Skills (PLTS);
- Functional Skills in English and Maths;
- An outdoor experience.

For DM Gosport, the outdoor experience involves the apprentices staying in the countryside (Dorset) for three days learning how to look after themselves (budgeting, cooking, putting up their tents etc). For some, this might be the first time that they have stayed away from home overnight. Subsequently, apprentices repeat the experience in phase three where they climb Mount Snowdon, but this time, they are fully responsible for all aspects of planning and managing the experience (e.g. arranging transport and equipment).

For their outdoor experience, QinetiQ apprentices carry out similar tasks such as building a raft, abseiling cliffs etc, the main point of the experience being to develop apprentices' personal and social skills and their self confidence .

Fig 1 .DM Gosport apprentices conquering Mount Snowdon

In year 2, DM Gosport apprentices complete 4-monthly internal placements in different process facilities, working on different weapons. In addition, they complete external placements including one to a local explosives museum. This involves restoring old guns, developing their diagnostic and problem solving skills as well as developing their practical engineering skills. As with the outdoor experience, these placements help apprentices to develop their communication skills and self confidence.

Fig 2. Brass Spitfire made by DM Gosport apprentices

Fig 3. Retirement present commissioned from DM Gosport apprentices

Over the whole apprenticeship, DM Gosport apprentices are entered into a number of competitions. These might be the MoD's own competitions or they might be industry-wide. A combination of completing practical engineering tasks for competitions, interviews and presentations explaining the engineering principles that they applied all help to reinforce and develop apprentices' "soft" skills.

As for DM Gosport, QinetiQ apprentices also carry out additional tasks which may be commissioned by external organizations. For example, The Skills Funding Agency asked QinetiQ apprentices to design and manufacture the torch for its "Pass the Torch" campaign which showcases how apprenticeships help businesses to grow their own talent and develop a motivated, skilled and qualified workforce. The body is made of brass, aluminum and carbon fibre, showing the progressive use of materials through the years. This makes use of all the different apprentices' skills, such as machining metals, cutting carbon fibre, CAD design and electronics.

Fig 4 .The Torch commissioned from QinetiQ apprentices

In addition to the main qualification that they will achieve, apprentices gain whatever qualifications they may need that will ensure that they complete the apprenticeship as a fully rounded individual who would be capable of being deployed to a range of different explosives facilities with the possible option of further specialization at a later date.

The Army's explosives apprenticeship is delivered within a 14 month window that can be increased if the learner is away from his work that prevents the gathering of evidence. Ammunition Technician apprentices undertake formal classroom training at a military training school including a seven week stint at the Defence Academy Shrivenham where they learn the science that underpins their work. Following this intensive period of training, apprentices return to their operational units for a further seven months of consolidation of their training, carrying out duties relating to the storage and maintenance of explosives (safe handling; issue and receipt; movement; logistics, maintenance tasks and so on). By the time that they complete the whole programme, they will be deemed to be fit for promotion to Lance Corporal.

The Army already has a well developed structure for personal development and, in addition to their technical training, military personnel can also carry out outdoor adventurous training activities in a number of locations across Europe such as canoeing, skiing, rock climbing, caving and parachuting.

**Benefits of implementing apprenticeships**

DM Gosport has an apprentice completion rate of 100% and, of these over 80% remain at DM Gosport. The recent recruitment exercise attracted 193 applications for 6 places – a testament indeed to the quality of the programme.

"We're grooming people from the ground up" said Julie Cope, QinetiQ Apprentice Adviser "giving them the skills, knowledge and qualifications they need. Apprenticeships give a brilliant grounding, combining job knowledge and expertise". Brian Wilson, Explosives Training & Standards Manager, QinetiQ agreed: "Apprenticeships are associated with quality… they are focused on the technical and on company needs." "For 16 – 17 year olds, they gain a nationally recognized qualification. The framework offers a developmental structure and apprentices can see that the company is investing in their future" explained Julie Cope. "They can take their achievements elsewhere too" she went on although she then pointed out that, at 95%, QinetiQ has the highest retention rate (i.e. of all apprentices in any discipline) in the UK (which averages 75%).

"You're investing in someone's future" explained Julie Cope. She went on to explain: "The workforce is aging and we are growing the next generation… we have seen benefits in the form of our excellent retention rates." Apprentices are seen as enthusiastic members of staff who want to share ideas and be proactive in making suggestions for improvement.

Deflog VQ Trust finds that the apprenticeship programme offers support to learners that would not otherwise exist – such as the support provided by assessors and functional skills tutors who help to identify and then meet their educational needs. Here are some of the comments that apprentices made:

"The tutor is very helpful and has the best way to get the message around… he is brilliant…ACE!!"

"Thank you. It was a pleasure to learn with you."

"Very worthwhile … learned loads and brought back old stuff I'd forgotten. Excellent all round!"

**Overcoming problems**

For DM Gosport, the apprenticeship programme is now well embedded and has been refined over the years. The recruitment, retention and training processes have been improved successively over the years and the framework is under constant review. The Apprenticeship Board that is responsible for the quality of the framework includes a standing agenda point of "Ongoing improvement" and the Board includes an apprentice to give the learner perspective.

QinetiQ staff occasionally have to be reminded not to expect too much from apprentices and to remember that they usually arrive in the workplace straight from school with no relevant skills or knowledge. Because they are on site like other members of staff, it is easy for supervisors to forget that the apprentices need to be given support and enough time to complete the requirements of the apprenticeship. To help overcome this risk, QinetiQ develops an Individual Learning Plan (ILP) for each apprentice and timetables support groups and constant monitoring of their progress to ensure that they get all the help they need.

"This is a very small pool to fish in" says Dave Nelson, Deflog VQ Trust Quality Manager "It's a very specific discipline and you must have people who are occupationally competent".

**Advice to others thinking about implementing an explosives apprenticeship**

Richard Morgan and Kevin Haydock were unanimous in saying "Do it!" They emphasized the need to ensure that apprentices would develop practical skills and pointed out that apprentice competitions and external activities are valuable developmental opportunities. Successful implementation of apprenticeships require a clear plan; they must be adequately resourced and everyone in the organization that is affected by the apprenticeship must be involved in ongoing briefings and communication to ensure that the apprentices get the right learning at the time they need it – so good project management systems are a must.

Julie Cope and Brian Wilson agreed wholeheartedly with DM Gosport's view: "Do it!" they said. "it's a lot of effort but the benefits are phenomenal" they explained. "It's a structured, systematic programme that embeds the culture and attitude that we require of our staff and it's brilliant for succession planning because you know what your staff can do. Apprenticeships are as valuable as university degrees" added Julie.

This is a very technical trade area that needs expertise to deliver the training and assess learning to the required standards, so you need to ensure that you have complete confidence in your delivery team" advises Dave Nelson. "Involve the delivery team throughout the development stage to ensure that the standards are achievable; engage with employers frequently to ensure that what has been developed and delivered is what they asked for".

**Value of apprenticeships and future plans**

At DM Gosport, all apprentices have bi-monthly one-to-one reviews with their on-site assessors to discuss their performance and progress and to evaluate the quality of any subcontracted training. Each apprentice's supervisor also writes a performance report.

For the Army, success is measured by learner and employer feedback that is gathered throughout the apprenticeship. Here are some of the things that learners have said about their apprenticeship training:

> "These awards are good for my future and are very good for civvy street…"

> "This course is encouraging me to go further in my education."

DM Gosport is now working toward Engineering Technician (EngTech) accreditation with the Institute of Engineering & Technology (IET) for all apprentices on completion of the programme.

QinetiQ has found that the introduction of the Explosive Substances and Articles National Occupational Standards (ESA NOS) into the business has highlighted the need for specific kinds of training. As a result of this, QinetiQ has seen a quantifiable reduction in the numbers of safety incidents. Staff will now question and challenge what they see as potentially unsafe practices and they now have the confidence to do this which, in turn, has encourages others to do the same.

"The apprenticeship is just the start" said Julie Cope "Apprentices can go into different roles and facilities and will be useful in any of these roles". QinetiQ plans to develop the model further. Apprenticeships have evolved over time as the business has evolved and next year may bring different challenges from this year. However, QinetiQ is certain that, because it has developed flexible workers through its apprenticeships, they will be capable of delivering what the business needs.

**Acknowledgements**

The author gratefully acknowledges the contributions of those who contributed to this article:

Mrs Julie Cope, Apprentice Adviser, QinetiQ

Mr Kevin Haydock, Apprenticeship Manager, Defence Munitions

Mr Richard Morgan, Head of Establishment, Defence Munitions

Mr Dave Nelson, Quality Manager, Deflog VQ Trust

Mr Brian Wilson, Explosives Training & Standards Manager, QinetiQ

Note to readers: the ESA standards are available free of charge and can be downloaded from:

www.homelandsecurityqualifications.co.uk/documents

**A note about the author :**Denise Clarke is the Managing Director of Homeland Security Qualifications (HSQ) – a British-based awarding body that specializes in the award of explosives-related qualifications. Denise has spent the last twenty years specializing in the specification and measurement of competence, working in a wide range of industries. Working with the industry, she has developed UK National Occupational Standards in Munition Clearance and Search and in Explosive Substances and Articles, creating qualifications and supporting assessment materials. HSQ now has seven qualifications assessment centres, delivering a range of bespoke, industry-recognized and nationally regulated competence-based qualifications. Please visit www.homelandsecurityqualifications.co.uk for more information.

## SAFETY SNIPPET

## Blast Injury: An Investigative Tool

### Dr Jackson Shaver

An engineer related the story about a post-blast scenario where he responded to assist the first response team within minutes of the event. He related how an employee who witnessed the event was in the break area describing to his co-workers how he had just opened the door to enter the production room when the force of the event threw him back out the doorway and into a walkway. The engineer had already seen the production equipment and damage to the facility which included dislodging of the relief panels before he encountered the employee and overheard the story. The engineer asked the employee if he was OK, how were his eyes, ears and head, all OK? When the employee stated that he was fine, the engineer politely excused himself and notified the investigation team that the employee's story, which had already been repeated several times (to whoever would listen), was highly suspect.

The absence of ear, eye, concussion or burn injuries indicated to the engineer that the employee's story was probably not factual. Auditory injuries from blast overpressure are very common and the result of mechanical injury to the sensory structures of the inner ear. The employee, when questioned later after the excitement, admitted that he had been in the walkway outside the production room when the event occurred and was not in the room during the event as he had initially reported to supervision. The engineer recognized the employee's account of being in the production room at the time of the event did not match the observed damage to the facility and production equipment.

In his textbook, Practical Bomb Scene Investigation, James T. Thurman provides investigative tools, including information regarding blast pressure and effects on the body that will assist post-blast investigations conducted in an industrial setting. The US Centers for Disease Control and Prevention (CDC) prepared a discussion of blast injuries that should be considered by post-blast investigators. A summary of a CDC outline for physical injuries resulting from a blast follow:

- *Primary: Injury from over-pressurization force (blast wave) impacting the body surface*
  - ◊ *Tympanic membrane rupture, pulmonary damage, hollow viscus injury*
- *Secondary: Injury from projectiles (fragments, flying debris)*
  - ◊ *Penetrating trauma, fragmentation injuries, blunt trauma*
- *Tertiary: Injuries from displacement of victim by the blast force*
  - ◊ *Blunt/penetrating trauma, fractures and traumatic amputations*
- *Quaternary: All other injuries from the blast*
  - ◊ *Crush injuries, burns, asphyxia, toxic exposures*

*For more information on blast injuries, visit: www.emergency.cdc.gov/BlastInjuries.*

Every event leaves clues as to what happened or what did not happen. It is essential to collect information and conduct the difficult task of putting things back together properly assess circumstances surrounding the event. Assessing blast injuries can be a support to the investigative process. Unlike the forensic examination of a bomb scene where the investigation team may not have specific details regarding the device and the setting is likely unfamiliar, industry has some very distinct advantages. In industry, it is highly probable the device or production equipment was likely manufactured (or purchased) and the setting is likely to be familiar or known.

Some businesses have established relationships law enforcement professionals and successfully used former and current law enforcement professionals to assist with mishap investigations. I believe there is much information the explosives industry can learn from law enforcement professionals who are highly skilled managers of bomb scene investigations, sites and questioning of witnesses to factually comprehend circumstances of an event. Becoming familiar with the techniques and tools used by law enforcement professionals can aid the investigation of mishaps in the explosives industry.

In another event, a safety engineer related how an employee used a radio battery charger probe in an attempt to straighten leads on a device in his workstation. The employee stated to his supervisor that the part had deployed in his hand by itself and there was nothing amiss in the production activity or handling. The supervisor reported the device had deployed due to static energy. The safety engineer discovered flash residue on the workstation surface and radio battery charger cable indicating the device was not handled properly. When this and other evidence was matched with the employee's injuries it became clear where the device was positioned and what had likely taken place. When confronted with the information, the employee confirmed what the safety engineer had determined was the cause of the event.

The SDI Operations Team had the opportunity to participate in a bomb scene investigation course intended for law enforcement professionals. Supervisors, engineers and technicians from the company had the opportunity to listen and learn from a qualified bomb scene investigator. The team was very impressed with the instructor's ability link the discussion, techniques and tools to manufacturing scenarios. One of the key points presented by a production supervisor following the exercise was that she would not rush to find answers in the future if there was an event. She was concerned that past investigation teams were in such a hurry to find answers that they may have missed collecting information that would help prevent future events, including the physical effects on personnel. The Operations Team expressed gratitude for the opportunity and experience. While industry is focused on process safety and prevention, it is wise to augment the investigation team skill level with training from certified fire and explosion investigators.

References:

Thurman, James T., Practical Bomb Scene Investigation, Second Edition (Practical Aspects of Criminal and Forensic Investigations), CRC Press, January 28, 2011

Bombings: Injury Patterns and Care, Centers for Disease Control and Prevention, US Department of Health and Human Services, http://www.cdc.gov/masstrauma/preparedness/primer.pdf accessed 3 March, 2015.

Preston, Dean, Blast Simulators and Overpressure Safety, The Detonator, Official Publication of the International

Association of Bomb Technicians and Investigators, November/December 2014

## HISTORY – A LOOK AT THE PAST AND A GLIMPSE OF THE FUTURE

### Explosives Initiation - Starting the Chaos

### Henco Bezuidenhout

It can be said that, from the early beginnings of mankind, there have been many changes with only one thing that has remained constant and that is progress. Progress ensures that man's day to day existence becomes easier even though its technical complexity has increased.. We know everything has a beginning and an end. Life started out straightforward, tough but simple, being a struggle for survival day to day searching for food and shelter from the environment. Man progressed. Today survival means: Is my smartphone fully charged, do I have an internet connection and chasing financial gain. Without us always being mindful of it, we still are pretty much dependent on sources of energy like heat and electricity and most resources still have their origin from one or another mine. Iron, gemstones and other minerals are being mined. It is then also here where we find the largest application of explosives (heat and pressure).

It is generally accepted that black powder is the earliest explosive. As early as 220 BC an accident involving black powder occurred when Chinese alchemists accidentally made black powder while separating gold from silver during a low temperature reaction [1]. One mistake led to another and eventually resulted in an explosion. Unfortunately, it is not known if these alchemists realised that they manufactured black powder. Greek fire was used in battle in 668 A.D. [2] and might well be regarded as one of the first pyrotechnic mixtures other than black powder. This can be said if we here understand the term pyrotechnic to be the mixing of materials for the purpose of burning.

In 1200 A.D. saltpetre first appears in the writings of Arabian Adb Allah. Considering that neither arms (weaponry), nor high power explosives were mentioned by the Polos as late as 1299, yet Arabic works exist describing black powder, strongly suggest that black powder was of Arabic and not Chinese origin [3]. Later in history two other prominent figures related to black powder are mentioned. They are Rodger Bacon and Berthold Schwarts.

Roger Bacon
(1214-1294)

1242 friar Roger Bacon published the formula for gunpowder. Rodger Bacon was an English scholastic philosopher that is also considered a scientist because he insisted on observing things for himself instead of relying on what other people had written. Bacon was born into a wealthy family in 1214 and died in 1294. He was trained in the classics, geometry, arithmetic, music and astronomy and was a student at the University of Paris as a young man where he received the degree of Doctor of Theology. Bacon spent forty years studying and lecturing on the natural sciences at Oxford University in England. For these efforts, he is considered to be the most prominent cultivator of the natural sciences during the middle ages. His skill in the use of optical and mechanical instruments caused him to be regarded by many as a sorcerer. Bacon was acquainted with the properties of mirrors, knew the powers of steam and gunpowder, had a working knowledge in microscopy, and possessed an instrument very much like a modern telescope [4].

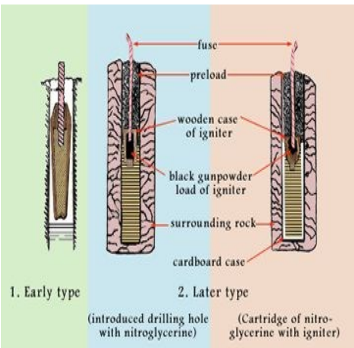
A German friar is the reputed inventor of gunpowder and firearms. He took the name of Berthold in religion, to which was appended the adjective Schwarz (black); either on account of the colour of his habit or because he was looked on as being addicted to the black art. It was in the course of his studies in alchemy that he discovered the explosive properties of gunpowder which he applied to firearms. A monument was erected to him in his birthplace in 1853 [5].

By the 17th century, black powder came to be used in Europe for peaceful purposes such as mining operations in Germany and Hungary. Despite reasons like high cost, lack of suitable boring implements and fear of roof collapse, the use of black powder in mining did spread rapidly, though it was highly accepted by the 1700. The first application in civil engineering was in the Malpas Tunnel of the Canal du Midi in France in 1679 [6].

After almost 700 years as the only explosives extensively used by man things were about to change. In 1846, the Italian Scientist Ascanio Sobrero discovered nitroglycerine. In 1866, Alfred Nobel (right) found a safer means of handling nitroglycerin in the form of dynamite [7]. These inventions, together with the invention of nitrocellulose in 1846 by Christian Schobein and trinitrotoluene (TNT) in

The beginning of what can be asked. All the variations of black powder, up to this point in history, needed to be ignited (stating the obvious). Only considering controlled ignition, this was achieved by means of open flame or glowing ember. This method was used irrespective of the intended application (commercial or military).

Black powder was often ignited with fuse. The fuse was developed by William Bickford in 1831 [8]. This procedure often required workers to manually light fuses with an open flame [9]. A hole was drilled in the rock and filled with black powder. Fuse was primarily manufactured from black powder itself and served the purpose of guiding the flame to the black powder charge in the hole. The discovery of dynamite brought with it the invention of the first blasting cap. Alfred Nobel was the inventor of a mechanism that reliably detonated dynamite. This was necessary as black powder did not have the capability to initiate dynamite reliably.




Alfred Nobel patented his blasting cap (also detonator) in 1865 and established a safer and more reliable means to initiate dynamite. Nobel first started to detonate the nitroglycerine by using a small charge of black powder contained in a glass bulb or wooden cylinder. Later Nobel used a mixture of gunpowder and mercury fulminate or the fulminate by itself. These formulations were later packed into a copper cylinder [10] (brown, 2010).

In 1865 mercury fulminate was not new. As part of the family of fulminates gold or aurum fulminate was described as:

***" a powder which kindles as soon as it takes up very little heat or warmth, and does remarkably great damage when it explodes with such vehemence and might that no man would be able to restrain it"***

***Basil Valentine (1603)[11]***

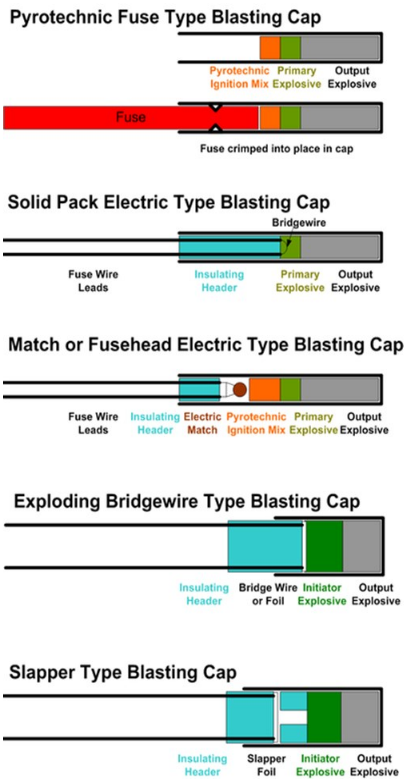
The Swedish–German scientist Johann Kunkel von Löwenstern had known mercury fulminate from the 17th century [12]. The family of fulminates were used in fireworks, toys and demonstrations of supposed magic. In 1800 Edward Howard reported on new fulminating mercury [13]. The application of fulminates leaned more towards the firearms industry. It was used in flintlock guns but proved to be less successful because of its power and sensitivity. It was only when Alfred Nobel used mercury fulminate in his blasting that it found its first real practical application [14]. Without significant modification, this device was used into the 1920's [15] hence changing the beginning forever.

The beginning signifies the start of a process that eventually leads to the bulk of the energetic material releasing all of its potential energy. Optimal energy release is essential in obtaining the desired performance from the explosives used. This process is often referred to as an energetic train. Mainly two types of energetic trains can be identified. These are low explosive trains or pyrotechnic trains, and high explosive trains or simply explosives trains. Both types of trains functions on the principle of energy augmentation. The process mainly consists out of an input, an intermediate signal and an output [16]. Up to the invention of the blasting cap the energetic train was predominantly low explosives. This means that an open flame was used to ignite an intermediate part. This intermediate part produced a controlled burning to ignite the bulk charge (black powder). The bulk black powder charge then reacted with severity determined by its volume, confinement and chemical make-up .

The invention of nitro-glycerine and more specifically the invention of dynamite established the capability of obtaining a detonation reaction when desired. The invention of the blasting cap opened up the doors for late 19th century explosives like TNT, picric acid, tetryl, pentaerythritol tetranitrate (PETN) and cyclo trimethylene trinitramine (RDX) to be used [17].

The blasting cap is the first part in a high explosive train. The principal function of a blasting cap is to transform an input signal into a detonation output signal. Nobel's first blasting cap did just that. The blasting cap continuously developed not only to keep pace with the development of primary explosives but also with the developments with regard to the input signal. Primary explosives saw significant progress in the late 19th century through to the 20th century establishing many fulminates, azides, styphnates and tetrazoles. The most predominant primary explosive used today is lead azide. Lead azide was discovered in Germany in the late 19th century and owing to its stability and ability to undergo an extremely rapid deflagration to detonation transition, it is still widely used today [18].

Input signals, or input energy, also developed over the years. The first explosive blasting caps (detonators) made use of a fuse or than just a normal flame carried into the cap. Electric and fuse head blasting caps later followed. These are the most common and most voluminously produced hot-wire type detonators produced. Interestingly enough the basis of this technology started in England in 1745 when a certain Dr. Watson of the Royal Society of England demonstrated that black powder could be ignited by the spark discharge from a Leyden Jar [19]. In 1875 Julius Smith and Perry Gardiner independently introduced an almost identical hotwire blasting cap. The Smith – Gardener blasting cap started out using mercury fulminate that was later replaced with lead azide (beginning of 1917)[20]. Related to this technology is the Match or Fuse head type blasting cap. Similar technologies are also incorporated in electronic blasting cap systems. Exploding bridge wire blasting caps were invented in the 1940's. Exploding bridge wire detonators were developed to react extremely rapidly and predictably [21]. Slapper blasting caps are an improvement on the electric bridge wire blasting caps, and both of these blasting caps use similar principles to initiate the output explosives.




We can see that irrespective of the input stimuli the blasting cap still augments energy from a low input to substantially higher output energy. The type of initiating system used is greatly dependent on the specific application. The application and environment in which explosives are applied have changed over the decades and with that the technology of explosives changed as well. New explosives formulations are being developed to accommodate modern requirements. The bases of these requirements are still physical safety and environmental compatibility (less toxic). Mercury fulminate has been abandoned because of these two notable shortcomings: It has poor thermal stability (safety related), and it has toxic and corrosive properties [22]. Not only is the safety and environmental properties of explosives immensely important from a modern day perspective but also is the waste generated from the explosives manufacturing processes. In order to reduce, control and monitor explosive waste, environmental legislations have been implemented [23]. Future explosive developments will be focussed on being more environmentally "greener" than current explosive compositions. This approach will not only apply to the final explosives product but also to its manufacturing process.

Old or new, hazardous or environmentally safe"r", applied commercially or for military purposes, the objective remains the same: to start the chaos .

Bibliography


1. Akahvan, J, 2011. The Chemistry of Explosives. 3rd ed. Cambridge: The Royal Society of Chemistry. p1
2. Explosives.org. 2009. History of Explosives and Blasting. [ONLINE] Available at: http://www.explosives.org/index.php/component/content/article?id=69. [Accessed 11 March 13].
3. The Firts Foot Guards. 2013. History of black powder - gunpowder history. [ONLINE] Available at: http://footguards.tripod.com/06ARTICLES/ART28_blackpowder.htm. [Accessed 12 March 13].
4. Roger Bacon. 2013. Molecular Expressions:Science, Optics and You - Timeline - Rodger Bacon. [ONLINE] Available at: http://micro.magnet.fsu.edu/optics/timeline/people/bacon.html. [Accessed 12 March 13].
5. Berthold Schwartz. 2013. Catholic Encyclopedia: Berthold Schwartz. [ONLINE] Available at: http://www.newadvent.org/cathen/13593b.htm. [Accessed 19 March 13].
6. A Short History Of Explosives. 2013. Fay Kellerman, Mystery Author at first look at the crime. [ONLINE] Available at: http://www.mysterynet.com/kellerman_faye/explosives.shtml_. [Accessed 11 March 13].
7. Nitroglycerin. 2013. Nitroglycerin. [ONLINE] Available at: http://www.ch.ic.ac.uk/rzepa/mim/environmental/html/nitroglyc_text.htm. [Accessed 19 March 13].
8. Anne Marie Helmenstine. 2013. Gunpowder Facts and History. [ONLINE] Available at: http://chemistry.about.com/od/historyofchemistry/a/gunpowder.htm. [Accessed 11 March 13].
9. The Use of Black Powder and Nitroglycerin on the Transcontinental Road. 2013. Black Powder and Nitroglycerin - The Transcontinental Railroad. [ONLINE] Available at: http://railroad.lindahall.org/essays/black-powder.html. [Accessed 11 March 13].
10. Brown, G.I., 2010. Explosives - History With a Bang. 1st ed. Gloucestershire: The History Press. p186.
11. Brown, G.I., 2010. Explosives - History With a Bang. 1st ed. Gloucestershire: The History Press. p179.
12. Klapotke, T.M., 2011. Explosives - History With a Bang. 1st ed. Gottingen: Hubert and Co. p1.
13. Brown, G.I., 2010. Explosives - History With a Bang. 1st ed. Gloucestershire: The History Press. p181.
14. Klapotke, T.M., 2011. Explosives - History With a Bang. 1st ed. Gottingen: Hubert and Co. p1.
15. Once Upon A Time - Alfred Bernhard Nobel. 2013. World Famous and Infamous - Alfred Bernhard Nobel. [ONLINE] Available at: http://www.jcs-group.com/once/famous/nobel.html. [Accessed 11 March 13].
16. Duguet, Jean-Rene, 2009. Initiation of Explosives and Pyrotechnic Materials. 1st ed. Port Des Barques: Cultures and Techniques. p7.
17. Akahvan, J, 2011. The Chemistry of Explosives. 3rd ed. Cambridge: The Royal Society of Chemistry. p20.
18. Duguet, Jean-Rene, 2009. Initiation of Explosives and Pyrotechnic Materials. 1st ed. Port Des Barques: Cultures and Techniques. p40.
19. Cooper, P.W., 1996. Explosives Engineering. 1st ed. New York: Wiley-VCH. p337.
20. Cooper, P.W., 1996. Explosives Engineering. 1st ed. New York: Wiley-VCH. p339.
21. Blasting Cap. 2013. Blasting Cap: Definition from Answers.com. [ONLINE] Available at: http://www.answers.com/topic/blasting-cap-2. [Accessed 19 March 13].
22. Duguet, Jean-Rene, 2009. Initiation of Explosives and Pyrotechnic Materials. 1st ed. Port Des Barques: Cultures and Techniques. p37.
23. Akahvan, J, 2011. The Chemistry of Explosives. 3rd ed. Cambridge: The Royal Society of Chemistry. p25.


## TONY'S TALE PIECE

**VILLANS**

Regular readers might be pleased to learn that this edition of Tailpiece will be relatively short. I would hope that it might set the trend for the future, but I'm old, set in my ways and very forgetful. Milk of amnesia anyone?

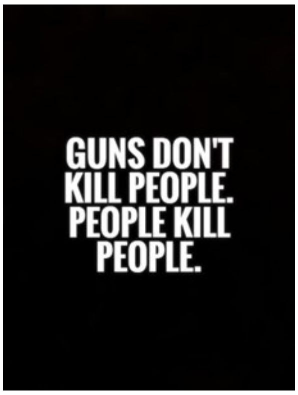
As many of you may already know I have devoted much of my life to the ancient Tibetan discipline of whole body relaxation called:

My apologies for using 7th Century Dbu Can script, but for interested parties, the above calligraphy may be pronounced phonetically as Kow-Chee-po' Tae-toe.

Part of the global fraternity's rigorous training regime demands that senior disciples like myself attend selected events where especially tranquil poses and sitting postures called 'krama's' must be demonstrated. At certain venue's, specialised elbow-bending techniques may also be exercised.

In line with a lifelong devotion to the discipline I recently attended a local gathering of the southern hemisphere's faithful. I was accompanied by my wife (not a practitioner of the art) plus some local and other non-Tibetan devotees. We were there not only to experience the body-hugging, cocoon-like metamorphism offered by the wicker chairs with their deep cushions, but also to enjoy a drop or two of Irish medicinal porter imported specially for the purpose from St. James's Gate in Dublin.

Later on, with the group battling the inner hindrances of the unfathomable mind we began to conjure the more difficult and deeper relaxation techniques forbidden to initiates and senior acolytes alike. With minds now open to all the energies of the cosmos and well lubricated to boot, we got onto the subject of guns. Guns or rugby, rugby or guns? Mm mm, rugby with guns, now there's game a few of us old reprobates might enjoy. Historically speaking though both guns and energetic materials share a common heritage, but unlike us 'Detonadoes', those in the gun fraternity have many messages to share. One that I enjoy is available both as a poster and as bumper sticker. The message is simple and to the point. It reads: “Guns Don’t Kill People – People Kill People.” I’ve included an example below:




I think we could take a leaf out of the same book. Our version of this popular poster might read:

**“Explosives Don’t Kill People – Unsafe Practices Do.”**

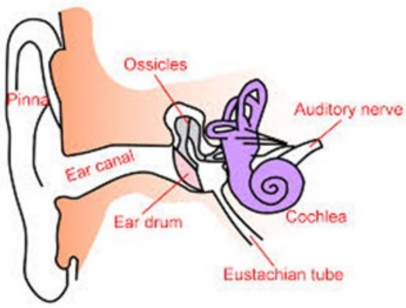
A bit trite? Well okay, but we all know and at some level accept that energetic materials possess the power to kill and injure. That they do so by shock, overpressure, blast, shrapnel and/or incendiary effects we understand, but is that all the industry has to offer in the way of hazard, or is there perhaps something more?

Unfortunately there is. Not the high profile bad-boys though. These guys lack the headline grabbing explosions and fireballs of popular imagination. No. What I’m about to set before you are the bit players, the less well known, the non-celebrities, background folk, a creepy brotherhood of the malign. They skulk in the shadows, emerging only to pluck at the sleeves of the unwary and the arrogant, the prideful and the ignorant. Who are they, this hidden army of affliction? Let’s take a moment and write some of them down:

**1.Noise.**

Noise is a truly nasty little monster, insidious and life destroying.

Noise though doesn’t hide. Noise can be **really loud** and enjoys telling it like it is. Noise deceives by making us listen to its unpleasant truth. Noise alone probably won’t kill you, but a lack of noise - sometimes called deafness - certainly can. How? Well for a start, you won’t hear the truck coming. What truck?




Noise works like this. Inside each of your ears there is a membrane (the eardrum) which can be set in motion by pressure fluctuations in the air. A linkage of tiny bones, the ossicles, the smallest bones in the human body, transmits this movement to a funny looking organ called the cochlea. The cochlea resembles a garden snail. Two retractable eyeballs on long stalks plus a grossly oversized body heavily coated with a translucent, slimy jelly completes the likeness.

By the way, I made up the bit about eyes on stalks, the grossly oversized body and the slimy jelly, but the rest is true. The cochlea is filled with liquid which carries the motion to a region of the inner ear that is packed with hair cells that - and don’t ask me how - convert the movement to electrical energy which the brain somehow interprets as sound. Too much noise wears out the hairs which cannot be repaired. Noise induced hearing damage therefore implies that both your inner ears are going bald. It’s a form of internalised alopecia that makes your ears significantly less sensitive.

.

**I SAID "HEARING DAMAGE MAKES YOUR EARS LESS SENSITIVE**."

Noise is measured in decibels (dB). Just listen to the wind blowing through the leaves on that tree over there. Wind rustled leaves produce about 10 dB whilst a busy street in downtown Johannesburg generates about 70 dB For the record, 70 dB is some 10,000,000 times louder than 10 dB, our gently rustling leaves.
Hearing damage begins at 80 dB
Machinery can be incredibly noisy, 90 dB and above. Planned explosions, the "joy de vivre" of our industry are even noisier generating sound pulses up to 200 dB
To possess a small degree of "deafness" may perhaps be seen as useful for folk working within noisy environments, indeed some believe it to be somewhat advantageous, but don't be misled. Noise = Damage. Constant noise above 80 dB equals **permanent** damage. Hearing only ever gets worse.
All of us have lives outside the workplace and it is here where noise exposure first begins to make its presence felt. In our twenties and thirties we felt invulnerable. At forty to fifty we didn't notice much going wrong at all, Oh sure, the TV sound had to be turned up a bit, but surely it's the same for everybody? Sadly it is not.

All too soon that deafness will soon begin to interfere with not only family life, but with everything. The reason is that continuous exposure to noises higher than 80 dB will eventually cause everyday speech to become incomprehensible. The sufferer can't make sense of it. Verbal expression becomes almost meaningless. Eventually a sufferer may even have to lip-read TV shows or else become wholly reliant on sub-titles. Foreign movies and Chinese Kung-Fu flicks can help here. The end result can be the development of some stunning martial arts skills. Later though there is isolation and perhaps depression.

If that's not bad enough, noise also has an infuriating little buddy. This blessed child of torment is called **Tinnitus**. Tinnitus is also known as 'Tiny Titus.' Should Tiny Titus get a hold of you, your life will change forever. Tiny is equipped with huge claws. They're used as anchors and dug in deep. Once securely established, Tiny never sleeps, never takes a break, never pauses for breath, **never** stops; **EVER**. He just whistles in your ears – one note – one pitch – for the rest of your life. Feed him (he's an energy parasite and likes loud noises most of all) and he grows........ larger and louder…….larger and louder. Soon he is all there is!

Fortunately, both hearing loss and tinnitus resulting from noise exposure are entirely avoidable. As an employee, simply do as the warning signs say and in noisy areas wear suitable ear protection. In terms of personal protective equipment (PPE) ear muffs, the type that cover the whole outer ear, are the best. Regular hearing checks can provide a useful way for both employers and employees to monitor well-being.

Last, but not least, a quick word on hearing aids. This is not some new and horrible mutation of **HIV**, but rather an improvement on the ear trumpets of old. Hearing aids, sometimes called deaf aids are small electronic, sound amplifying devices often used by people who have reached a particular stage in their journey towards hearing loss. They are not cheap, a fact that can lead to a misleading conclusion. When judged on cost alone, you might be forgiven for assuming that these devices provide a total answer, but think again. A friend of mine was recently heard telling his neighbour, "I just bought a new hearing aid. It cost me fifty-four thousand Rands. Fully integrated 5th generation cryo-hardened microcircuitry, the latest indocrone software, a fully implantable pannacotta audiocell; glass coated, polonyum particle batteries. You won't believe me, but they recharge in direct sunlight in less than a minute and last for weeks. It's state of the art, the best money can buy." "Really." answered the neighbour. "What kind is it?"

"Twelve-thirty."

In most countries the manufacture of energetic materials falls under the multi-coloured umbrella of the chemical industry. I have no idea how many chemicals exist out there, but it is a really big number. Most of them will do little to improve our lives, but let's be clear, the hazards such chemicals present are countless. The chemical threat is truly a multi-faceted beast

Chemicals can be solids, liquids, gases or smokes. Concentration (the strength, reactivity, or level of active ingredient in the chemical) can dramatically alter its effects. Some chemicals are spontaneously combustible and others react violently in the presence of water. If that alone isn't enough to worry you, the chemical hazards or CH, (the aficionado's delightful reference) reads like a directory of the detestable, a litany of the loathsome - all operating beneath our radar. These complexes and compounds can pollute the air we breathe, the food we eat, the water we drink. Some chemicals are even absorbed through our skin or mucous membranes. They are pernicious and often life threatening. There are two main groups, organic and inorganic. Organics contain carbon, inorganics do not. Some chemicals can cause cancer whilst others contribute to mutations in our children. Just look at three-eyed Bobby over there. Don't look now though, I think he's also got eyes in the back of his head.

There are the corrosives; acids and alkalis that burn human tissue and can cause permanent blindness if they enter the eyes. Some chemicals are 'sensitisers,' seemingly benign at first contact, but malicious nonetheless. Such compounds 'sensitise' you. Further exposure results in allergic reactions or even dermatitis, an industrial disease.

Then there are the poisonous chemicals and chemicals that start fires and others that support fires.

I mentioned earlier that chemicals were subtle and may lead us astray in a host of ways. For instance, you cannot tell just by looking whether any particular substance is dangerous or not. Touching, tasting or smelling any unknown substance is foolhardy in the extreme. For example, TNT an explosive common in the manufacture of munitions is terribly, awfully bitter, yet people have used this characteristic to confirm that some unknown solid is indeed - at least on the balance of probabilities - TNT. Unfortunately TNT is injurious to most cells of the body, but especially those of the liver, bone marrow and kidneys. Ingest a tad too much TNT and yellow liver atrophy or toxic nephritis can follow. There's even a song about it:

"Yellow liver, it's in my mind and clouds my eyes,
It's in my blood, the taste I love,
Got no time for explanation, got no time to lose.
Tomorrow night you'll see the funeral showing on the news
Yellow Liver, Yellow Liver."

The best defense against this unwholesome horde is knowledge. Consult the literature. Start with the M aterial Safety Data Sheets, (MSDS) then move on to poison registers and chemical publications and textbooks. Learn about what you are working with, how best to deal with it, what (PPE) is necessary and what to do in the event of an emergency or when things go wrong.

Be especially on guard regarding products marketed using trade names only. "**GREASO**" for instance may be especially good for clearing blocked drains, but it might just contain sodium hydroxide, a powerful corrosive also known as caustic soda. Don't get caustic soda in your eyes; it's not a fun experience. Permanent blindness is a likely outcome. Always check what you are using. You know it makes sense!


A sub-species of the chemical hazard group is a warty little critter called **ionizing radiation**. Exposure to ionizing radiation can cause burns, cancers and leukemia, infertility and genetic mutation. What I know about radiation is next to nothing. 'Next to nothing' by the way is a techno-speak for almost total ignorance. Most

A sub-species of the chemical hazard group is a warty little critter called **ionizing radiation**. Exposure to ionizing radiation can cause burns, cancers and leukemia, infertility and genetic mutation. What I know about radiation is next to nothing. 'Next to nothing' by the way is a techno-speak for almost total ignorance. Most of what I have picked up comes from the grainy black and white images circa: August 1945, showing the aircraft Enola Gay, a big mushroom shaped cloud and the scattered survivors of Hiroshima and later Nagasaki.

The industrial uses of radioactive materials involve smoke detectors, density meters and various pieces of plant monitoring and control equipment. Fitted and operated properly these systems are entirely safe. One thing I have learned is never to place the small tubular shaped vessels containing the actual radioactive material in an area where there is even the slightest chance of the containers and their contents being blown to smithereens in some unforeseen accidental detonation. It is probably true to claim that the Alpha particles emitted by such devices lack both range and penetrating power, but if they enter the body via the mouth or respiratory system they can do massive damage. Beta particles are more damaging as they can penetrate more deeply and Gamma radiation (like X-Rays) just drive right on through. X-Rays aren't good, but at least they can be switched off, Gamma radiation

### 3. Dust

Dust is the laziest member of our little company of the malign, but very effective for all that. Dust likes flat surfaces where, due to a lethargic lifestyle it can build up, spreading out and pushing its tentacles everywhere. Some dusts can even get into the threads between a nut and bolt.

Household dusts are mainly made up of a mixture of dry and shed human skin, animal fur, insect waste, lint, organic fibres, soil, mites and soot. Unappetising certainly; life threatening, generally not. Many factory generated dusts, however, are toxic.

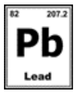

Dust though is nervous and stirs itself at even the slightest disturbance. Dust is made up of tiny, solid particles that become airborne at every opportunity. Smoke is essentially a form of dust.

For people, the main problem is one of inhalation. Breathe the wrong dust in for just a tad too long and all sorts of nastiness can be set in motion. Silicosis, emphysema and chronic obstructive pulmonary disease are the typical medical outcomes. Beryllium dust though is a real doozy. Exposure to even tiny amounts of beryllium dust results in ulceration, granulomas, acute pneumonitis, dyspnea, cyanosis, right side heart failure and eventually a straight green line and single tone on the heart monitor. Real fun stuff beryllium.

Some dusts can even penetrate skin. Dust can settle on to clothing, it can be transferred to the mouth and ingested; it can even be taken home. Some dusts can create explosive atmospheres. Coal dust is a good example although other dusts can also explode. Primary explosive dusts remain readily detonable and must always be considered especially dangerous. Their sensitivity to stimuli may even be enhanced.

Dust build up is countered by plant designs that avoid flat surfaces and square corners, both mechanisms intended to facilitate easy cleaning. Air extraction and filtration – unfortunately a serious no, no for primary explosive dusts - also help, although air extraction has a downside. In inclement weather, cold air drawn in from the outside may lower the temperature in the workspace. Workers may compensate by reducing the air extraction rate. By doing so they may be severely compromising their own health. Cleanliness and good hygiene practices are the real keys. As for PPE, dust masks and respirators remain a last line of defense to be used only when all else has failed.

### 4. Lead




The last of our list of bogey men for now, but certainly not least. Lead is the ultimate ogre because lead is everywhere. It can be found in storage batteries, petrol, industrial paint, solder, plastics, pyrotechnic compositions, delay elements, fishing weights, rubber, even in toys. Lead is dangerous in all its forms - the metal itself, its oxides, inorganic salts and organic compounds.


Lead is single-handedly responsible for most poisonings in the workplace. It is really not your friend.
In the manufacture of pyrotechnics, the oxides of lead have few equals. They are near perfect low-temperature oxidisers. Non-toxic replacements are keenly and urgently sought, but have been a long time coming. Lead is an accumulative poison, easy to ingest and slow to get rid of - the posh word for 'getting rid of' is excrete. Excrete is not today's word though. Today's word is "Excrescence."
An excrescence is a disfiguring protuberance or outgrowth on a human or animal body, tree or plant. You can amaze your friends with that one.
Most lead enters the body via the air passages of the nose and mouth. Breathe in, breathe out. Once inside the body it is absorbed by the lungs and passes into the bloodstream. There is no certain level at which the effects of poisoning begin to manifest themselves. It varies, person to person. A blue line around the gums is though a sure-fire indicator of lead poisoning. Absorbed lead affects bone marrow and thus red blood cell production. It damages the nervous system and for some reason also affects the muscles of the wrists, causing "lead droop." In the end of course, it can kill. It would appear that having lead in your pencil is no longer a joke and anyway, pencils today contain graphite, not lead.
If you are exposed to lead in any sort of process environment then having clean air to breathe is the best preventative against long term effects as, if there is no lead in the air then all that is left is to keep process lead from getting in to your mouth. Beards and facial hair must be forbidden. Why, because they interfere with the seal between a respirator and the skin of the face. Make sure too that the respirator supplied is the correct one for particulates. Keep lead from reaching your mouth by washing your hands frequently and pay particular attention to the areas under your fingernails. Use a nailbrush to remove any accumulated contamination. Wash hands properly before eating or smoking. Shower thoroughly and change your clothing before going home. Contaminated clothing must not leave the workplace. Finally, make sure that you get regular blood tests in which your lead levels are established, monitored and recorded.

And now for something completely different.

A humble suggestion. How do you find out how effective your health and safety training programs actually are? Oh sure, the trainee signs off that he/she has received a particular training module, but how do you know that the information imparted has actually been understood and has stuck?
You have signatures, but are meaningful are those signatures? If you are a manager I would suggest you find out. How? Here is a suggestion. Run a poll. Take a statistically significant number of employees from an area of interest and present each of them with a simple checklist. No consultation or internal discussions allowed. Fill it in right away. Individuals can remain anonymous, but the specific groups must be identifiable. Immediate supervision should not, however, be included. Answers should be by tick box, Yes or No.
Here are a few examples of useful questions( Areas of interest can be followed up and corrections or improvements implemented as required):

- *Do you have a Safety Representative?*
- *Is there a Safety Committee that meets with management?*
- *If so, does it get anything done?*
- *Is your workplace fit to work in?*
- *Is it well lit?*
- *Is it comfortably heated?*
- *Is it ever too hot or too cold?*
- *Can you work comfortably?*
- *Is the work rate too fast for safety?*
- *Are dangerous substances used in the process?*
- *Do you know what to do if any of them are knocked over, leak or spill?*
- *In high risk areas is there anything that could cause fire or sparks?*
- *Can you take toxic materials home on your person or clothing?*
- *Are the washroom/shower facilities good enough?*
- *Are walkways always kept clear?*
- *Can all escape doors be opened from the inside?*
- *Are explosive materials always kept within license limits?*
- *Are all waste chemicals disposed of safely?*
- *Do you know how to sound the alarm?*
- *Have you been trained to operate any of the fire-fighting equipment?*
- *Is a person trained in first aid always available*
- *Do any machines run hot?*
- *Are guards fitted to all the machines?*
- *Do they really keep you out or can you get past them?*
- *Is PPE available?*
- *Is it the right PPE for the hazard?*
- *Does it really protect you?*
- *Is it comfortable for the length of time it must be worn?*
- *Does "TOXIC" mean poisonous?*
- *Does "CORROSIVE" mean slippery?*
- *Are "Permit to Work" systems used?*

I am sure better checklists can be drawn up. They can even be individually tailored to specific areas of interest. Just apply commonsense.

Keep 'em safe.

**ACKNOWLEDGEMENT OF AUTHORS/PRESENTERS**

TERRY BRIDGEWATER – CHEMRING

RAVI CHAUCHAN-JIEDAC

RON PEDDIE- EXPERT PANEL

HORST MARZ-EXPERT PANEL

DENISE CLARKE-HSQ UNITED KINGDOM

JACKSON SHAVER-SPECIAL DEVICES INC

HENCO BEZUIDENHOUT-AELMS

TONY ROWE-RETIRED EX AELMS