QUARTER I , MARCH 2015

SAFEX NEWSLETTER NO. 52

SAFEX INTERNATIONAL
EST•1954

CONTENTS

NEXT CONGRESS 15-20 May 2017 in Helsinki ,Finland

NOTE FROM THE SECRETARY GENERALS'S DESK

I have now been in this position for three (stressful) months and is still learning the rules of engagement as defined by my very competent predecessor Boet Coetzee. I want to take this opportunity to thank Boet and Bets for their many years of dedicated work to bring SAFEX International to the high standard and credible global organisation it is today .

SAFEX Members undertake to increase safety learning in the industry through sharing of incidents and the countermeasures to prevent these from occurring again .Over the last decade there has been a considerable decline in sharing learning events for various acceptable reasons – but this has taken away from the high value SAFEX brings to the global industry. **This is thus an urgent call to keep those incident notices and reports coming !**

It is notable from incident reports and the open press/ internet that there has been an increase in vehicle related incidents over the last ten years .Accidents where explosive laden vehicles burned – sometimes to detonation with and without injuries and loss of life. The industry has been very fortunate as big incidents with fatalities have been few, but imagine the scenario where a transport vehicle starts to burn in peak traffic on a highway . We as an industry now have to contemplate:

-have the proper risk assessments been done

-do we have the correct vehicle design

-are the truck operator/ contractors properly trained

-are the local authorities trained and aware of the potential hazards

-do we have trained emergency response procedures in place

-are we properly briefed to deal with the media

These are all areas where SAFEX with the help of its members can play a proactive role. At the Congresses there are training events and Workgroup sessions dealing with the relevant Safety issues to assist you as members .These events expose you to the latest thinking globally by the industry ,as well as relevant legislative issues . The next SAFEX Congress will be held in Helsinki , Finland from 15 till 20 May 2017 ,please diarise now to ensure your attendance .

In this Newsletter we are starting with a new series of publications on historical incidents—there is a lot of learning in these incidents to facilitate prevention of similar and other incidents in general. Andy Begg , will through these articles , rekindle the corporate memory to take another step towards operating under conditions where " No harm to anybody anytime ,anywhere" becomes a reality . If there are any old incidents in your area of expertise you would like to include in this learning opportunity , please forward to Andy and myself .

The following Incident Notifications have been received and circulated since the beginning of the year :

IN 01-15 MMU truck fire in Russia.

IN 02-15 Cartridged Explosive Fire on Pallets in Canada .

IN 03-15 Laboratory Detonator Explosion in Germany

IN 04-15 Rework Mortar Propellant Explosion in Turkey.

IN 05-15 Burning Ground Incident ,Australia

A big thank you to the members for these notifications and again a sincere call to get these through to me to ensure the learning is spread throughout the industry!

MEET THE NEW GOVERNERS –DAWIE MYHARDT

Dawie Mynhardt is one of the newly appointed members to the Board of Governors. He is currently a director at BME South Africa, overseeing Manufacturing, Research and Development, and Engineering projects. He sees the appointment to the board of Governors as a privilege and an opportunity to reach out to all the manufacturers of explosives, in our collective drive to save lives through the prevention of catastrophic workplace incidents.

Dawie always had a lively interest in Chemistry and Engineering. He had a short stint as an entrepreneur, upon graduation 30 years ago, before he joined a global mining water treatment company. He started his career in the explosives industry at AECI in 1988. He will always be grateful for the strong mentorship and guidance he was able to enjoy from seasoned industry leaders during the forming stages of his career. Dawie joined BME, a division of Omnia Group (Pty) Ltd, in 1998.

The manufacturing and handling of explosives takes place in an unforgiving environment where there is absolutely no room for ignorance or complacency. The SAFEX Workgroups provide a neutral platform where we can all learn from each other and Dawie looks forward to work with the respective group leaders and explosives experts in our endeavours to continually improve safety practices in an ever learning environment.

Dawie and Elsabe have three children, Dawie (Jnr), Ellen and Barend – all studying at University in preparation for their respective careers. The Mynhardt family enjoys the outdoor live and spending holiday times together. Dawie thoroughly enjoys his woodworking hobby whenever time permits.

The SAFEX International Board of Governors at the Annual Board Meeting at the ISEE Conference in New Orleans

Front Row : Alexander Chernilovskiy; Claude Modoux ;John Rathbun (Chairman) ;Piet Halliday; Andy Begg

Middle Row: Dawie Mynhardt; Noel Hsu; Rahul Guha

Back Row: Enrique Barraincúa ;Thierry Rousse; Terry Bridgewater; Steve Dawson; Edmundo Jimenez

BOARD MEETING IN A NUTSHELL

The annual Board Meeting was held at the Sheraton Hotel ,New Orleans during the ISEE Conference . It was the first time that the meeting was chaired by John Rathbun ,the incoming Chairman ,and attended by the new governors Noel Hsu ,Edmundo Jimenez and Dawie Mynhardt . Dawie will be taking over the Workgroup portfolio whilst Andy Begg will become the custodian of the Expert Panel .Rahul Guha has been tasked to investigate the viability of a SAFEX Chapter in India , this will be a first for SAFEX and thus will be well supported by the Board.

The Basis of Safety Module has been launched on the eLearning website and members can now subscribe to this module for internal use ,at the cost of € 100 per learner .

An important output of the Board Meeting was fixing the date and venue for the next Congress, as advertised on Page 1.

The Ammonium Nitrate , Security and Emulsion Workgroups also had productive meetings during the course of the Conference after the Board meeting .

QRA CORNER

The Bowtie Risk Assessment Method

Dr Michael du Plessis

Greenice Pty Ltd

Introduction

The bowtie method is a risk evaluation method that can be used to analyse and demonstrate causal relationships in high risk scenarios. The method takes its name from the shape of the diagram that is created in the process, which looks like a man's bowtie. A bowtie diagram provides a visual summary of all plausible accident scenarios that could exist around a certain haz-

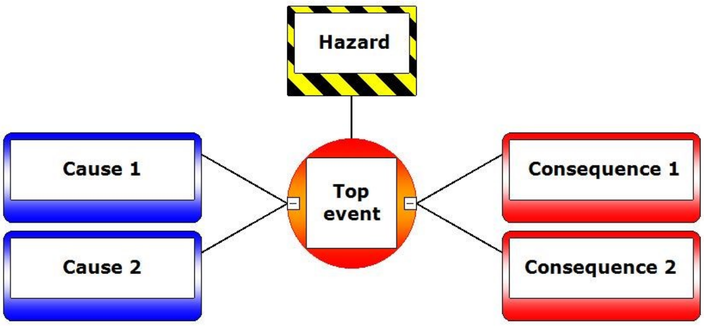


Figure 1. Outline Bowtie Diagram Elements

There is some anecdotal evidence to suggest that the Bowtie methods were first developed by ICI in the late 70's. In the early nineties the Royal Dutch Shell Group adopted the bowtie method as part of the group's HEMP standard for analysing and managing risks. Following Shell, the bowtie method rapidly gained support throughout the oil and gas industry. The bowtie method has now spread to industries outside of oil and gas to industries such as aviation, mining, maritime and chemicals.

The use of the bowtie method in the commercial explosives industry is not wide-spread but is growing. It provides an easy to understand way to make a decision about whether the current level of control of major hazard scenarios are sufficient. Increasingly bowtie diagrams are being used in safety cases to show regulators that risks are As Low As Reasonably Practicable (ALARP).

The bowtie method

A bowtie starts with the hazard we want to analyse. The method therefore builds on existing hazard identification and hazard management tools. In bowtie thinking, a hazard is something that if a loss of control of the hazard occurs, an abnormal situation can arise and the company is now exposed to potential harm of the hazard. The event that occurs on loss of control of a hazard is called the *Top Event.*

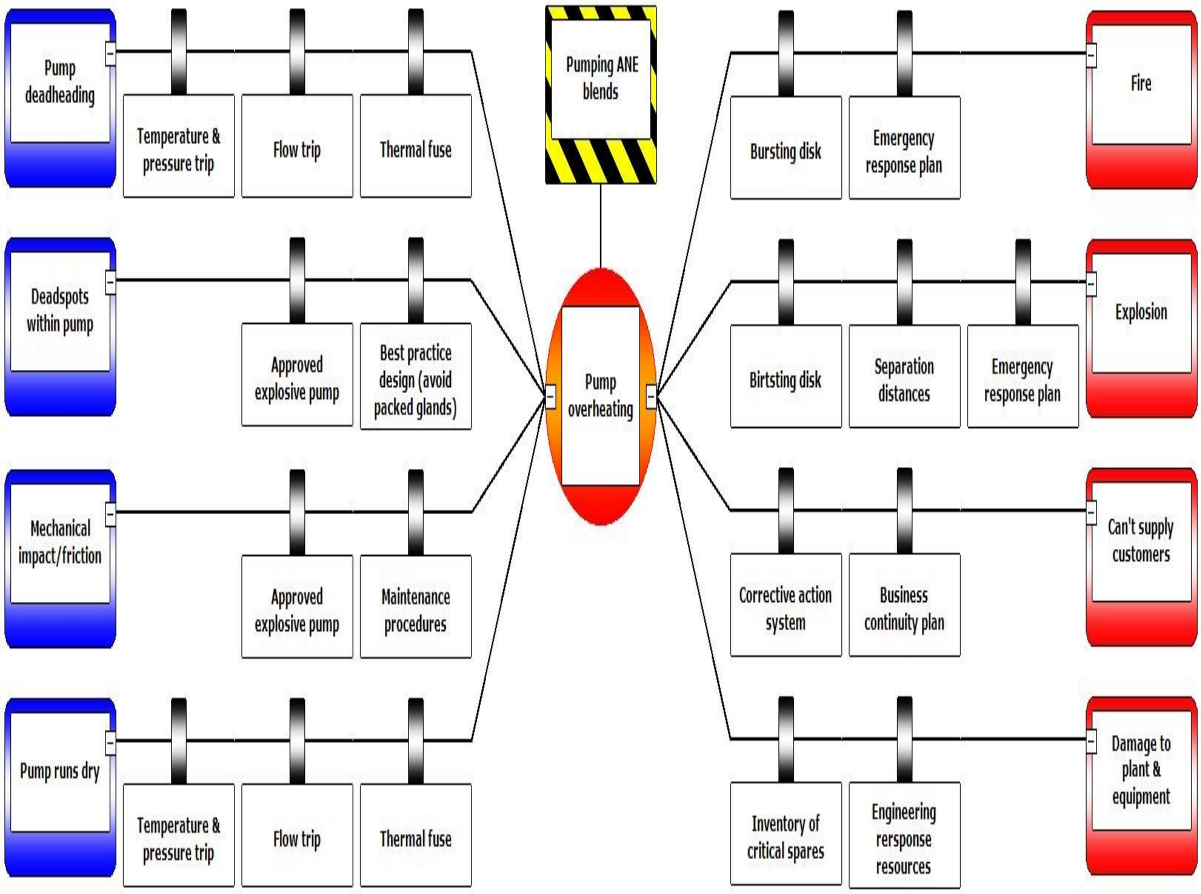


Figure 2 shows a simple bowtie diagram for the hazard – *pumping ammonium nitrate emulsion (ANE) mixtures*. The top event in this scenario is overheating of the ANE pump (i.e. loss of control of pumping that could lead to the pump overheating). Note that hazards may lead to multiple top events, each with a separate bowtie diagram. The next step is to identify the causes that could lead to the top line event. Causes that could lead to the pump overheating are shown on the left side of the bowtie (e.g. pump deadheading). The consequences (or outcomes) that could lead to the top event occurring are shown on the right hand side of the bowtie (e.g. explosion of ANE).

The next step is then to identify what controls are in place to prevent the top event occurring (e.g. high temperature trips). The second set of controls, on the right hand side of the drawing show controls in place to manage/reduce the consequences of the top event occurring.

A traditional risk matrix approach is used in the bowtie method to assess the possible loss or damage that a consequence might cause. Each consequence on the right had side of the bowtie is assessed on their frequency and severity and whether or not the risk is sufficiently controlled.

Once the control measures are identified, the bowtie method takes it one step further and identifies specific conditions or actions that make it more likely that a control measure will fail. These are called escalation factors. There are control measures for escalation factors as well. These barriers protect the primary control from an escalation factor. In the example above, a primary control to prevent overheating of the pump may be a high temperature sensor/trip. An escalation factor may be that the sensor is not maintained properly and fails to detect an over-temperature situation. In this case, the control measure for the escalation factor could be a scheduled maintenance program and pre-start checks for critical controls.

One of the best explanations of the bowtie method can be found at the UK Civil Aviation Authority website:

http://www.caa.co.uk/default.aspx?catid=2786 ard and by identifying control measures the bowtie displays what is being done to control those scenarios. The bowtie diagram provides a simple, visual explanation of a risk that would be much more difficult to explain otherwise.

Challenges building bowties

The zoom level, or level of abstraction at which the bowtie will be built is an important decision to make. In practice bowties should not be too specific because the diagram will become too large if all bits of information are included. But the bowtie should also not be too generic, since relevant information that is necessary to put the analysis into practice might be lost. Depending on the zoom level / abstraction level, there will be either more diagrams which are more detailed, or fewer diagrams which are more abstract.

Formulating hazards for the bowtie method can be challenging. Effective bowtie analysis requires interpreting the meaning of a hazard in a different way. It takes some time to reframe hazards that come from traditional hazard identification methods into a form that defines the scope of the bowtie and the top events.

Defining the top event(s) may also require new thinking. The top event is usually not yet a catastrophe, disaster or actual damage; it is still possible to recover from it, at least to some extent. Catastrophes and disasters are typically consequences in the bowtie method, and not top events.

Sometimes a generic bowtie is created where the causes and consequences are specified in other bowties. In this case a cause or consequence can become a new top event in another bowtie. In this manner several bowties will be linked, creating a chain of events. This is called chaining bowties.

Building bowties

The most powerful way to apply the bowtie method is to build diagrams in a workshop setting with input from multiple stakeholders. The Workshop should build on information from other hazard identification processes (e.g. HAZOP) and risk assessments. The process of building a bowtie diagram is made much easier with the use of an interactive software package. Microsoft Excel bowtie templates are available but of limited practical use. For organisations planning to use the bowtie method more widely, it is recommended that an appropriate software package be implemented.

Conclusion

The bowtie method provides a useful way to analyse the risk and controls for a process. It provides a visual representation of a risk scenario and how the risk is being managed. Its application in the commercial explosives industry is growing. In some jurisdictions, regulators have requested that risk scenarios be presented as bowtie diagrams in safety cases for facilities.

The bowtie method does not replace existing hazard and risk assessment tools. It provides a useful way of presenting information in a coherent and consistent manner.

EXPLOSIVES COMPETENCE

Improving explosives competence (SAFEX introduction)

All explosives manufacturers recognise 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 to present 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: Implementing explosives qualifications

In SAFEX newsletter 47 (4th quarter, 2013), we looked at the implementation of the Explosive Substances and

Articles National Occupational Standards (ESA NOS) and in the article for newsletter 50 (3rd quarter, 2014), we discussed the assessment of competence. A number of the points made in these articles also apply to the implementation of qualifications that are based on the ESA NOS so we suggest reading this article in conjunction with those featured in newsletters 47 and 50.

HSQ's explosives qualifications

The vast majority of Homeland Security Qualifications' (HSQ) qualifications are based on the ESA NOS and, as such, are designed to accredit the competence of those who work with explosives. All HSQ's competence qualifications are designed to be assessed in the workplace although in some specialized circumstances, candidates may be tested through a simulated experience. This is largely due to safety requirements or it might be because the opportunity for candidates to demonstrate their competence in a particular area occurs so infrequently that a simulated experienced needs to be set up.

All HSQ's competence qualifications have been recognized by the UK explosives industry.

The assessment of HSQ's competence-based qualifications involves the appointment of an assessor (an employee of the organization that is delivering the qualification) and an internal verifier (IV) who is also an employee. Both appointees must hold relevant nationally regulated qualifications in assessment. The role of the assessor is to guide the candidate through the assessment process – planning their assessment, helping them to identify assessment and evidence-collection opportunities and clarifying requirements. When the assessor is satisfied that the candidate has reached full competence, then the assessment will take place. The role of the internal verifier is to ensure that all assessments are carried out with the required degree of rigour and quality and to ensure that all assessors are interpreting the requirements of the qualification in the same way. This ensures that all candidates are treated equally and are assessed against the same standard. The role of the External Verifier (EV) – an appointee of HSQ – is to ensure that all HSQ's centers are operating to the same high standard and to support the center and all its staff in the implementation of the qualifications.

Some of HSQ's centers deliver bespoke qualifications. These are designed by the center and are approved by HSQ in the usual way. However, they differ from HSQ's industry-recognized qualifications in that they are designed to meet a specialist need. For example, bespoke qualifications might provide accreditation for the knowledge taught through explosives training courses. Alternatively, they might be competence-based but are designed to meet the requirements of roles that do not match those of mainstream qualifications.

We interviewed a number of people who have personal experience of implementing competence-based qualifications. This is what they said.

Why implement explosives qualifications?

"In 2009, the UK's Ministry of Defense (MoD) published a requirement for all explosives workers to demonstrate their competence. This applies both to those employed by the MoD (military and civilian) and to the explosives workers employed by MoD's suppliers so it goes right across the industry and the driver is therefore both by regulatory and driven by the customer" said Dave Winterborne (Qualifications Assessor and Internal Verifier). "This means that we need to understand people's behaviours because wrong behaviours often lead to safety failures" he went on. "We need a structure for the entire workforce that operates on several levels so that we can structure individuals' learning and assess their behaviours in the workplace against fixed and absolute benchmarks ."

Indeed, across Europe, the impetus for members of EUExcert is the regulatory requirement to demonstrate the competence of the explosives workforce. EUExcert has recommended the use of qualifications because of their ability to demonstrate the competence of an organization's workforce through the structure of independent assessment and verification. One of the aims of EUExcert is to enhance the mobility of explosives labour across the EU and the implementation of qualifications facilitates the achievement of this aim. From the perspective of the individuals working toward a qualification, its achievement is an overt demonstration of their competence and is a powerful motivational tool.

Models of assessment

Assessment of HSQ's explosives qualifications can be carried out either in-house by an organization's own appointed Assessors and IVs or it can be outsourced. Most organizations use their own Assessors and IVs but there are other models of assessment.

QinetiQ is committed to ensuring that all its explosives workers in the UK will be trained and assessed as competent in working with explosives. This is being achieved through the attainment of qualifications. Because of the scale of this endeavour, QinetiQ has taken the innovative step of commissioning a third party training organization – Ramora UK – to deliver the knowledge and understanding components of a number of HSQ's competence-based explosives qualifications. The training and qualification assessment is delivered on Ramora's premises through a bespoke qualification which has been created by QinetiQ and Ramora with HSQ's help. This means that the assessment of the required knowledge and understanding is completed off site at the end of the training process, leaving only the assessment of the practical application of that knowledge and understanding (in the form of competent performance) to be assessed in the workplace.

Within the Royal Logistic Corps of the British Army, Deflog VQ Trust (a specialized training company) delivers the L2 Apprenticeship in Explosive Storage and Maintenance to Ammunition Technicians. The assessors are Deflog VQ Trust employees who take the learners through the Apprenticeship whilst attending military training. "Apprentices leave DEMS Kineton with a military qualification and they then complete the Apprenticeship in Explosives Storage and Maintenance back in their units. This provides for the extra time needed … to complete the Apprenticeship requirements, develop their "soft skills" and demonstrate competence in the job role in the field" explains Dave Nelson (Quality Manager, Deflog VQ Trust).

Structure of workplace assessment

In some industries, it is considered that there is a risk that the manager of an individual candidate may make biased decisions and judge their staff to be competent when in fact they have not quite reached the required standard. Consequently, they are not allowed to act as their Assessor. However, as Dave Winterborne points out, "Even when a candidate's manager is the Assessor, independence can still be achieved by using an IV from another part of the business so the final decision on an individual's competence is still objective" – a point with which Ken Cross (Chairman of EUExCert UK) agrees: "The level of rigour that is applied through the structure of assessment and verification is appropriate to the absolute certainty that the required standards have been met – a point on which regulators agree".

Assessment of competence in working with explosives naturally brings its own challenges as Max Burnett (Qualifications Assessor, Internal Verifier and Senior Verifier, Homeland Security Qualifications) explains "[Assessment] is hampered with the hazardous nature of the occupation and the need to allow additional personnel - Assessors - within the vicinity of hazardous tasks. To cater for this, a degree of simulation is allowed but this requires additional time and resources to set up." This point was also made by a representative of organization A (a defense GOCO) who explained that the issue of the presence of additional people could be overcome with the use of simulation and providing photographs and recordings of work carried out along with peer reviews and personal logs. Whilst setting up simulated activities has a cost attached to it, there are compensatory factors as Max Burnett went on to explain: "The work and the skills needed in the explosives industry has not changed, but until the development of the ESA NOS, there was no audit trail of who could do what. Too many agencies are involved e.g. the HSE - and organizational managements are frightened that they will be liable should they be found to be wanting when it comes to regulatory inspections into organizational competence following an incident. If all agencies' inspections were carried out against the ESA NOS, the whole picture would be clearer and organizations would need to put mechanisms in place to achieve this" he suggested.

Max Burnett certainly agreed with Dave Nelson's point that "In many industries, there is a gap between the needs of job roles and qualifications. However, there should be more integration to create synergy between what the job demands and using the qualification to meet these demands. Many organizations in such industries are often unwilling to make the investment to develop people in this way. However, in the UK explosives industry, the industry has specified what it needs [i.e. the ESA NOS] and people can be trained against these standards" he said.

Benefits

Throughout this series of articles, we have alerted readers to the benefits of the ESA NOS and related qualifications so we will avoid repeating what has already been said. However, it is worth mentioning a few points that contributors to this article have identified.

Dave Winterborne summed up the value of implementing qualifications when he said "I have worked with a number of organizations that have implemented explosives qualifications. In my experience, the value lies in the fact that qualifications are assessed independently and verified externally so it is not just internal managers' judgments as to who is and who is not competent. The achievement of a qualification is an unequivocal measure and their implementation helps to standardize an organization's approach."

QinetiQ has found that a range of benefits ensue from individuals' achievement of a formal qualification, for example, greater motivation resulting from enhanced confidence This does not just apply to the younger elements of the workforce: older people have also become more engaged and appreciate the recognition that goes with being properly qualified. Some now have an increased understanding that the supervisory component of the qualification that they are pursuing is a fundamental part of their day to day job, and the resulting job enrichment is seen to be rewarding as they help to foster the growth of younger people.

QinetiQ managers were in agreement when they said "From a corporate point of view, when the HSE carries out an inspection, it is helpful to have an organization-wide demonstration of competence through the delivery of explosives qualifications." But that is not the only benefit. "It is also about continuity across the company: certificated individuals can work across different sites but they will recognize that the same standards apply" they said. This obviously has significant business benefits as individuals need only induction training when they move from one site to another and any operational bottlenecks can be resolved quickly by assigning more staff to a site in the certain knowledge that they will be able to "hit the ground running". Conversely, for individual workers, their enhanced flexibility opens up career opportunities for those who are willing to move between different sites and/or different job responsibilities. "Interacting with other team members means that you can learn new things when working on different sites" added Danny Williams (Shoeburyness Explosives Manager, QinetiQ) – which can only enhance corporate capability. "Customers and contractors now know what to expect because business practices are consistent across all of QinetiQ's sites and the structure of the qualifications has enabled QinetiQ to develop its career framework. People are now able to see for themselves the skills, experience and qualifications that they need to progress up the career ladder, which in itself, is a strong incentive to enhanced performance" said Phil Hilton.

Overcoming challenges

Human nature often wants to overcomplicate matters and the implementation of qualifications is no exception. For QinetiQ, the perception of bureaucracy that exists in some quarters has been overcome through the development of assignment-related workbooks that simplify the presentation of the qualifications. Following a briefing, candidates can more easily understand what they need to do in order to gather and organize their evidence of competence "Candidates now know exactly what they need to achieve and the task doesn't look so daunting", explains Phil Hilton.

An extract of one of the workbooks showing candidates one of several assignments that they must complete for HSQ's L2 Diploma in Explosives Operations is at the end of the article

QinetiQ managers have been pleasantly surprised that they have not encountered more of the "I've been doing this job for twenty years and you can't teach me anything new so why do I need a qualification?" attitude. The extensive briefings that explain the reasons for QinetiQ's business decision to qualify its explosives workers has helped to overcome the potential for such negativity. However, it has proved challenging for all assessors to be able to complete their assessment qualification, particularly on remote sites, because candidates for qualifications in assessment must have access to candidates who are working to their own qualifications. As the development with Ramora gathers momentum, this will ease the pressure. Other organizations found the same problem of a lack of time, sometimes compounded by a frequent turnover of staff, especially in a military environment.

It seems that everyone in the world loves qualifications except the UK!" said Ken Cross. "In fact, organizations probably want to recruit people with qualifications but they are often not prepared to invest in them once they are employed." So, in other words, there may be a problem in obtaining the commitment to implementing qualifications at the most senior level. Max Burnett suggests a way around this problem: "Everyone in an organization with a vested interest should be involved in the planning and delivery of qualifications. This includes finance, HR, line managers, operational managers, the senior management including the Chief Executive. If one person fails to fulfil their role, then the implementation of qualifications will not succeed."

Phil Hilton (Weapons Division Explosives Operations Manager, QinetiQ) certainly agreed with this sentiment: "Good practice was already taking place in the business but the consistent management of qualifications means that it is now happening right across the board" he added.

When helping our centers to establish themselves, we at HSQ have certainly found that centers tend to underestimate the time needed to meet the qualification administration and assessment process. Delivering qualifications in the workplace is resource-intensive to start with and sufficient resources need to be put in place early on. However, given sufficient planning and development work up front, the delivery of competence-based qualifications does not need to be an arduous process.

What would you do differently next time?

Dave Winterborne's extensive experience in the implementation of qualifications led him to the conclusion that the key to success is to get everyone affected on board and to understand the benefits: "Were I to implement qualifications in another organization, I would allow more time for a pilot. I would also want to generate more awareness of the whole qualifications process and the resulting benefits right across an organization, targeting middle management in particular because this is usually the area of greatest resistance" he said.

Indeed, the single biggest factor identified by all interviewees that affects the successful delivery of qualifications is to gain the buy-in of everyone involved: not just senior managers, but middle managers, supervisors and the candidates themselves. Max Burnett went on to point out that the ESA NOS must be an integral part of an organization's working practices and must be embedded into organizational culture – all of which needs to be sort out right at the beginning of the implementation process.

Dave Nelson suggests: "In an ideal world, Assessors could continue their role as mentor to those who have completed a qualification and act as a "Master of Skills". If a nucleus of such occupational experts could be formed and managed, this could help to bring on and develop the skills of those relatively new to the industry.,,"

What would you do the same next time?

Max Burnett explained how confused people can become: "People often do not understand the difference between implementing standards and implementing qualifications. The ESA NOS must be in place prior to the implementation of qualifications and people need to see the link between the ESA NOS and task instructions. Historically, there have been two separate check sheets – one for the fulfilment of the task and a separate one for the qualification. These should be brought together into one. The first task to do, therefore, when implementing a qualification, is to map the task to the role by creating a role profile" advises Max Burnett. Dave Winterborne's experience led him to the same conclusion: "I advise starting with developing explosives role profiles because these are fundamental to the success of absolutely everything to do with developing and measuring competence because, through role profiles, you know what needs to be done and who does it. They give you the structure you need" he advised.

QinetiQ's managers agreed that the implementation of qualifications must be sufficiently resourced and they would again appoint key individuals to manage this process: "We need to track the progress of 450 people and we need a mechanism to manage this" explains Phil Hilton. The appointment of an Explosives Training and Standards Manager and administrative support has been fundamental to the success of QinetiQ's implementation of competence-based qualifications. In particular, the creation of the workbooks has enabled the streamlining of the necessary administration (such as evidence mapping). "We would create the workbooks again" said Danny Williams "because it simplifies what needs to be done". As with all other interviewees, all agreed on the importance of creating standardized role profiles in the first place and reducing these to as few as possible.

"We are a test and evaluation business - not a full time training organization - and we would advise others not to try to do it all themselves unless they can commit adequate training resources. That is why we have brought in Ramora to help" said Phil Hilton.

QinetiQ has set up two pan-organization working groups which share general and specialized best practice across all QinetiQ's explosives business areas. Examples of some of the outcomes of the groups include the continuing consistent structure of Range Standing Orders and the peer review process, the enhancement of the intranet and access to information and good practice. QinetiQ plans to seek accreditation of the work carried out by these groups as CPD activity that may be endorsed by the Institute of Explosives Engineers.

What advice would you give?

"Talk to HSQ!" Dave Winterborne was kind enough to say "…and to other HSQ-approved qualifications centers – the UK explosives industry is happy to share information, ideas and best practice" he added.

"Keep it simple!" was the unanimous response from QinetiQ's managers "and talk to others who have already implemented qualifications".

"Don't try implementing qualifications piecemeal" advises Ken Cross. "The benefit comes in implementing the whole thing rather than picking out bits of a qualification for individual development purposes. Once you implement a full qualification, it relates to individuals' annual reports and to the assurance of competence of the whole workforce so you need to be able to demonstrate full competence, not just certain aspects of it."

"All managers should be trained as assessors – I mean in how to assess individuals against the detail of the standards and this is different from assessment for appraisal purposes. At the very least, managers should be aware of the techniques" recommends Ken Cross. "The Human Resources (HR) department of an organization needs to take control of the implementation of qualifications because it is part of an organization's employee development strategy. It is also a clear demonstration to regulators that an organization is fulfilling thoroughly its duty of care to ensure that its workforce is trained, currently competent and safe" suggests Ken Cross. "So, HR should create role profiles, chase up annual reports (measured against the ESA NOS), log Personal Development Plans and follow up reviews – which can all be done through the implementation of qualifications" he added. "Then, they should be using the aggregated results for manpower planning purposes, succession planning and to commission training. In short, management decides it but HR manages it."

Dave Nelson pointed out that you may need to take a different tack: "There are very few organizations offering approved qualifications so your specific needs may not be met – be prepared to assist in the development of the qualification you need" he advised. The representative from organization A was quick to agree with this point "we found that people snapped up occupational health and safety qualifications because there was a clear match between their roles and the qualification" he explained.

"People often overcomplicate the tasks involved in implementing explosives qualifications: mapping and cross-referencing is the key" said Max Burnett. "Also, if you retain the general section of the candidate's portfolio electronically, then this will shorten the portfolio and make it much more manageable" he added. The representative of organization A agrees with the importance of having a role profile in place as he explains: "Have a well established role profile … You are changing people's lives by getting them to do a qualification so it's got to be relevant to the job and it has to mean something to the individual… Doing the legwork before implementing a qualification is really important. So much the better if you have an HR department to help you as you need to integrate the qualification into business processes" he went on.

Future plans

"When an organization decides to implement explosives qualifications, it needs to make a significant investment. The resulting benefits are long term, so the organization needs to take a similarly long term view of the investment needed" advises Dave Winterborne.

QinetiQ may in future require its subcontractors to provide demonstrable proof of their safety in working with explosives through the attainment of explosives qualifications. "We can prove that we meet the MoD requirement for the demonstration of competence and this will be end-to-end including subcontractors" said Danny Williams. Indeed, over the coming years, having seen the benefits of implementing explosives qualifications, it may be that QinetiQ implements other competence standards, training and qualifications in other parts of its business. At the very least, this will "formalize existing good practice" as Phil Hilton explains "and it is also a robust demonstration of competence."

It will be interesting to see the results of the EUExcert project as each of the five participating industry partners will be using the ESA NOS in some way or other during the coming year and two of them will be implementing qualifications based on the ESA NOS to demonstrate the competence of their explosives workforces internationally.

In conclusion

All contributors took the same view in response to the question as to whether or not the implementation of qualifications was cost-effective. In different ways, they all agreed that organizations could not afford *not* to implement qualifications if the workforce is working with explosives.

"Explosives are no different from any other hazardous material – it is a question of applying controls that are relevant to those materials" said Shaun Dooley. Organization A has seen the value of the ESA NOS in contexts other than explosives and has used the NOS to train people on the use of non-explosive hazardous materials, non-explosives equipment and the preparation of non-explosives work areas.

QinetiQ managers summarized the value of implementing qualifications and the cross-industry collaboration that has come about as a result of the developments of the ESA NOS and subsequent activity when they said: "The explosives business is the benchmark of good practice which would have been fragmented and good practice not shared without cross-industry cooperation so we all need to work together because it is the cooperation of the explosive industry's partners (including the regulator) that contributes to success".

[1]See newsletter 51
[2]government owned, contractor operated

[3]This is described in detail in *Business benefits of operating competence-based qualifications* which is available at: www.homelandsecurityqualifications.co.uk/documents
[4]This is described in more detail in newsletter 49
[5] See newsletter 48

Acknowledgements

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

Mr. Max Burnett, Qualifications Assessor, Internal Verifier and Senior Verifier, Homeland Security Qualifications Ltd

Mr. Ken Cross, Chairman of EUExCert UK

Mr. Jim Edwards, Trainee Trials Safety Manager

Mr. Phil Hilton, Weapons Division Explosives Operations Manager, QinetiQ

Mr Dave Nelson, Quality Manager, Deflog VQ Trust

Mr Danny Williams, Shoeburyness Explosives Manager, QinetiQ

Mr Dave Winterborne, Qualifications Assessor and Internal Verifier

www.homelandsecurityqualifications.co.uk/documents

Question 2	
Reference to criteria	**3.13** *3.05* **3.16** *3.05* **3.20** *3.05* **4.3** *1.01,1.03,1.04,4.05* **4.4** 1.02, 3.01 3.03 4.05 **4.5** 3.04, 4.05 **4.6** 3.05 **7.2,** *1.7, 2.04, 3.05* **7.14** *2.05* **11.9** *2.05* **11.25** *2.05* **11.27** *2.05* **13.1** *3.05* **13.2** *2.01, 3.05* **13.6** *1.06, 1.08, 3.05* **13.8** *3.05* **13.10** *3.05* **13.13** *1.05, 2.05* **13.15** *3.05*
You have been tasked with receiving a consignment of ammunition for either disposal or for trial. Describe how you would identify the stores for receipting (paperwork) and where you would place them relevant to your particular battery, taking into account license limits and working within your level of responsibility. Explain what actions you would take if you identified a problem.	
Write your answer here	

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.

Andy's Incident Recall

Recall of previous incidents involving explosives.

Over many years we have learned much from incident investigations that has helped us to improve our safety in explosives operations and this is why SAFEX is passionate about incident reporting and investigation. We rely on the quality of the investigation and information provided in the reports to provide us with details required to help us learn and improve. Today we have access to a large database of past incident reports - some containing many details but others less so. However, in today's increasingly litigious environment it is becoming more difficult for companies to perhaps include as much detail in their reports as they would have done in the past. As time passes organisations change, experienced people move on and inexperienced people move in. However, the value to be gained from reading the "older" incident reviews does not change and they remain a valuable source of information that is still as valid today as it was when the incident occurred. I suspect that these older detailed reports are not accessed as frequently as they should be just because "they are old". To help address this it is our intention to re-issue some of the older incident reports as articles in the newsletter. Some of our readers may be familiar with the incidents but many will see them for the first time – it is hoped that all members will benefit from their recall.

Explosion in a truck carrying a load of mixed explosives products.

On March 1989 a delivery van in the UK with a load of 800Kgs of explosives caught fire and detonated resulting in one fatality , 107 other injured persons and €40 million damages. The investigation of this incident identified with a high degree of certainty the root and underlying causes of the incident with some unexpected findings. The findings also illustrate why it is very important in every explosives operation to ensure that any changes made to the operation – however small and apparently insignificant at the time - must be assessed.

Background

The truck was a standard explosives truck authorised in the UK for carrying explosives and contained NG based explosives, packaged emulsions, detonators and 2 cases of fuseheads. At that time it was legal to transport detonators and explosives in the same vehicle/compartment.

The truck was on a routine delivery but the driver took a wrong turn and entered a small industrial estate. He realised his mistake and drove into a small yard to turn round. As he went into the yard he went over a speed control bump.

As he went over the speed bump his attendant was aware of a flash behind them and as the driver turned around he saw blue smoke in his rear view mirror. He stopped the vehicle, got out and saw smoke coming round the damaged rear roller door of the cargo space. He raised the alarm and the area was evacuated . The emergency services were called and the area was secured. The firemen were advised by the driver not to tackle the fire and everyone exited the yard.

The truck exploded after 12 minutes and one fireman killed by piece of shrapnel.

Yard photographed some time prior to the incident-From HSE Official Report

Figure 2 Aerial photograph of area before explosion (*Photograph reproduced by kind permission of Skyviews and General Ltd*)

Yard photographed after the incident —from HSE Official Report

Figure 3 Aerial photograph of area after explosion (*Photograph reproduced by kind permission of Peterborough Evening Telegraph*)

Investigation

The remit of the investigation was to find the cause of the explosion and identify those actions necessary to prevent a re-currence.

This current review of the incident will focus on the cause of the explosion and the circumstances (failures) that led to the explosion.

The Load

At the time of the incident the truck was carrying :

650kg emulsion

56kg cast boosters

75kg dynamite

750 electric detonators

10 000 Vulcan fuseheads in small metal boxes contained in a larger wooden case

2400 Cerium fuseheads in small metal boxes contained in a larger wooden case

Findings

It was established by reviewing the statements, sensitivity tests on the various products and simulation tests that the transit of the vehicle over the speed bump initiated a sequence of events with evidence pointing to fire preceding explosion. Fire spread to the detonators and the rest of the cargo and mass detonation was almost inevitable.

The investigation quickly focussed on the cerium fuseheads in the load as the likely cause of the fire.

Cerium fuseheads are normally used in the same factory as they are produced in for igniting delay elements in detonators (routine production) but in this case they were being sold to another producer for a different application. Cerium fuseheads burn with a very high temperature and are heat and friction/impact sensitive. The fusehead composition used for the units in question was examined and confirmed to be extremely sensitive both to impact and friction as expected.

As part of the investigation the method of packing was looked at in detail and it was found that the small metal boxes in which the fuseheads were packed were rusty and had loose rust powder inside them. It was then shown that fusehead mixtures contaminated with rust(1%) had a tenfold increase in impact sensitivity.

Tests were conducted on the fuseheads as packaged at the time of the incident to simulate the effect of the truck traversing the speed bump – these tests involved dropping full packages (boxes) from controlled heights.

Boxes of fuseheads dropped from a height of 1.2 metres exploded with a small fireball and caught fire in some tests but not others. The tests were all recorded on video for detailed examination. In other tests a box of fuseheads was ignited in the rear of an equivalent truck and the effect recorded.

Figure 1 *Simulation trial illustrating the result of initiating a box of cerium fusehead combs in a vehicle*

The effects in the simulation were very similar to those reported by the driver.

The investigation then focussed on the method of packaging the fuseheads. It was established that these fuseheads had been supplied to this customer for many years without incident. However, it appeared that the packaging had been changed due to a request from the customer.

In production the fuseheads are made on a strip called a "comb"

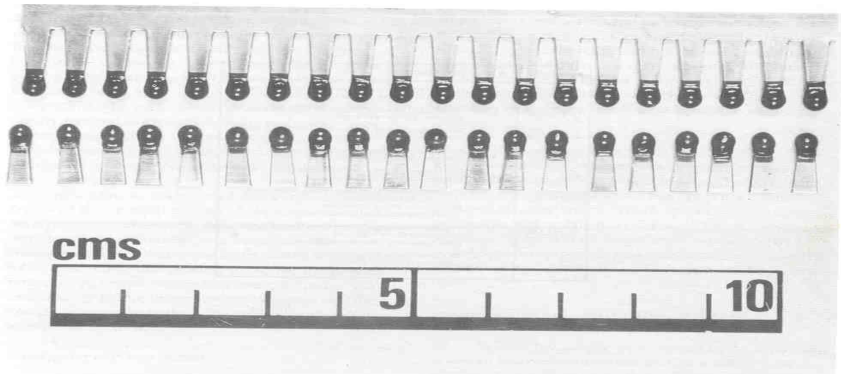
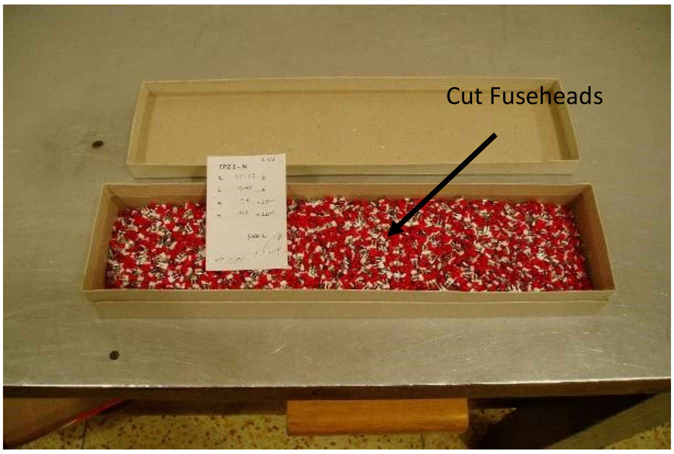


Figure 5 Cerium fusehead comb (above) and (below) cut fuseheads

For normal manufacture this "comb" is passed through a cutter which basically cuts each fusehead off the comb to give single fuseheads.

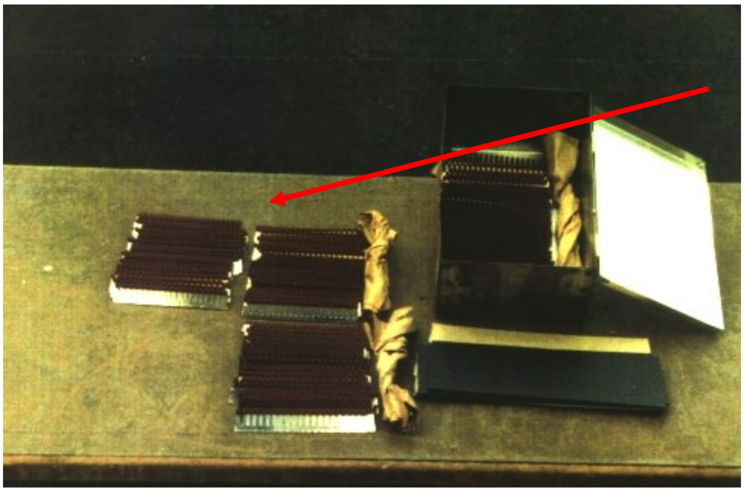


Originally the cut fuseheads for this customer were packed in small square tins, each the size of a match-box and each one of these tins contained 500 cut fuseheads.

10 of these tins were then placed inside a larger tin and 5 of these larger tins were then placed inside a wooden box - making 25,000 fuseheads per package. This was a relatively small market for a "special" product with one customer.

However after some years the customer started to pressure the local salesman on price and the salesman offered a price reduction if the customer would accept uncut fuseheads (he knew the manufacturing process and that the fusehead combs were a routine semi-product and therefore should be quicker/cheaper to make). The fusehead plant supervisor agreed that this could be done but it would require a change in the packaging as now that they are supplying combs to the customer rather than fuseheads, the small matchbox size tins cannot be used. It was decided to leave the small tin out of the packaging.

The combs were now packed directly into the larger tins - 400 combs in each (20 fuseheads per comb)
And 2 tins are placed in the large wooden box which now contains a total of 16,000 fuseheads.



Fusehead Combs

The plant foreman saw no need to consult his superiors on this move, because as far as he was concerned:

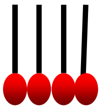
- The outside packaging looks exactly the same
- No new product has been produced
- The wooden case now contains 16,000 fuseheads when previously it held 25,000 and in his mind this was sure to be an improvement in safety

In the investigation it was also found that the supplier of outer tin box had been changed to a local supplier. The new tins had the same dimensions and basic material of construction but as supplied they had higher levels of rust.

So several small (and presumably those people involved thought "insignificant") changes had taken place in the packaging.

But in the investigation it was considered that:

- Fusehead combs can generate more friction between units when subjected to shaking than when cut because of the way in which they are packed – the "drops" of fusehead composition will all be in contact with other "drops". As the combs will be aligned in parallel.

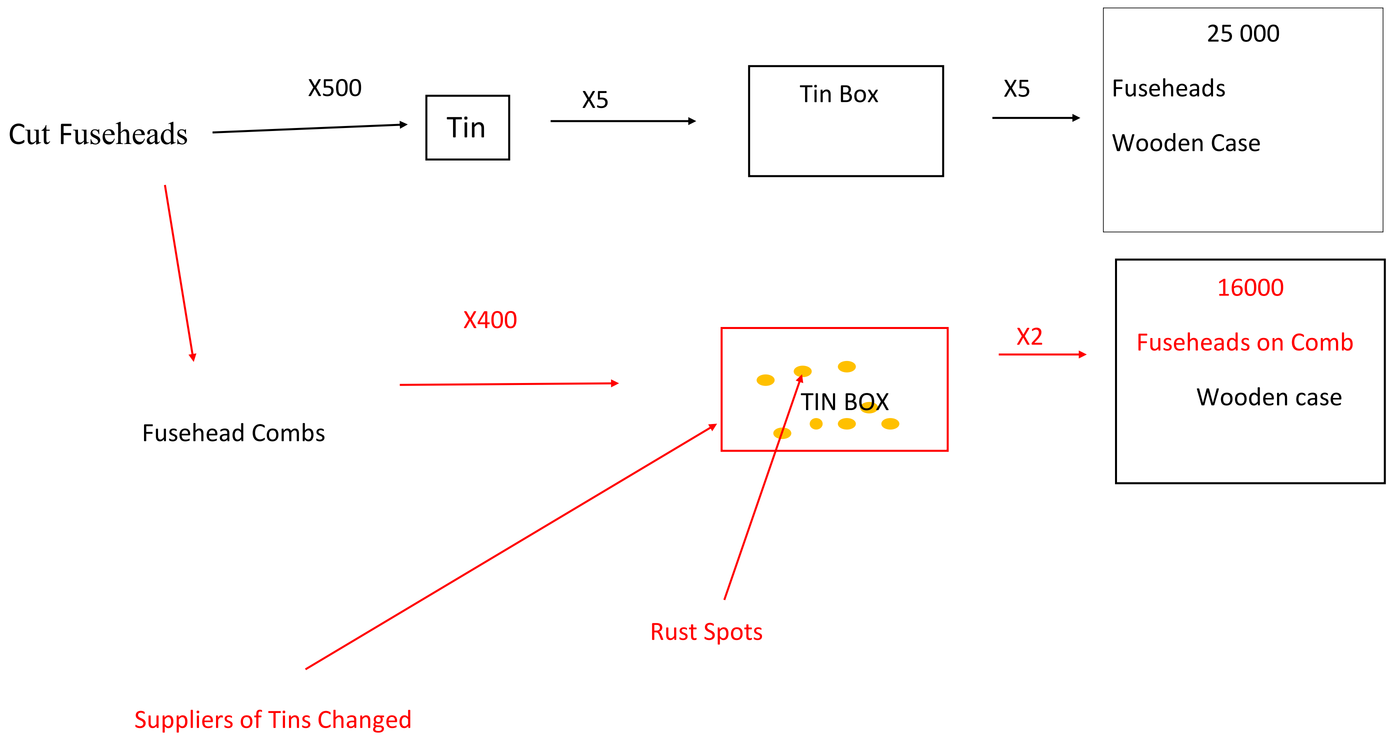


- Rust significantly increases the fusehead composition sensitivity to friction and impact.

The result was that these 2 small changes – cut fuseheads to combs and a change in supplier of tin boxes increased the sensitivity to friction and impact and explosion and fire resulted. The fire of the fusehead box then spread to the rest of the cargo including the detonators which would certainly explode in mass as soon as the fire reached them and this in turn would initiate the remainder of the cargo resulting in a mass explosion.

In the investigation it was noted that several of the safety procedures in the factory had failed - in particular the need for all changes to operations and packaging to be formally assessed and approved before being implemented. In this case those personnel involved thought they were doing the right thing and that the changes being made were small and would not introduce any additional hazards – but these changes were made with disastrous consequences.

Changes made (red font)



It is quite common in operations for people – operators, supervsors and even managers - to think they have identified a better way to do some part of the operation. It might be quicker, easier, cheaper - - . And they may think it is not necessary to formally apply the "Management of Change" procedure – or worse, they may not even be aware of it.

However, the "Management of Change" is a vital safety system in our operations as this incident clearly illustrates. Are you sure your "Management of Change " procedure is robust and is being fully implemented?

Tony's Talepiece

After numerous articles featuring the basis of safety," something entirely new was called for. This article is called "Bangers - Not to be Held in the Hand!" and talks mostly about misfired detonators. Some of the cultural traditions around the outdoor grilling of meat are briefly discussed, but no braai tips or recipes are included.

Disclaimer:

The views and opinions expressed in this article represent only those of its author who is not very bright an' anyway walks with a bit of a trot. The views and opinions do not necessarily reflect those of SAFEX either or for that matter any other body dead, alive or permanently moribund. Issues around the integrity and accuracy of the article are left entirely for the reader to assess.

BANGERS ! *(Not to be Held in the Hand)*

Preface

I wish that I could say that the purpose of this document was to provide a concise summary based on all of the available methodology for dealing with misfired detonators. Sadly I can't and the document does not. Certainly the necessity for such a manual has grown over the years. The need is driven by a shrinking skills base and a marketplace where technological advances are fast outstripping popular understanding. An example of this effect is conveniently provided for us by the cellular telephone.

Most of us can use a cellphone. We can operate the keypad well enough to make a call, send a text message or take a picture, but few of us know much beyond end-user basics. There aren't many though who could actually repair the device should it go wrong.

As with phones so it is with detonators. In recent days, detonator and initiating system designs have undergone huge increases in complexity. For example, the older and much simpler initiating system known as "Connector/Capped Fuse and Ignitercord" has all, but disappeared. It has been replaced with systems based on shock tubing or even the higher tech, electronic, and even RF communicating detonators, hybrids and/or other combinations. The number of manufacturers competing for market share has also increased dramatically. This has resulted in a bewildering variety of products whose true natures often shelter behind coined, non-descriptive or other meaningless names.

The treatment of misfires is fast becoming a thorny issue, one in which little has changed for over a hundred and fifty years. It hasn't really mattered until now. The industry was always a conservative one. Indeed until fairly recently, customers tended to view changes with suspicion. The last 10 years though have seen huge advances in technology, but the problem of misfires has either been overlooked or fallen by the wayside.

Modern detonators, despite the massive selection of varieties and technologies available; then as now, are still designed with the intention to explode violently. End user safety therefore remains of paramount importance.

It is easy to that say that workers having to deal with misfired or damaged detonators should be trained to understand the hazards involved, but as so few end-users fully comprehend the new technologies now in use, how can the risks be properly understood, never mind be meaningfully assessed? Indeed, who tests misfires for sensitivity anyway? Has any manufacturer or research facility even thought of doing so?

That workers should be taught to avoid all unnecessary exposure by the proper use of safety equipment remains a given, but perhaps the safety equipment itself also needs to change?

An additional recommendation might be that workers trained to deal with misfires be subjected to a practical re-examination every 6 months as a check against any failures in control measures.

Introduction

ALL EXPLOSIVES ARE POTENTIALLY VERY DANGEROUS AND MUST BE HANDLED AND USED WITH CARE. IT ACCORDINGLY REMAINS THE RESPONSIBILITY OF EVERY PERSON ABOUT TO ADDRESS ANY MISFIRED DETONATOR(S) TO BECOME FAMILIAR WITH AND TO FOLLOW ALL APPROVED SAFETY PROCEDURES BOTH LOCAL, AND NATIONAL AND TO AVOID ALL IMPROPER, INCORRECT OR ILLOGICAL ACTIONS WHATSOEVER.

First, let's make one thing very clear. Working with misfired detonators or primed and misfired explosives charges are unquestionably two of the most dangerous operations in blasting.
Missed holes probably present the maximum degree of hazard associated with explosives operations, but every year, all around the world, there are injuries (sometimes permanent and all too often life changing) to personnel attending to misfires. Worse, misfires don't always go "pop" (a synonym for something undergoing a destructive and extremely violent explosion) the first time they are disturbed. In fact, damaged detonators have been known to unexpectedly detonate more than 24 hours after recovery – this despite being handled many times and transported over many kilometers.

When a detonator explodes unexpectedly it can be a very up-close and personal experience, one that can leave both psychological and physical scarring in its wake. Faces, eyes and hands are the parts of the body most at risk, but when multiple detonators or additional explosives are a feature of the incident, death – and sometimes more than just one - can also be an outcome.

***

Detonators in their role as explosive initiators clearly form the most critical part of any blasting set up. The raw power that is packed within such a small package is terrifying, yet the devices themselves appear benign and unthreatening, an impression which unfortunately lends the lie to their true nature.
Detonators are designed to respond to a specific, but relatively small stimulus. Once received by the detonator itself, the initial, often tiny, impulse is progressively amplified; often almost instantly. Signal amplification is accomplished using a series of electronic, pyrotechnic or explosive interfaces. It is a process similar to that of lighting a charcoal braai.
The analogy is a good one as apart from the interface similarities the very act of lighting a braai is not without risk. People are injured every year doing so, sometimes very seriously indeed.

Using the traditional method of braai lighting, a base consisting perhaps of crumpled newspapers and dry wood is first constructed (some architectural or engineering experience may prove useful here). Pieces of

After much careful adjustment of the charcoal the first match is struck. It is usually promptly blown out by the wind or the matchstick itself breaks. Muttering often follows. A second, third or even fourth match may briefly flare into life before, amidst the mounting tantrums and chaos, a flame finally reaches the paper which ignites and begins to burn. In theory the burning paper ignites the wood, the wood then

Grilled meat, fish or the occasional human being aside, the initial small impulse – provided by friction in the aforementioned example – was the striking of the match. The most sensitive part of the chain was the pyrotechnic composition making up the match head.
Inside a detonator - once the firing sequence has been initiated - similar things begin to happen, a resistance wire glows, a tiny spurt of flame briefly lights the darkness or a shock wave, followed by some incandescent particles, reaches out. All are seeking a target surface. Whatever the type of detonator, the substance or mixture making up the particular surface being targeted always comprises of materials selected precisely for their sensitivity and ability to react to such specific stimulation. So, just like the pyrotechnic composition used to coat the head of the match, certain portions of a detonation train may be particularly sensitive to some alarmingly small stimulus. While the match-head demonstrates a singular sensitivity to friction; in the case of a detonator whose internal construction is far more complex, critical sensitivities may also include electrical, thermal and/or mechanical stimulation applied both singly and/or in combination.

What is a Commercial Detonator?

A commercial detonator consists of a thin-walled metal (usually aluminium or copper) tube, having about the same diameter as the average pencil, but closed at one end. Individual units may be defined either as an instantaneous or delayed action initiators. They are intended to be initiated by flame, electric current or shock energy.
A typical commercial detonator contains pressed increments of high explosive, part of which may consist of a primary or initiating explosive. Primary explosives, it should be pointed out, are never your friend.
An appropriate means of initiation, delay and/or communication is then fitted. Finally, a flexible closure plug is inserted. The plug is crimped tightly into place providing a robust and waterproof seal.
Detonators contain highly sensitive compounds and mixtures which, under certain conditions are themselves readily initiated by shock, impact, friction, heat, flame, electrostatic or incendiary spark.
Detonators are not benign; they are not firecrackers either. They do not think, only respond and they feel no remorse. Not quite ruthless in the strictest sense of the word, but when detonators explode, Ruth is often entirely absent.
Detonators are not to be trifled with or treated as playthings. On the contrary, detonators demand absolute respect. They are intended for the initiation of blasting explosives in single, multiple, consecutive or sequential blast patterns.

***

Commercial detonators are traditionally expected to function reliably across a wide range of differing applications. They must perform favourably under the harshest of environmental conditions whilst coping with all the compatibility issues the use of different bulk and in-hole explosives can bring.

Consider for a moment the negative aspects of strong sunlight, exposure to the aromatic components of various oils, high or low rock temperatures, long sleep times, high humidity's and water immersion, all of this whilst remaining almost immune to the effects of poor storage conditions, age, abuse and even poor blasting practices. Added up, it makes any attempt to provide any sort of meaningful guidance around what exactly has happened when things go wrong extremely difficult, but there are still further complications. The range of lacing and connecting practices, individual preferences, legal issues, local rules and mining regulations, plus a host of contributory and non-contributory causes further muddies the waters.

Clearly, in the light of the above, the safety of any potentially hazardous procedure is improved if the procedure is conducted in a defined manner. The aforementioned "defined manner" is normally prescribed in writing in the form of a work or operating instruction written after considering the safety and relevance of the procedure.

This is clearly not the case with the end-user treatment of misfired detonators. Misfires have existed as long as there have been detonators and downhole explosives. From time immemorial they have been dealt with by "competent and experienced men" using methods and practices based on "best judgment". Experience, shrewd common sense and with good powers of observation were once deemed to be sufficient, but times have changed. Skepticism is the new watchword. Rule of thumb practices must go. Knowledge must be the new key.

It is probably "impossible" to provide a handbook covering all such eventualities and while there will always be uncertainty, if the necessarily broad guidance and advice set out in this document is followed, such hazards may be reduced.

The Accident Potential

The category of hazard assigned to a hazardous material is based on the nature of the material. The UN system sets out 9 classes of dangerous materials. Class 1 is exclusively assigned to explosives. The category is then further subdivided into 6 sub-divisions based on group characteristics, their accident potential and known explosive effects. Number and letter combinations are then assigned that best define these properties.

Detonators are classified as Category 1.1B explosives placing them firmly within the group of devices that contain primary explosives and possess a mass explosion hazard.

Safety and Manufacturing Criteria

Commercial detonators are manufactured to very high standards indeed. Qualification testing is rigorous in the extreme. There are impact, friction, thermal, electrical and electrostatic test regimes designed to ensure manufacturing, transport and end-user safety. In addition, every component must meet stringent specifications. Detonators must also meet the safety standards demanded by all national and - if intended for export - by international legislation as well. Explosive increments are pressed to eliminate any possibility of loose powders and any necessary anti-static measures are also incorporated. Provided they are used by trained and competent personnel, properly manufactured commercial detonators in good condition are entirely safe to handle. No health hazards are associated with their normal use.

Detonator Varieties

Enormous numbers of detonators are initiated around the world every day. Most of them will fall into one of the four categories discussed below:

By far the oldest design is the plain detonator for capped fuse. This type of detonator has, for both technical and historical reasons, a narrower diameter than its contemporaries. Although narrower, the 8D version contains an explosives column running almost the whole length of the tube. Despite its narrower shell it remains a full-strength detonator in all respects. The 8D instantaneous electric detonator (IED) is obsolete. There may a few still out there though so take heed. The fusehead requires only a few millijoules (mJ) of electrical energy to cause it to initiate and may, under certain specific conditions, also be susceptible to RF.

Next is the electric detonator, a designation which also includes the permitted coal mining delay detonator series. Electric detonators are "dumb detonators" and are not to be confused with **Electronic** detonators, which belong to a different family of initiators altogether. For instance, electric detonators are not programmable and rely on internal pyrotechnic trains for their timing, nevertheless, both instantaneous and delay variants are available.

The third group is made up of delay detonators designed to be initiated using shock tubing. They are sometimes referred to as "non-electric" or NONEL detonators. Once again, both instantaneous and delay varieties are produced.

Finally there are the EED's – **electronic** delay detonators. Each electronic detonator contains a highly accurate, electronic time delay system which once connected and activated allows each detonator to be addressed individually and even programmed in-hole to provide delay intervals accurate to less than 1 millisecond. The heart of most electronic detonators lies in their microchip based circuitry and integrated, energy storing capacitor(s). Unusually, an early iteration of the electronic detonators available in South Africa was manufactured with a shell molded from clear polycarbonate. It was possible to see inside, perhaps taking away some of the mystery. The system was, however, not programmable employing fixed delays instead. It was relatively successful, but was soon rendered obsolete and withdrawn.

Despite a wide range of shell lengths and initiating systems, the total mass of detonable explosives contained within each of the above detonator variants is fairly similar at around 1 gram. The exceptions are 6D plain detonators for capped fuse and permitted coal mining detonators, both of which are manufactured with base charges containing a significantly lower mass of explosives. Unfortunately even the reduced mass of explosives pressed within these variants offers little in the way of good news for those tasked with dealing with them. The loss of a mere 4 fingers vs the loss of the whole hand is hardly likely to make a victim feel particularly blessed.

Despite being carefully made and dependable in use, commercial detonators contain hazardous ingredients, which are, potentially at least, very dangerous. In the final analysis a detonator has, but one function, to explode violently. Detonators are therefore intended for use only by trained and competent personnel familiar with the hazards associated with such products.

Damaged Detonators

Unfortunately, commercial detonators that have suffered mechanical damage, up to and including blast damage can no longer be viewed or handled with the same degree of confidence as fresh units straight out of the box. The metal shell of a detonator provides far more than simply structural integrity so, if there is damage to the outside of the shell, then it almost certain that internal changes have also taken place. In such cases some or all the internal safety features may have been compromised.

Definition of a Misfired Detonator

Misfire: a misfire is defined as "Any explosives that, following initiation, have failed to explode". In the South African Occupational Health and Safety Regulations a misfire is defined as follows: **"A charge or part of a charge which, on initiation, failed to completely detonate or function, a dangerous condition".** A more comprehensive definition could also include the following additions "**The term misfire shall also include any detonator(s) - damaged or not - recovered from a muck-pile, discovered in the vicinity of a recently blasted face or retrieved at a processing plant**."

Causes of Misfires

Any detonator may misfire for any number of reasons. A very small percentage can result from faulty manufacture, poor soldering or welding, (possibly creating intermittent connectivity) incorrect pressing pressures and/or fuse-head damage. The vast majority though occur through human error and/or poor blasting practices.

Mishandling

Not only are misfired detonators hazardous, misfires are also expensive. Time that might be more profitably be spent elsewhere must be devoted to dealing with their extraction and subsequent destruction. Most misfire situations though could generally have been avoided by applying fit-for-purpose testing procedures combined with the necessary attention to detail and a whole lot of care. A truism around misfires states: *"By far the best way to address misfires is not to create them in the first place".* Once created though, any misfire is potentially dangerous. A misfired detonator can also be highly sensitive and may readily detonate if mishandled.

What exactly constitutes mishandling? It is a difficult question. One answer might be as follows:

Mishandling can be defined as any improper, incorrect or illogical activity which exposes those person(s) dealing with a misfired initiator to an increased risk of injury or death and/or additionally threatens existing facilities or infrastructure with destruction or damage.

Due to the range of uncertainties around the condition of any misfired detonator it is always best practice to treat such devices as **EXTREMELY UNSAFE**. Any misfired detonator may for a number of reasons have become unstable and might detonate very easily. Certain types of misfired detonator can be very dangerous indeed.

Unforeseen Detonation

Misfired detonators that have been subjected to the mandatory 30 minute time-out or re-entry period do not normally spontaneously explode. There has to be some type of triggering event. The triggering event itself can be and often is provided by the very person attempting to address the misfire. It can be impact, friction, exposure to heat, flame or incendiary sparks, an electrostatic discharge, a flow of electrical current or an adverse chemical reaction. If moved, tampered with, struck, subjected to friction, heat or an electrostatic discharge, a misfired detonator can explode violently and without warning. Entirely circumstance dependent, their unforeseen detonation can lead to any or all of the following:

- Single or multiple death(s)
- Traumatic amputation
- Puncture wounds
- Lacerating wounds
- Blood loss
- Hearing loss or damage
- Destruction or damage to plant, equipment or infrastructure

Damage

It must be understood from the start that physical damage to a detonator is no small thing and must never be ignored. That a damaged detonator is a dangerous detonator must always be the assumption. This is because the internal condition of a damaged detonator is always unknown. On-board safety mechanisms may have been altered, destroyed or rendered intermittent. Worse, the stability of delay and explosive trains can no longer be assured.

For instance, moisture ingression may have occurred. The presence of moisture inside a detonator can lead to undesirable chemical reactions, especially if the shell of the detonator is manufactured from copper or a copper alloy. In the case of electric or electronic detonators, the presence of moisture can even create temporary electrically conductive

That primary explosives are toxic is true, but they are also extremely sensitive to impact, friction, flame and electrostatic sparks and can detonate if so stimulated. Unless the base portion of the tube or shell is broken off completely, this type of damage often results in the creation of a "hinge" at the point where the 2 sections of shell are still joined. Should any primary explosives be trapped within this area then any movement of the damaged detonator causing the "hinge" to open or close can result in immediate detonation.

The Shrapnel Hazard

The "business end" of a detonator lies at the closed end of its metal tube. In most detonators (the exception being the 8D plain detonator for capped fuse) the increments making up the base charge exist as a ca 25 mm long, pressed column. When caused to initiate a detonator will explode violently, producing a bright orange/white flash and an extremely loud and, if a person is nearby, a potentially ear damaging bang. The energy released upon detonation is enormous and may be accompanied by thousands of high-velocity metal fragments most of which once made up the detonators' metal shell. A single detonator fired centrally within an empty 1 liter capacity steel paint can is lesson enough. In a fraction of a second the once pristine and smooth walls of the can are blown apart. The steel sheeting has been instantaneously transformed into a number of perfectly functional cheese-graters. The damage results from both the pressure wave and the metal fragments punching cleanly through the tins' once-confining steel walls. In a similar manner, if the closed base section of a detonator should detonate whilst enclosed within a closed human fist, traumatic amputation of several fingers is the best a victim could hope for. The collateral damage to any nearby soft tissue by high-velocity metal shrapnel may also be extensive. In the case of an (unexpectedly) exploding detonator, the further away you are, the safer you are likely to be.

Detonators possessing a copper shell present an even more significant shrapnel hazard. This is caused not only by the high initial velocity of the fragments, but because copper is so dense, the added momentum possessed by those fragments. In the case of a single copper shelled detonator, the danger zone may extend out to 10 meters. In addition the metal fragments tend to be particularly sharp. Exposure to the type of high velocity shrapnel emitted by copper shelled detonators generally results in multiple puncture wounds accompanied by deep lacerations of any exposed tissue. This may be accompanied by copious bleeding. Deeply penetrating punctures and embedding of metal particulates may also result.

Safety Critical Behaviors

"Don't Create Misfires In The First Place"

- Do obey all laws and regulations both national and local.
- Do not handle explosives at all unless you are competent (trained and passed out) to do so.
- Don't use product that is out of date and never use detonators that show signs of abuse, tampering or damage.
- Do not tamper with, dissect or attempt to gain access to the internal components of any detonator
- Do check each detonator assembly for damage before inserting it into the hole.
- Don't use electric and electronic detonators or employ detonators from different manufacturers in the same blast.
- Use only the blasting equipment, blasting cable and/or harness wire recommended by the manufacturer for the type of detonators being used.
- There are a number of different variants of electronic detonators available and although they may all look very similar, don't be misled, they may not be compatible at all. Be careful not to mix up the different types.
- Do not log, tag, charge, lace, program or connect any initiating system unless fully competent to do so (this means trained, passed out and signed off) as it is vital that you understand the initiation system you are using.
- Always treat, store and handle all detonators with care.
- Never allow detonators to be exposed to direct sunlight or high temperatures for extended periods.
- Avoid driving over wires or connections and be on guard against any mechanical damage to closure plugs, shock tubes or leadwires that might result in the ingress of aggressive or electrically conductive liquids.

Post Blast (Misfired Detonators)

DON'T BET YOUR LIFE ON A MISFIRE:

Don't attempt to investigate a misfire too soon. First of all "Recognise the Danger" then put into practice these basic safety guidelines:

◊ Know the type of detonator you are dealing with. Understand how it works and the specific hazards associated with its type. (if unsure contact the manufacturer for assistance and training)

◊ Beware of unsafe acts

◊ Be intelligently cautious.

◊ Do not proceed if unsure.

◊ Don't take shortcuts.

◊ Have a plan should the situation change.

- No further work shall be undertaken in the area of the misfire except that undertaken to address or remove the misfire hazard.
- All mandatory work or operating instructions detailing how such work should be carried out is available and are being followed.
- Ensure that adequate and detonator-specific training has been received and is still up to date.
- Safe handling procedures have been recently refreshed.
- The requisite re-entry period has fully elapsed.
- Approved PPE, including suitable eye protection is available and being worn correctly.
- All personnel in the area have been advised that a misfire has occurred (remember to be on guard against accidental or unauthorised entry by other possibly uninformed personnel).
- Wherever possible any approach to the misfire should be made from the closure plug (mouth) end of the detonator.
- Avoid moving or disturbing the device.
- Clearly mark its location.
- Do not attempt hide or relocate any misfire – even if you genuinely intend to come back later and deal with it.
- Do not tread on the device or subject it to any form of pressure.
- Always record and follow up on every misfire - not only in an effort to identify its cause, but so that suitable steps can be taken to prevent reoccurrence.
- If the misfire is an electric or electronic detonator, has the power source, shot exploder, blaster or blast key been removed and is it in your possession?
- The firing cable been disconnected and if still capable of communication or delivering energy, additionally shorted or shunted out.
- Walkie-talkies, cellphones or other RF devices are forbidden within 10 meters of a misfire regardless of type. (*Do not operate any radios. A handheld 2-way radio is capable of generating a transmission burst of close to 5 watts. This is potentially sufficient energy to fire some fuseheads. The use of such a device close to electric detonators or their firing cables is strictly forbidden. Cellular telephones are also capable of 2 watt pulses during normal operation and are also forbidden. The battery charging terminals on both two-way radio's and cellular phones may carry current sufficient to accidentally fire detonators. Keep them away from all detonators).*
- Lightning. You can never tell where or when lightning is going to strike. Flashes of lightning going to earth can set up momentarily high potentials
- Always work with minimum quantities of explosives. Be aware that bringing additional explosives close to a misfire, does, in the event of an unplanned or accidental initiation, increase the injury risk. For this reason the use of detonating fuse, boosters or other means of locally supplementing or increasing the available explosives mass should be avoided.
- Don't place misfired detonators where they create a hazard for other employees
- Avoid the accumulation of misfired detonators. The more explosives, the bigger the bang.
- Do not subject any misfire to abuse. Avoid excessive impact or friction and never attempt to re-use any misfired device.

- Don't attempt to straighten a bent detonator.
- Don't hand, toss or throw a misfired detonator to any other person.
- Don't put a misfired detonator into a pocket or within your clothing.
- Don't take explosives home.

Shrapnel holed detonators

An example of a shrapnel-holed shock tube detonator

Do not add additional explosives to any misfired and especially shrapnel-holed detonators either by taping misfired detonators together, wrapping them in detonating fuse, or by introducing blasting explosives.

Always treat shrapnel damaged detonators with extreme caution. In the case of electric or electronic detonators be aware that an unfired and mechanically unsound fusehead can potentially be initiated by stray electrical energy or an electrostatic discharge, but certain rare types of damage can dramatically enhance sensitivity.

Be aware that any detonator which visually deviates from the norm may be potentially hazardous. It is not always known what effect a particular abnormality may have on the properties of the detonator. Treat all non-conforming devices with **EXTREME** care.

Mechanical damage to a detonator's metal shell can include anything from minor dents, chemical corrosion, holes or splits in the shell, bends, shrink-wrapping, (a term implying the total collapse of the detonator shell usually due to excessive shock coupling) partial fracture and even complete bisection of the shell. Damage can result from tampering or deliberate abuse, poor blasting practice a term which includes improper application and/or, missed or incorrect connections. The practice of leaving unwanted initiators at the base of any face being blasted is an unsatisfactory method of disposal and one that frequently results in blast or fly-rock damaged detonators becoming buried in the muck pile. They usually re-emerge later to present a real and ongoing threat to personnel.

Do not tamper with, attempt to dissect or insert any tool or article into any shrapnel-holed detonator or any detonator for that matter.

Do not shake, hit or throw any shrapnel holed detonator

Do not bring or otherwise store any shrapnel damaged detonator closer than 10 meters from any other detonators or explosives as a strike by high velocity shrapnel can cause initiation.

Be aware of the enhanced sensitivity to electrostatic discharge shrapnel damaged detonators may possess. Do not introduce electrostatically generating materials like plastic bags, plastic tape or other non-conductors within 5 meters of any shrapnel-holed detonator. Because the protective walls of its metal enclosure no longer fully coherent, an electrostatic discharge directly to the sensitive internal components becomes possible. In the case of electronic detonators a typical microchip contains thousands of transistor junctions. The tracks printed onto and within a chip are a micron or so wide. When

Do not add additional explosives to any misfired and especially shrapnel-holed detonators either by taping misfired detonators together, wrapping them in detonating fuse, or by introducing blasting explosives.

Always treat shrapnel damaged detonators with extreme caution. In the case of electric or electronic detonators be aware that an unfired and mechanically unsound fusehead can potentially be initiated by stray electrical energy or an electrostatic discharge, but certain rare types of damage can dramatically enhance sensitivity.

Be aware that any detonator which visually deviates from the norm may be potentially hazardous. It is not always known what effect a particular abnormality may have on the properties of the detonator. Treat all non-conforming devices with **EXTREME** care.

Mechanical damage to a detonator's metal shell can include anything from minor dents, chemical corrosion, holes or splits in the shell, bends, shrink-wrapping, (a term implying the total collapse of the detonator shell usually due to excessive shock coupling) partial fracture and even complete bisection of the shell. Damage can result from tampering or deliberate abuse, poor blasting practice a term which includes improper application and/or, missed or incorrect connections. The practice of leaving unwanted initiators at the base of any face being blasted is an unsatisfactory method of disposal and one that frequently results in blast or fly-rock damaged detonators becoming buried in the muck pile. They usually re-emerge later to present a real and ongoing threat to personnel.

Do not tamper with, attempt to dissect or insert any tool or article into any shrapnel-holed detonator or any detonator for that matter.

Do not shake, hit or throw any shrapnel holed detonator

Do not bring or otherwise store any shrapnel damaged detonator closer than 10 meters from any other detonators or explosives as a strike by high velocity shrapnel can cause initiation.

Be aware of the enhanced sensitivity to electrostatic discharge shrapnel damaged detonators may possess. Do not introduce electrostatically generating materials like plastic bags, plastic tape or other non-conductors within 5 meters of any shrapnel-holed detonator. Because the protective walls of its metal enclosure no longer fully coherent, an electrostatic discharge directly to the sensitive internal components becomes possible. In the case of electronic detonators a typical microchip contains thousands of transistor junctions. The tracks printed onto and within a chip are a micron or so wide. When these are struck by an electrostatic discharge, the tiny metal tracks and junctions undergo a massive and usually catastrophic meltdown. It all happens in but a moment.

Electrostatic Hazards

One world class electronic detonator design, no longer in production, successfully replaced the conventional fusehead technology of the time with a series of integrated "hotspots." Today, most if not all, electric and electronic detonators contain fuseheads.

Static electricity is a well-known phenomenon which can result in high voltage sparking when objects are in close proximity or touched together. The electrostatic cycle is Generation, Accumulation, Discharge.

3. Hazardous conditions can exist were an electrostatic discharge passes through any electrically sensitive material or system. When conditions are right, sufficient energy to fire certain unprotected types of fusehead can easily be accumulated by equipment and personnel. ANFO blow-loading operations for instance are notoriously prone to generating static. Detonators fitted with fuseheads are therefore not used with blow-loaded ANFO.

4. When using any electrically operated detonator there is always the potential for it to being prematurely fired by electromagnetic radiation, (RF) stray electrical currents or electrostatic discharges. It is also theoretically possible for an electrostatic spark generated by a human being to initiate misfired or damaged electric or electronic detonators, shock tubing and even shock tube detonators.

5. The use of high pressure air for any purpose should be avoided in the vicinity of misfired or damaged detonators as its use can result in electrostatic discharges.

6. Clothing made from synthetic materials and rubber soled and other types of non-conducting footwear are not suitable for controlling static electricity and should not be worn by personnel engaged in the handling, storage or use of

Do not add additional explosives to any misfired and especially shrapnel-holed detonators either by taping misfired detonators together, wrapping them in detonating fuse, or by introducing blasting explosives.

Always treat shrapnel damaged detonators with extreme caution. In the case of electric or electronic detonators be aware that an unfired and mechanically unsound fusehead can potentially be initiated by stray electrical energy or an electrostatic discharge, but certain rare types of damage can dramatically enhance sensitivity.

Be aware that any detonator which visually deviates from the norm may be potentially hazardous. It is not always known what effect a particular abnormality may have on the properties of the detonator. Treat all non-conforming devices with **EXTREME** care**.**

Mechanical damage to a detonator's metal shell can include anything from minor dents, chemical corrosion, holes or splits in the shell, bends, shrink-wrapping, (a term implying the total collapse of the detonator shell usually due to excessive shock coupling) partial fracture and even complete bisection of the shell. Damage can result from tampering or deliberate abuse, poor blasting practice a term which includes improper application and/or, missed or incorrect connections. The practice of leaving unwanted initiators at the base of any face being blasted is an unsatisfactory method of disposal and one that frequently results in blast or fly-rock damaged detonators becoming buried in the muck pile. They usually re-emerge later to present a real and ongoing threat to personnel.

Do not tamper with, attempt to dissect or insert any tool or article into any shrapnel-holed detonator or any detonator for that matter.

Do not shake, hit or throw any shrapnel holed detonator

Do not bring or otherwise store any shrapnel damaged detonator closer than 10 meters from any other detonators or explosives as a strike by high velocity shrapnel can cause initiation.

Be aware of the enhanced sensitivity to electrostatic discharge shrapnel damaged detonators may possess. Do not introduce electrostatically generating materials like plastic bags, plastic tape or other non-conductors within 5 meters of any shrapnel-holed detonator. Because the protective walls of its metal enclosure no longer fully coherent, an electrostatic discharge directly to the sensitive internal components becomes possible. In the case of electronic detonators a typical microchip contains thousands of transistor junctions. The tracks printed onto and within a chip are a micron or so wide. When these are struck by an electrostatic discharge, the tiny metal tracks and junctions undergo a massive and usually catastrophic meltdown. It all happens in but a moment.

Electrostatic Hazards

One world class electronic detonator design, no longer in production, successfully replaced the conventional fusehead technology of the time with a series of integrated "hotspots." Today, most if not all, electric and electronic detonators contain fuseheads.

Static electricity is a well-known phenomenon which can result in high voltage sparking when objects are in close proximity or touched together. The electrostatic cycle is Generation, Accumulation, Discharge.

3. Hazardous conditions can exist were an electrostatic discharge passes through any electrically sensitive material or system. When conditions are right, sufficient energy to fire certain unprotected types of fusehead can easily be accumulated by equipment and personnel. ANFO blow-loading operations for instance are notoriously prone to generating static. Detonators fitted with fuseheads are therefore not used with blow-loaded ANFO.

4. When using any electrically operated detonator there is always the potential for it to being prematurely fired by electromagnetic radiation, (RF) stray electrical currents or electrostatic discharges. It is also theoretically possible for an electrostatic spark generated by a human being to initiate misfired or damaged electric or electronic detonators, shock tubing and even shock tube detonators.

5. The use of high pressure air for any purpose should be avoided in the vicinity of misfired or damaged detonators as its use can result in electrostatic discharges.

6. Clothing made from synthetic materials and rubber soled and other types of non-conducting footwear are not suitable for controlling static electricity and should not be worn by personnel engaged in the handling, storage or use of misfired electric or electronic detonators. Conducting footwear and cotton clothing is always the recommended option.

7. There are also dangers associated with plastic self-adhesive tapes such as parcel tape, box tape or electricians tape when they are used in conjunction with misfired/damaged detonators. These hazards are generally poorly understood and are rarely more than outlined in the available literature. A number of different literature references do though exist which describe incidents where the use of plastic adhesive tapes with electric detonators have led to the loss of life or limb. Please be very aware of the electrostatic hazard that plastic self-adhesive tapes might represent when used in conjunction with static sensitive explosives and / or misfired or damaged detonators. The use of a paper tape such as masking tape is the recommended alternative.

8. Lightning is a hazard with most initiators and many explosives. Radio waves (RF) and stray electrical currents can also provide a means of initiation. Misfired or damaged detonators may be more sensitive than normal to initiation by such mechanisms. The RF hazard may be minimised by prohibiting cellular phones, walkie-talkies or other potential RF transmitters from operating within 20 meters of any misfired or damaged detonator.

9. A capacitor is a device for storing electricity. Some varieties of electronic detonators contain a small, but high-quality tantalum capacitor that only becomes charged during the final firing cycle. The possible presence of a charged capacitor needs to be taken into account should misfires or damaged detonators be discovered later. In the case of an undamaged electronic detonator, protection structures at the rear of the board provide a preferential discharge path to the copper shell and also act to prevent any electrostatic discharge reaching the fusehead via the shell. In some designs, additional electrostatic protection is provided by a special insulating sleeve that surrounds the fusehead.

ACKNOWLEDGEMENTS

Dawie Mynhardt

Director ,BME

Dr Mike du Plessis

Expert Panel

Denise Clarke

Homeland Security Qualifications

Andy Begg

Individual Associate

Tony Rowe

Retired from AELMS