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From the Secretary General's Desk

2018 is already on a downwards slope to December and the year end. The seasons are changing, the climate is changing, business is changing, are we as an industry adapting fast enough to ensure a safe future for the next generation/s. Are we developing new products and processes that changes the whole safety environment in a much more positive manner? Our industry is historically a very conservative one in adopting anything "new". Electronic detonators were developed in the late 1980's and only really made headway as a technology over the last decade and a half. Cutting edge technologies are being developed, is our industry ready to look at applications like 3D printing, printed electronics, printed pyrotechnics, cutting edge primary and secondary explosives etc, to replace historical processes and products. These are potentially safer and more environmentally friendly technologies. Is our industry prepared to invest capital to develop a new world of commercial explosives?

Over the last quarter only one incident notification has been filed:

- IN18-07 HMX Explosion in India.

Some more details are supplied on the truck explosion in June 2018 in Benxi City in China.

Unfortunately, there has also recently been a tragic accident at one of our member companies in South Africa, SAFEX would like to take this opportunity to extend our condolences to this company and all the people affected and extent to them an offer of assistance should they require it. Incidents in this industry has an impact on all dealing with explosives and each of us should do some introspection and review our own operations to ensure safety standards are maintained.

SAFEX CONGRESS XX
SALZBURG 2020

24 MAY TILL 30 MAY 2020

Remember the motto: No harm to anybody ever!

Please let me have reports on all your incidents and critical near misses. Remember that the learning from any incident potentially saves lives and business interruption. If you are in doubt as to what to report, please contact me.

In this issue we continue with our SMS series and explain how **Training** and **Emergency Systems** contribute to safer operations. We also touch on burning ground issues under the "Did you know" series. SAFEX would like to build on this burning ground article by asking you, to supply us with your thoughts on burning ground control and operation. Remember we are here to learn from each other! The history around UN classification and current issues makes for interesting reading. A short insert on Maritime Shipping of explosives is followed by Tony's Tale Piece with an interesting take on the history of capped fuse and detonating cord.

A reminder that the eLearning Portal is now available with immediate effect to everybody through a slight increase in your annual fee. Please feel free to contact me for details and access-it is a valuable component in your training toolbox

Update on the June 2018 Truck Explosion in China

Presented by Andrea Sánchez Krellenberg

"The government issued an investigation about this accident at the end of August. The report from Liaoning province State Administration of Work Safety（SAWS) is available, but in Chinese.

Location and time of the accident: The accident was happened in Benxi City of Liaoning Province (northeast China), the time is 16:00, June 5, 2018.

Consequence of the accident: 14 fatalities, 10 injured, direct economic loss: 47230K RMB, it's about 6.3 M euros.

Punishment: Blasting work permit of blasting company TX was abolished, and 5 million CNY penalty. Temporary suspension of HM construction company's work permit and 5 million CNY penalty. Mine company LX got 4 million CNY penalty. 12 directors and managers of TX, HM and LX companies were prosecuted for their criminal liability.

Direct reason of the accident: Blasting company TX transferred 23 boxes emulsion explosive and 385 detonators to SSL iron mine of LX mine company. According to Chinese regulation, TX company is responsible for transportation, storage, blasting and cleaning service. But they asked the SSL mine project department of HM construction company to do above work, SSL mine project department doesn't have a work permit to do above work. When operators of SSL mine project department of HM construction company were moving emulsion explosive to underground with a bucket, some operator threw detonators into the bucket, the detonators crashed on the inner wall of bucket and were initiated, and then the exploded detonators initiated explosives".

Fifty years of explosives classification

By

Ken Price

As part of the current review of Chapter 2.1 of the Globally Harmonised System (GHS), (the chapter that sets out labelling requirements for explosives) the Explosives Working Group of the United Nations Subcommittee on Transport of Dangerous Goods and others are regularly referring to the "Transport Classification System". By this we mean the classification system in the United Nations Model Regulations for Transport of Dangerous Goods.

As GHS applies to all stages of the life cycle of chemicals (including explosives) it seems a little incongruous that a transport classification system should be the basis of classification for storage and other stages of an explosive's life cycle. In fact, recognising this, some jurisdictions have developed separate classification systems for explosives storage and transport.

This paper gives a potted history of the origin of the United Nations classification system that is the basis of most classification systems, world-wide.

To paraphrase an email from Evan Bale, recently retired Inspector of Explosives, UK:

In the Olden Days, the UK Explosives Act 1875 introduced a system for the Authorisation of explosives based on chemical make-up or specific types (eg, Nitro-based mixtures, Ammunition, Fireworks). This system was used in most Commonwealth countries.

Explosives were also assigned a Category and this was used to determine the separation distance required between public places and explosives factories and magazines. I don't know when this system was introduced and suspect it was developed later than the Authorisation scheme as gunpowder manufacture declined and other explosives were introduced. The Categories were:

- *Category X - Explosives having fire or slight explosion risk or both, with only local effect.*
- *Category Y - Explosives having a mass fire risk, or moderate explosion risk but not mass explosion risk.*
- *Category Z - Explosives having a mass explosion risk with serious missile effect.*
- *Category ZZ - Explosives having a mass explosion risk with minor missile effect.*

This comes from a 1941 guide to the Explosives Act, which had no clarification of what is meant by 'slight' or 'moderate explosion',' local effect' or 'serious missiles' nor does it explain how the categories were developed.

Thus, for non-military explosives, there was effectively a two part classification system.

Explosives were put into one of seven classes based on their chemical makeup of the explosive (Gunpowder, organic nitro-based, inorganic nitrate based, azide types and so on).

And each explosive was categorised according the effect it produced when it exploded: X, Y, Z and ZZ. The former was used to group explosives with like chemical properties and the latter was used to set safety distances.

American Table of Distances (ATD)

The following is gleaned from the IME publication of the American Table of Distances 2004 and the US Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF).

From 1909 studies were carried out in the bUSA to develop safe distance guidelines for separating explosives magazines from rail lines on the basis that foreign regulations were not suitable for the conditions in USA. The resulting ATD was based on data gathered from explosions around the world over the previous 50 years and was published in 1910. It has been refined numerous times since then: to allow for barricades; to make provision for separations to manufacturing plants, dwellings and roads; to include military explosives; to differentiate between property damage and personal safety; and then to recognise different traffic volumes on highways. The IME version of the ATD uses the uniquely American explosives categorisation system and is not designed to accommodate varying explosives characteristics, however the IME ATD and more refined tables for "low" explosives are published in the ATF explosives regulations.

Military Involvement

The British based system of classification considered both the chemical properties of the explosives, (primarily to address how it should be handled and used) and the potential effects of a premature explosion (important for storage). However, there was a third major element that needed consideration, which was primarily of interest to military users of explosives.

Civilian users avoid introducing initiating explosives (detonators) until the last possible time in the sequence of preparing for a blast. But military explosives are regularly and routinely stored and transported containing their own means of initiation. And this impacts on the classification system.

International Harmonisation.

The modern history of explosives classification (for the purpose of setting storage conditions) started with the publication of NATO Storage Guidelines in 1963, (AC/106-D/5 dated 1 September 1963). Prepared by a Restricted Sub-Group, **AC/106,** consisting of representatives of France, Germany, the United Kingdom, and the United States, these experts, meeting as specialists and not as national representatives, made a study of the systems used in France, the United Kingdom and the United States which took into account national trials and an analysis of archives relating to damage from accidental explosions or acts of war. This attempt at consolidation involved each member working outside the scope of some of his own nation's regulations.

The four specialists of the Restricted Sub-Group who drew up the original document were reconstituted in 1964 as the **AC/74** Restricted Sub-Group of Experts on the Storage of Ammunition (STORAM) to supplement the document. This task included revision of the original document and completion of annexes on hazard classification tests, storage on military airfields, storage in ships and barges and underground storage. AC/106-D5(Revised) was issued in 1965.

Soon after this, NATO started to show an interest in safety while transporting explosives. The Group of Experts on the Safety Aspects of Transportation and Storage of Military Ammunition and Explosives **(AC/258)** was created in 1966 to continue the classification work. A Storage Sub-Group, set up under its aegis with broader representation, prepared a new revised version published under reference AC/258-D/70 dated December 1969. This was a very full document, including both the basic principles from the original document and recommendations dealing with special cases such as storage on military airfields, on board ship, underground, in the vi cinity of petroleum products or near radio transmitters. The Quantity - Distance (Q/D) Tables were produced in a new format, using metric units only, in order to simplify the presentation. Certain corrections and rationalizations were introduced in the tables and in the criteria for Quantity Distances. Smaller intervals were introduced in the values of explosives quantity to eliminate the need for frequent interpolation and the consequent risk of mistakes. Values of Q/D were rounded off to give uniform precision of about 1%. This eliminated cases of unduly large errors in the small distances in the original tables.

AC/258 had always hoped that the various national storage regulations would be harmonized on the basis of the principles in its own storage document (AC/258-D/70). Therefore in 1970 the Conference of National Armaments Directors (CNAD), on the recommendation of the Group, formally invited nations to adopt the principles, in whole or in part, as the basis of their national regulations as a matter of policy. Over the next few years various member nations made declarations of intent or firm commitments.

In many cases, however, the timing of the change was linked to another innovation, the adoption of the International System of Classification of Explosives formulated by the **United Nations Group of Experts on Explosives** which dealt with the safety of both military and civil explosives during transport. The **AC/258** Group adopted the UN system of compatibility groups as an amendment to the storage document in 1971. Evidently the ultimate degree of standardization could not be achieved until the International System of Classification as a whole was incorporated in the storage document. This involved replacing the NATO hazard classes by the divisions of the UN explosives class.

International System of Classification of Explosives

Information on the United Nations classification system is documented in the United Nations Recommendations on Transport of Dangerous Goods (the Recommendations) and the reports of the various subcommittees that developed the system. The classification descriptions below are extracted from the published Recommendations from 1964.

Over the years, from the 1960's the Recommendations have developed and changed. Some of the salient points are set out below.

Class 1 in 1964.

The 1964 Recommendations stated:

"An explosive is a substance, whether or not contained in a device specially prepared, manufactured with a view to produce a practical effect by explosion or a pyrotechnic effect, or any other substance which, by reason of the nature of its explosive properties, is to be treated as such, provided that for the purpose of this definition:

(a) an explosive atmosphere of gas, vapour or dust shall not be considered to be an explosive; and

(b) that substances listed in a class other than class 1 should not be deemed to be explosives.

At this time, Class 1 comprised three divisions with five subdivisions:

Division 1.1 Explosives with a mass explosion risk

1.1.1 Initiating explosives; contrivances which contain both explosives and their own means of ignition.

1.1.2 Explosives substances, other than initiating explosives; contrivances containing explosives but not their own means of ignition.

1.1.3 Contrivances designed to produce illumination, incendiary, smoke or sound effects; igniters; starter cartridges; small arms ammunition; fireworks liable to explode violently.

Division 1.2 Explosives which do not explode *en masse*[1].

1.2.1 Contrivances containing explosives with or without their own means of ignition.

1.2.2 Samples of explosives other than initiating explosives.

Division 1.3 Explosives having a fire hazard with minor or no explosion effects.

Explosives substances and articles in this division include:

- Firstly, substances which cannot explode en masse, but the ignition of which gives rise to considerable heat radiation,
- Secondly, articles which, by their nature or as a result of the manner in which they are packed, cannot explode en masse, but which, in the event of fire, burn one after another producing minor or no explosion or projection effects.

Notes – points of interest

- The terminology has many phrases not seen today such as contrivances, and *en masse*.
- Small arms ammunition and blanks are classified as mass explosive so are in Division 1.1.
- Under the split between mass explosive/non-mass explosive there was emphasis on whether or not the article or material contained its own means of ignition. I believe this is a reflection of the needs of the military because, as a regulator of civil explosives, it was extremely rare and actively discouraged that explosives be transported or stored with a means of ignition.

Class 1 in 1966.

One major change was made in the 1966 edition.

[1] A load was said to explode *en masse* when the explosion affects the entire load almost instantaneously.

A new clause was added to the definition of explosive:

"The following shall not be deemed to be explosives… devices containing explosive in such small quantity or of so mild character that their inadvertent or accidental ignition during transport shall not cause any external manifestation either by fire, smoke or heat or loud noise or by visible damage to the outer packaging."

Notes – points of interest

This appears to be the first recognition of what we might now consider to be *de minimus* explosives or 1.4S explosives. The subcommittee appears to be recognising that some materials may contain explosive contents but they should not be subject to regulation. This brings to my mind such things as safety fuse (which contains gunpowder), maybe fuse ignitors of various sorts, possibly some fireworks.

Class 1 in 1970

There were two big changes in the years to 1970.

- One was the introduction of Division 1.4 – so called "safety" explosives that present no significant hazard.
- The other saw the first mention of compatibility groups as a means of minimising the risk of either significantly increasing the probability of initiation or the magnitude of an effect. These compatibility groups were incorporated into the NATO guidelines around that time.

Thus, in the 1970 publication, Divisions 1.1 and 1.2 remained the same as 1966.

There was a minor change to Division 1.3 simply to emphasise that explosives in this division would not mass explode.

A new hazard division was added:

Division 1.4 Explosives which present no significant hazard

1.4.1Items in this subdivision are so packed or designed as to present only a small hazard in the event of ignition during transport. The effects are largely confined to the package and no projection of fragments of appreciable size of range is to be expected. An external fire would not cause mass explosion of the package.

1.4.2(Safety). Items so packed or designed that any explosive effect during transport is confined within the item or package.

Issues of interest in 1970

- Division 1.3 continues to use discursive text without subdivisions.
- The concept of "safe" explosives, introduced in 1966, is refined with Division 1.4.
- There is reference to a test method to determine mass explosion risk. The test method was included in an appendix, it was covered in less than three pages and it was the precursor of the Series 6 tests. There was a test on an inner package, a packaged (for transport) article test, a multiple package test and a fire test.
- There are two pages of "Suggestions regarding the segregation between the different kinds of explosives". These Suggestions described the 12 compatibility groups (A-L and S) and gave guidance about stowage across different hazard divisions. There was a further suggestion that compatibility groups could be displayed on labels. The compatibility groups were adopted into the NATO codes at this time.

1970-1976

This appears to be a period of significant change in the activities and output of the Committee of Experts. Its 1973 publication was simply a supplement to the 1970 edition and both had several lists of dangerous goods: alphabetical, alphabetical by class and numerical in order of serial numbers. Each list had supplementary information, particularly the explosives lists which had started to introduce compatibility groups. And all the publications up to 1973 appear to be simple copies of the original typed documents. It must have been a nightmare for the secretariat managing cross references in the multiple lists.

Class 1 in 1976

The 1976 edition is the first in an orange cover – the first Orange Book (ST/SG/AC.10/1). It was typeset for printing and included a preface explaining how to find specific recommendations for a substance or article. The explanation guided the reader to the alphabetical index to find the UN Number. Chapter 2 then contained the list in numerical order, a form not unlike the current list.The general definition of explosives was unchanged from 1966.

A new hazard division was added: Division 1.5, very insensitive explosives substances. [Wouldn't it be nice to be able to go back to that time and keep what are now 1.5 explosives in division 1.1 as a "very insensitive" hazard division 1.1 category with other mass explosives. By doing that perhaps like hazards could be grouped and risk levels treated separately.]

The explosives list (UN numbers 0001 to 0343) included the Proper Shipping Name, Class, hazard division and Compatibility Group, Special Provisions and the reference to the packing method.

To find information like how to classify, what tests to do and how to do them there was a chapter with special recommendations relating to class 1; the fore-runner of the Manual of Tests and Criteria.

Particular issues of interest in the 1976 Edition

There was a significant change in the hazard divisions with no subdivisions.

All references to the presence or absence of the means of ignition are tied to the compatibility groups.

Division 1.1 Explosives which have a mass explosion hazard

(A mass explosion is one which affects virtually the entire load practically instantaneously);

Division 1.2 Explosives which have a projection hazard but not a mass explosion hazard;

Division 1.3 Explosives which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard.

Explosives in this division comprise:

(a) those which give rise to considerable radiant heat; or

(b) those which burn one after another, producing minor blast or projection effects or both;

Division 1.4 Explosives which present no significant hazard

Explosives in this division are so packed or designed as to present only a small hazard in the event of ignition or initiation during transport. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire must not cause practically instantaneous explosion of virtually the entire contents of the package;

NOTE: *Explosives in this division which are so packaged or designed that any explosive effect during transport is confined within the package except when an external fire has degraded this packaging, are in Compatibility Group S (Safety explosive)*

Division 1.5 Very insensitive explosive substances

This division comprises explosive substances which are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport. As a minimum requirement they must not explode in the fire test;

NOTE: *The probability of transition from burning to detonation is greater when large quantities are stowed in the hold of a ship, and this fact may have to be taken into account.*

2017

From 1976 to 2017 there was hardly any change to the classification system.

Some clarification was added to the description of 1.4 to make it clear that any accidental effects should not hinder fire fighting or other emergency response.

And hazard division 1.6 was added in that time: Extremely insensitive articles which do not have a mass explosion hazard

So What?

This is one of the few papers I have written without any need for a hard conclusion or recommendations. Just a simple history paper. But if you have managed to come this far, some questions for after class.

1. In the workplace, does a classification of a single detonator mean anything other than that it is explosive?

2. Similarly for a cartridge of blasting explosive or a reel of detonating cord.

1. What would be the consequences of changing the classification system to something like:

1.1 mass explosive hazard. (articles or substances, sensitive or not, with or without projectiles). E.g blasting explosives, most military ammunition, fireworks in freight containers.

1.2 projection hazard but not a mass explosion hazard. E.g. some military ammunition, rockets;

1.3 fire hazard but not mass explosion hazard, e.g, some smokeless powder,

1.4 minimal hazard. E.g. small arms ammunition, blanks, small fireworks.

Acknowledgments

Thanks to the Secretariat at the United Nations office in Geneva, particularly Rosa Garcia Couto and Olivier Kervella for access to the original documents back to 1964 and supplementary advice. (Papers prior to 1964 are stored in New York, but that's another story.)

Thanks to Evan Bale from the UK HSE for background information on the UK classification system.

Thanks to Brent Knoblett, US DoD for some leads to NATO papers.

CONTINUATION OF OUR SERIES ON SAFETY MANAGEMENT SYSTEMS

PART ONE BY ANDY BEGG

TRAINING

Training
Training is a topic that tends to be taken for granted when we see personnel going about their tasks on a day to day basis yet there have been many cases where following an incident or during an audit it is found that the personnel involved have either not been formally trained or were trained "a long time ago" but the process has changed during that period. These pitfalls can be avoided by implementing a formal training programme for all personnel from line operators to senior managers and specialists.

Basic principle:

Personnel will be formally trained in all tasks they are required to undertake, plant SHE rules and emergency procedures. Training will be validated and recorded.

Procedure for training

Scope

This procedure will be implemented to ensure that:

1. all personnel are aware of and understand the SHE hazards associated with the tasks they are required to undertake
2. all personnel are trained so that the tasks can be carried out with due regard for safety, health and environmental protection issues.
3. all personnel, contractors and visitors are trained in and understand the general SHE rules of the plant or facilities.
4. all personnel, contractors and visitors are trained in the plant emergency procedures and alarm system.
5. all personnel understand the hazards associated with the chemicals and materials handled
6. re-training is carried out on a regular basis

Contractors may need to be trained in specific procedures such as the local Permit to Work System and in such cases should receive the same level of training as employees.

Examples of the tasks that personnel may be required to be trained in include:

- Plant and equipment operating instructions or procedures.
- Hazard studies and risk assessments
- Permit to work systems
- Decontamination procedures
- Driving specialised vehicles such as fork lift trucks, explosives bulk delivery trucks and pumping units
- Hazards associated with chemicals
- Basis of Safety documents and practices
- Incident investigation

Training requirements

1. In many cases the training requirements will be based on detailed operating instructions.
2. Job training will include all potential sources of harm, how they will be avoided and consequences of failure to do the job safely.
3. The training will be given by someone who is competent to do so, for example an experienced co-worker, supervisor or external training specialist.

4. Once the trainer is satisfied that the person should be competent in the task, the trainer will observe the person carrying out the full cycle of the job and will test the knowledge of the person regarding the potential hazards and actions to take in the event of an emergency, if relevant.

On satisfactory completion of this, the person will be formally signed off as competent to carry out the task unsupervised with the exception of certain critical tasks that may require the person to be regarded as a trainee for a specified period of time. One such task could be Hazard Study Leader.

Training file

All personnel will have a personal training file that

1. Identifies the tasks in which they are required to be competent
2. Records their degree of proficiency in each with date assessed and date for subsequent retraining
3. Plans their future training programme to reach and maintain full proficiency

Special Situations

In certain cases, it may be necessary to re-train personnel within the specified period.

1. Where the task or equipment has been changed and the operating instructions have been changed.
2. Where the individual has been absent from the task for a lengthy period of time e.g. doing another job, long term illness etc.

In no case will any person be required to undertake a task in which he or she has not been given, or is in the process of being given, training.

Audit protocol

<u>**Training**</u>

1. Does the location have a training policy or standard that requires all personnel to receive training in the SHES aspects of every job or task they are required to undertake?
2. Does the location have a training plan or programme that includes all employees?
3. Is the training plan consistent with the location operations and requirements? For example:
    a. Ergonomics
    b. Chemicals hazards
    c. Basis of Safety
    d. Conducting Hazard Studies, Risk Assessments, Incident Investigations
    e. Decontamination of plant equipment
    f. Permit to Work
    g. Mine site safety
    h. Electrical safety
    i. Driving safety
    j. Visitors
4. Is training competency based and is trainees' understanding evaluated?
5. Is training provided by company personnel only or does it include training given by external resources?
6. Does the training include SHES and operational issues?
7. Are accurate training records kept for all employees?
8. Is re-training given on a routine basis?

9. Is the training plan updated annually?
10. Does the plan take account of new legislative and company requirements?
11. Is the plan regularly reviewed for progress against identified milestones or targets?

Inspection guide for the auditor

- Inspect the training plan
  - ◊ Does each employee have a personal training file? Is it up to date? Cross reference with the training plan requirements.
  - ◊ Has the previous year's training plan been completed and if not are there carry-on actions?
  - ◊ Does the training plan include internal and external training?
- On the plant or location select several individuals doing specific tasks and talk to them about their training
  - ◊ Have they been trained
  - ◊ When trained
  - ◊ By whom and how do they rate the training? Good, ok, poor?
  - ◊ Check in their training file to confirm that the file is correct
  - ◊ Ask some specific questions about the task they are undertaking to assess whether or not they have been adequately trained
    - For an explosives plant operator ask about some sources of ignition from the BOS document for the process, controls etc.
    - Was training given in correct PPE and its use?
    - For a vehicle driver ask what checks he does on a daily/weekly basis before using the vehicle, if a checklist is used ask to see it and do a double check that lights are working etc.
    - For personnel who do much company driving have they had defensive or advanced driver training?
    - For an operator on a mine ask about safety zones, hazards of working under a crest, precautions to be taken prior to re-entering after a blast, explosion hazards of the products being used, electro-static hazards
    - For an emulsion pump operator ask about hazardous conditions, no-flow pumping, hazardous conditions driver training
    - For a raw material store supervisor ask about hazards of incompatible materials – oxidizers/fuels, aluminium, sodium nitrite hazards
    - Truck operators – fall from height, sliding vehicle
    - Office worker – emergency procedure, emergency doors (keep access clear, nothing on outside to impede escape)
  - ◊ Ask personnel if they are aware of any recent incidents or the industry that could be relevant to their operation and what the recommendations were.
  - ◊ Ask about plant emergency procedures, date of last exercise
  - ◊ If there is work being carried out on the plant under the PTW procedure check signatories on the permit against training records
  - ◊ Ask what action would be taken if the person considered the task to become "unsafe" in their view.

PART TWO BY STEVE CALDWELL AND ANTONIN KAVARICH

EXAMPLE OF A TRAINING PROFILE COURTESY OF ORICA MINING SERVICES

Employee Employee

Plant / Site

No.	Skills
101	Employee Induction (C)
102	Orica Policy Review
103	WorldClass Induction
201	SHE Induction (C)
202	Right to know (USA) WHMIS (CAN) (C)
203	Accident/Incident Reporting
204	Fire Fighting
205	Emergency Planning (C)
206	Drug and Substance Abuse (USA) (C)
207	Manual Handling
208	MSHA - Basic (USA) (C) Employee Induction (C)
209	MSHA - Annual Update (USA) (C)
210	OSHA Training (USA) (C)
211	First Aid
212	CPR
213	Safework Permit
214	Accident Investigation
215	Change Notices
216	Defensive Driving
217	Blasting Safety
218	HM126/HM181 (USA) TDG (CAN)
219	Hazardous Waste Management
221	Respiratory Protection
222	Air Quality Testing
223	Hazwopper (USA)
224	Stairways and Ladders
225	Power and handtool Safety
226	T.E.R.P.S. (USA) TER (CAN)
227	Regulatory Compliance
301	Forklift Operations
302	Articulating Equip. Operation
303	Bulk Materials Handling
304	Quality Assurance Procedures
305	Safe Pumping / Explosives
306	Pump Maintenance
307	Emulsion Manufacture
308	Hot Solution Manufacture

Skills	No.
Fuel Blends	309
ANFO Manufacture	310
Packaged Blasting Agent MFG.	311
ANFO Truck Operation	312
Blend Truck Operation	313
Emulsion Truck Operations	314
ANFO Blower / Oiler	315
Hand-Bulk	316
Gassing System	317
De-Watering Truck Operation	318
Motorized Stemming Equip.	319
DOT (USA)	320
Vehicle Inspectors Cert. (USA)	321
Brake Inspectors Cert. (USA)	322
General Product Knowledge (C)	323
Customer Relations (C)	324
Truck Electrics	325
Truck Hydraulics	326
Blasting Operations	327
Drilling Operations	328
Clerical	401
Inventory Systems	402
Interpersonal MGT Skills	502
Communication Skills	503
Professional Selling Skills	504
Pro. Presentation Skills	505
Employee Management Skills	506
ISO 9002	507
Trainer / Mentor Cert.	508
Team Building for Managers	509
SHE Management	510
ICI Basic Explosives	511
Internal Audit Training	550
WorldClass Sales & Marketing	551

Continuous Improvement		1998				1999				2000				2001			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Competencies Accomplished	Plan																
	Actual																

- (red) Skill required but employee not trained and does not possess skill
- (blue) Employee "assumed" to possess this skill through on the job experience
- (orange) Employee has successfully completed training manual and has demonstrated this skill to the trainer

WorldClass

PART TWO BY STEVE CALDWELL AND ANTONIN KOVARICH

EMERGENCY SUPPORT SYSTEMS

In the last newsletter the need for emergency plans was discussed. Here we present some points to consider regarding systems that are needed to support emergency planning and assist emergency controllers. Some of these are:

ALARMS AND EMERGENCY LIGHTING

Emergency alarms should be powered by backup electrical systems to ensure they operate during power outages or when the normal power supply is damaged or disrupted.

Explosives manufacturing plants are normally required to have emergency lighting systems wired to a separate backup electrical supply such as standby generator or UPS for smaller plants. This is to provide lighting to ensure workers can find their way out of their buildings in the event of a fire or explosion. There are specific standards for these systems and for checking, testing and verification.

SYSTEMS TO ENABLE THE EVACUATION OF EXPLOSIVE PLANT ON THE APPROACH OF LIGHTNING STORMS

In some countries it is a requirement to evacuate explosives buildings in the event of the approach of a thunderstorm. The designers of plant and processes need to bear this in mind so that provision is made for emergency process shutdowns or if this presents a greater risk than the possibility of a lightning strike, for continued but unmanned operation.
The need for procedures for the evacuation of explosives plants and termination of operations on the approach of lightning storms must be determined. To do this a Quantitative Risk Assessment must be carried out by a professional QRA assessor together with a team of suitably qualified personnel.

The risk assessment must identify the risks factors associated with lightning including the following:

- The frequency of lightning activity in the location of the operation. Mountains and large bodies of water often provide some of the conditions necessary for the development of thunderstorms.
- The risk to the manufacturing operation if hastily terminated or abandoned and the risk during subsequent restart. Whether the material in process can be desensitised by drowning and the risks associated with this option.
- The sensitivity of electronic control systems. In modern manufacturing plants an immediate shutdown can introduce an unacceptable hazard.
- Type of operations being conducted and the sensitivity of the explosives being handled in that configuration, e.g. a plain detonator is much less sensitive than a detonator with its firing leads attached.
- The cost of shutdown and the cost to restart operations in relation to the probability of false alarms.

If, after having conducted such a QRA, it is determined that it is necessary to terminate certain explosive operations, or to evacuate non-essential personnel from the area when termination of operations is not practical, it is essential to have an advance warning of lightning activity and a warning alarm system audible to all affected personnel.

The relative importance of each of the factors identified in the risk assessment will vary with each individual operation. In addition, some operations may have some factor that influences the type of warning system necessary that is specific to that particular operation only. Therefore, before selecting a warning system each operation performed at the facility should be considered.

The first step in selecting a warning device is to determine how much advance warning is required. Lightning can create a hazardous condition well before it reaches the location of the explosive operation. In addition, the spatial separation of successive strikes is about 3 km with separations of up to 10 km recorded. Simple systems such as ‘Flash to Bang” time monitoring for low risk operations and short warning times to Electric Field Mill monitors for high risk and long warning times can be implemented depending on requirements.

FIRE PROTECTION SYSTEMS

Although it is common wisdom not to allow personnel to fight fires involving explosives or ammonium nitrate directly, fire protection systems are still necessary to prevent fires from spreading from ancillary equipment such as transport vehicles to explosive product or from one building or compartment to another after an explosion or deflagration.

Pyrotechnic plants in particular require fire protection systems to prevent fires from spreading and not necessarily to put fires out. A badly considered fire protection system can cause more damage than the fire itself: For example, when water is sprayed onto a pyrotechnic fire the resulting massive evolution of steam and pressure can cause structural damage resulting in the fire spreading even further.

There are specific requirement for fire protection systems, pumps and accessories including detection systems, sprinkler systems etc, but also for power supplies to allow them to operate during outages and without tripping or stopping because of damage caused by fires they are intended to put out. Fire protection pipework must be independent of process water systems and have points where a fire tanker can remotely inject water into the system in the event of failure of fire pumps. The USA's NFPA and the EC Joint Commission set the standards for fire protection systems. There are also quarterly testing and annual certification and validation requirements.

EFFLUENT CONTAINMENT

Plant designers often forget about containment systems for contaminated fire drench water. These containment systems need to be properly designed to contain all deluge water. They need to be checked for integrity periodically. There also have to be plans for disposing of or treating contaminated fire drench water.

CAMERAS

CCTV cameras and recording systems are a significant help to emergency controllers to monitor evacuation, movement of people and traffic, and post event occurrences. They also are an extremely useful tool to analyse the causes of incidents after the fact and are useful when re-evaluating emergency responses. Consideration must be given to the positioning and protection of the cameras to maximise their effectiveness following an incident.

Outdoor CCTV cameras can monitor entrances, gateways, access roads, surroundings of buildings. In buildings they can monitor machinery, production lines and high risk workplaces.

There are electrical standards for CCTV cameras (or their enclosures) that are exposed to explosive dust and gasses. This is to ensure that the cameras themselves do not introduce a risk to operations.

Caution

When recording consider the data recorded. In the recording media there could be personal data in many cases. Businesses are able to collect and process data only for a well-defined purpose. They have to inform the user about purposes for processing. The legal requirements such as the General Data Protection Regulation (GDPR) have to be observed.

LONE WORK OR SOLITARY WORK PLACES

There are two types of solitary workplaces:

- Remote workplaces without increased incident risk.

  Solitary work at remote workplaces if within the mobility area of a working person no other persons is present or visits the location regularly.

- Workplaces with increased accident risk

  Solitary work at workplaces with increased accident risk if a person is working outside the range of visibility and audibility of other persons.

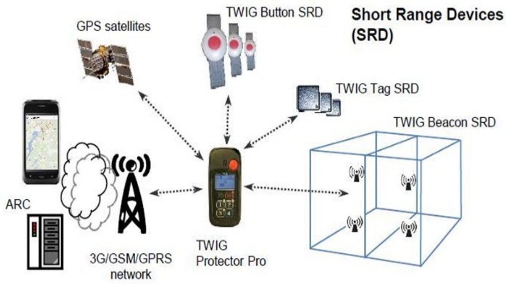
Solitary work can be found in almost all fields of operations for example:

- At automated production processes or hazardous steps of production.
- At plant facilities and equipment in special operation, such as maintenance, cleaning, repair and control work.
- At magazines, customer sites, waste disposal.
- With overtime, shift- and flexible work or work on Sundays and public holidays.
- Outdoors with environmental conditions such as storm, snow, vision, coldness, danger of avalanches, impassable areas

An effective protection is present if assistance after an incident for the solitary working person (first aid and any subsequent medical help) is carried out in a "socially accepted time"

Automatic personal protection systems (e.g. TWIG) is applied in all cases where the mobility and capability of acting of the solitary working person is not preserved and interval controls will not or cannot be applied.

The TWIG Protector Ex is the ultimate GPS/GSM personal safety device, designed to protect lone workers in explosive hazardous areas. An alarm button or automatic Man-Down function activates a predefined emergency protocol, transmitting latest know position and opening two -way voice connection to the Alarms Receiving Centre (ARC).



UN Transport of Dangerous Goods Sub-Committee

53rd session, July 2018

by

Ken Price

This article is extracted from a personal summary of some of the issues relating to explosives discussed at the United Nations meeting of the Sub Committee of Experts on Transport of Dangerous Goods in July 2018. A lot of it is drawn from the report of the explosives working group, which was written by David Boston (Owen Oil Tools, USA). The formal report of the Secretariat will be available on the UNECE web page in early August.

Electronic detonators

The explosives industry has for several years been trying to have electronic detonators recognised by name to clearly distinguish them from other detonators. The Australian Explosives Industry and Safety Group (AEISG) has been leading the debate on the issue and we finally prevailed in July 2018. A new Proper Shipping Name for electronic detonators will appear in the next edition of the United Nations Model Regulations. As for existing detonators, the new entry will be for hazard divisions 1.1B, 1.4B and 1.4S.

The discussion focussed on the advanced initiation requirements and that conventional initiation methods cannot be used to initiate these types of detonators.

The entry will be *DETONATORS, ELECTRONIC programmable for blasting* and there will be a new definition in the Appendix:

"Detonators with enhanced safety and security features, utilizing electronic components to transmit a firing signal with validated commands and secure communications. Detonators of this type cannot be initiated by other means."

Minimum Burning Pressure Test

For several sessions, IME has expressed concern that the Koenen test is inappropriate for ANE and wishes to allow alternatives to be used to assess properties of emulsions. Their primary concern is that the Koenen is not a reliable test and very stable emulsions will fail the test even though such emulsions are much safer in pumping operations. The complication is that the Koenen works well for AN Suspensions and Gels.

The issue was discussed extensively at the CIE Conference in Ottawa in April and that progress translated into progress at

UN. Taking account of the comments and advice from the working group, IME, with assistance from Canada, will submit a formal proposal for the 54th TDG session. The proposal will likely allow ANEs that fail the Koenen test to demonstrate their safety in a minimum burning pressure test.

Exercise in logic: What is an explosive?

Dr Nie Shulin from Sweden with encouragement from Bob Sheridan (Australia) started a discussion on the definition of Class 1 in the United Nations Model Regulations. Both are experts in logic and that is the focus of the following text. Skip it if you wish.

The current definition in the United Nations Model Regulations for class 1 is:

2.1.1.1 Class 1 comprises:

(a) Explosive substances (a substance which is not itself an explosive but which can form an explosive atmosphere of gas, vapour or dust is not included in Class 1), except those that are too dangerous to transport or those where the predominant hazard is appropriate to another class;

(b) Explosive articles, except devices containing explosive substances in such quantity or of such a character that their inadvertent or accidental ignition or initiation during transport shall not cause any effect external to the device either by projection, fire, smoke, heat or loud noise (see 2.1.3.6); and

(c) Substances and articles not mentioned under (a) and (b) which are manufactured with a view to producing a practical explosive or pyrotechnic effect.

Stripped of all the excess verbiage, this definition essentially says:

2.1.1.1 Class 1 comprises:

(a) Explosive substances (except blah blah blah);

(b) Explosive articles (blah blah blah); and

(c) substances and articles manufactured with a view to producing a practical, explosive or pyrotechnic effect.

Bottom line – why not simply say

Class 1 comprises substances and articles which produce an explosive or pyrotechnic effect except...

Then list all the exceptions:

- *things not itself an explosive but which can form an explosive atmosphere of gas, vapour or dust;*
- *things that are too dangerous to transport;*
- *things where the predominant hazard is appropriate to another class; and*
- *devices containing explosive substances in such quantity or of such a character that their inadvertent or accidental ignition or initiation during transport do not cause any effect external to the device either by projection, fire, smoke, heat or loud noise (see 2.1.3.6) are not included in Class 1*

Makes sense to me.

Explosives and Globally Harmonised System

As the GHS started to become seriously considered in some jurisdictions it became apparent that the labelling requirements were unrealistically onerous. For example, is there any benefit in labelling a stick of explosive, or a booster with the words: “mass explosion hazard”. The key information for users, and for the public who might find orphan explosives is: “Danger, Explosive”. After all, this labelling has been effective world wide for decades.

And after several years reviewing Chapter 2.1 of GHS the Subcommittee is accepting this point of view and it will likely come into effect in the near future.

DID YOU KNOW THAT……?

Did You Know that Burning ground preparation, discipline, planning, packaging, identification is essential to the safe operation of this type of destruction facility ?

Preparation: Waste must be prepared to facilitate burning; for example, primer caps are stored in water to desensitize surface contamination of caps with sensitive composition. Water has to be strained out to enable burning; once, water accumulated at the bottom of the burning pan leaving non-detonated caps after burning; an accident occurred while shoveling residue. The desensitizing liquid was replaced with diesel fuel. Volatile powders should be wetted with desensitizing liquid to prevent wind dispersion while dumping and prevent ignition due to static electricity or friction while spreading on burning patch or pan.

Discipline: Workshop operators should be trained in the preparation of explosive wastes because they can be casual with wastes. Explosive waste mixing is dangerous for burning ground personnel. Waste pyro powder was mixed with igniter fuses; before burning ground, personnel unknowingly spread the mix, they wetted the powder with diesel as they were instructed. When the wood rake hit the igniter hidden under the powder stack there was ignition of igniter without ignition of the powder. Injury was prevented because instructions were followed.

Planning: Small quantities of propellant were burned in the same burning pan. One day, burning ground personnel spread fast burning stick propellant first and slower burning large calibre propellant above it; the result was a mass detonation. Also, it was found that the stick propellant manufacturer spread their waste propellant in two inch thick layers while our instructions called for 3 inch thick layers. Small quantities are to be laid side by side. Burning practices of manufacturers of new type propellants should be requested.

Packaging: Proper packaging of wastes is important to prevent leaks and friction during the transport of the wastes to the burning ground. Transparent plastic bags for inert wastes also prevented lost explosive components from ending up in waste inert dump. In some areas metal detectors are used on inert waste bags.

Identification: Identification of wastes is of the utmost importance as well as knowing the quantity so burning ground personnel comply with burning quantity limits. A pail seemed to contain inert dust. When operator transferred it to a larger waste pail a flash fire occurred, and operator suffered light burns.

Prepared by Maurice Bourgeois

Let us know of your burning ground incidents , experiences, learning and operation .We all have this largely neglected operation ,assist us all to doing it in a safe manner!!

Ammonium Nitrate Modeling in the AN Module of IMESAFR

by
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Background

AN is the main raw material used in the commercial explosives industry, accounting for roughly 75-80% by weight of the total explosives consumption--over 90% if one excludes water from the raw material list. As billions of kilograms of explosives are used annually in the explosives industry globally, this means that very large amounts of AN are manufactured, stored, and transported on a regular basis. A large AN plant can manufacture more than five hundred million kilograms per year. There are AN stores in remote areas of the world that contain millions of kilograms of material; in more populous areas, there are stores of 500,000 kilograms or more.

AN is classified as an oxidizer for purposes of transport; this classification has been extended in most jurisdictions to also cover storage. However, the United Nations (UN) definition explicitly recognizes AN and ammonium perchlorate (AP) as the two hazard division (HD) 5.1 substances that can explode under certain conditions. For instance, UN regulations change the classification of AN to HD 1.1 above an organic content of 0.3% (figures range from 0.1 to 0.3). AN is an ideal raw material for explosives because it can be manufactured in very large quantities, is low cost, and is extremely stable in all normal conditions. It also has a very high energy density, especially when used in an oxygen-balanced explosive formulation, e.g., Ammonium Nitrate/Fuel Oil (ANFO) or Ammonium Nitrate Emulsion (ANE). However, "extremely stable" is not synonymous with "inert," as there have been a significant number of AN explosions during manufacturing, transportation, and storage globally (indeed see https://en.wikipedia.org/wiki/Ammonium_nitrate_disasters). High energy density is great when the release is controlled to time and place, but a significant risk when at least one of those is not controlled.

As an HD 5.1 substance, there are no quantity-distance (QD) requirements for the protection of populations except in those countries where AN is classified as a 1.5 or 1.1 material because of terrorism concerns. Accordingly, AN stores have historically been located based on operational requirements with a lesser consideration for any hazards or risks to the public. Since the incidents at fertilizer facilities in West, Texas, USA (fire and explosion in 2013) and Toulouse, France (explosion in 2001), both regulators and companies have had a greater focus on risks to the public from AN stores.

IMESAFR (Institute of Makers of Explosives Safety Analysis for Risk) has become the most widely used QRA tool for the commercial explosives business. It was developed by APT Research (APT) for the Institute of Makers of Explosives (IME) based on the SAFER (Safety Assessment For Explosive Risk) software, which was also developed by APT for the U.S. Department of Defense. IMESAFR is a sophisticated, probabilistic fully quantitative risk assessment tool, largely based on historical data for event frequencies and large-scale test data for determination of consequences.

The basic concept of a quantitative risk assessment (QRA) is:

$$P(f) = P(e) \times P(f|e) \times E(p)$$

This equation defines the risk, or probability of fatality (P(f)), to be the product of the probability of the explosives event (P(e)), the probability of fatality given an event (P(f|e)), and exposure to the potential event (E(p)).

IMESAFR has been developed to assess risks in situations where quantity-distance (QD) cannot be met, and also where risk management is appropriate and/or required. The development history of the software and its capabilities have been described in previous SAFEX articles. The most current description of the software and its capabilities are described in Reference 1. Please contact either Joshua Hoffman at IME (jhoffman@ime.org) or Mary Robinson at APT (mrobinson@apt-research.com) for further information.

Previous versions of IMESAFR modeled all events, including those involving Hazard Division (HD) 5.1 as TNT explosions with an equivalence factor applied. When IMESAFR became available as a risk management tool for commercial explosives companies, many also used the software tool to estimate the risk from large AN stores. The availability of IMESAFR was very useful for explosives companies to determine evacuation circles, make siting decisions, etc. However, this was clearly a very conservative approach as AN explosions will be much less ideal than TNT explosions, on which the IMESAFR TNT engine is based. While some degree of conservatism is desirable in risk calculations, over-conservatism can cost money with no meaningful risk reduction.

Because of this conservatism, there was a desire for a version of IMESAFR that would better model AN explosions. There were concerns about the relatively low amount of test data available upon which to build/validate an AN Engine. Nevertheless, the IMESAFR Development Team (Reference 1) and APT agreed that the Module could be built and was worthwhile. The IME therefore contracted APT to develop the AN Module.

Throughout this paper there will be references to the AN Engine and the AN Module, which are not quite synonyms. The AN Engine is 'inside the algorithms', specifically how an AN explosion is treated differently from the standard TNT Engine. The AN Module is the 'whole package', e.g. inputs, outputs/risk calculations, the Potential Explosion Sites (PESs) and Exposed Sites (ESs), etc. So, the AN Module contains the AN Engine but it is the AN Engine that is the revolutionary change in quantitative risk calculation tools.

AN Initiation Mechanisms, Frequencies, and Yields

The first thing that must be stressed with the AN engine vs. the TNT engine is that there is no TNT equivalency input or conversion to a TNT equivalence within the AN engine. There are two Net Explosive Weights/Net Explosive Quantities (NEWs/ NEQs) that are broadly quoted: 32% (Reference 2) and 42% (Reference 3). The latter is the absolute maximum chemical energy available relative to TNT and the former is the best scientific and perhaps conservative view of the maximum amount of energy likely to be released in an AN explosion, given the high non-ideality of pure AN explosions. (Note that these values assume a % contribution of 100%.) The standard IMESAFR software has the capability to run AN scenarios, but the program converts the AN with a fixed TNT equivalence and then treats it as a TNT explosion. Therefore, outside the AN Module, IMESAFR treats AN as an ideal explosion with a low chemical equivalence. While this approach gets some things more or less correct in the calculation, other calculated values (e.g., pressure and impulse) could differ significantly from reality. The AN Module, on the other hand, treats a kilogram of AN as a kilogram of AN, not 0.3 kg of TNT. How this model was developed and works is dealt with later in this paper. This section deals with how AN can be initiated and what this means for event frequencies and yields.

The IMESAFR Development Team and APT reviewed the available information and decided that the SAFEX Good Practice Guidelines (GPG) for AN Storage (Reference 4) contained the best distillation of knowledge on the initiation of/yields from AN explosions. The GPG identified three accidental initiation mechanisms, with the maximum expected yields and event frequencies for each of those mechanisms:

- Shock/Projectile initiation – 100% of AN reacts; Event frequency = 1.17 E-06
- Contamination – 50% of AN reacts; Event frequency = 1.17 E-06
- Fire – 10% of AN reacts; Event frequency = 2.34 E-06

These initiation mechanisms and yields are based on analysis of data from accidents. Each of these ignition mechanisms has a default event frequency for risk calculations. These default event frequencies were derived by the SAFEX Workgroup in the same way that the default event probabilities were in the TNT engine version, i.e., historical accidents were used as the numerator and the number of AN storage sites was used as the denominator. This obviously valid approach is still somewhat problematic as the number of historical major accidents was very small (exactly one for contamination scenarios (Toulouse) and that one is still controversial) so relatively minor events were included. Also, the number of AN inventories was conservative, as only significant “AN piles” were included. The derived event frequencies appear to be very low but the methodology ensures they are conservative.

For a more detailed discussion on each of these initiation mechanisms, please refer to the recent paper (Reference 5) given by these authors at the National Defense Industrial Association’s International Explosives Safety Symposium in San Diego, California, USA in August 2018.

AN Airblast

An examination of the AN waveform would indicate that it is inherently different than a TNT wave form—at the same distance, the pressures are generally lower, the rise time of the shock front may be slower, the rate of energy release is different, and thus the durations and impulses of an AN event will be significantly different than a simple multiplicative factor times a TNT answer. In addition, AN residual particulates released to ambient air will be slow to react, if at all, as the oxygen in air will not assist the reaction unless the AN is contaminated.

There are three possible levels of modeling that could be developed and used within the AN Module:

- Level 1 (lowest detail)
  - ◊ Scale to AN effects using a single value for TNT equivalence
  - ◊ TNT equivalence would be independent of explosive weight and distance
  - ◊ Same equivalent weight used to scale both pressure and impulse
- Level 2 (moderate detail)
  - ◊ Create curve fits of pressure vs. distance and impulse vs. distance for AN from available test data and modeling
  - ◊ Pressure and impulse models would not necessarily be the same
- Level 3 (highest detail)
  - ◊ This level would calculate the true AN pressure-time waveform at every required distance
  - ◊ Pressure and impulse would be calculated as functions of explosive weight and distance
  - ◊ Pressure and impulse models would be independent from each other

For the current version of the AN Module, it was decided that only detonating AN would be considered. It was further decided that a Level 2 model would be developed for predicting the airblast (peak pressure vs. scaled distance and scaled impulse vs. scaled distance) generated by AN detonating in the open. Such a model could be based on data from three sources:

- Previous testing programs
- Reverse-engineering from accidents and incidents
- Numerical simulations

Each of these sources have inherent strengths and weaknesses and the algorithms in the AN Module were developed from of a combination of these sources.

i) Previous Testing Programs

Data generated by defined tests are the most desirable. However, the tests that have looked at the airblast from detonating AN have been few in number. Further, although much testing has been carried out as part of restricted or classified programs, these data are not available for public release or distribution. There are other problems with much of the reported test data, as well:

- The actual pressure measurements are not reported—only TNT equivalences derived from the measurements.
- The shape of the container or stack of AN: shape has a dramatic effect on the measured airblast. This requires, as a minimum, that the dimensions and construction materials of the charge container be well-defined. If they are not, assumptions must be made which could lessen the validity of the data.

After a comprehensive literature survey, APT located and utilized data from five distinct sources, which represent the extent of reported useable test data.

ii) Reverse-Engineering from Accidents and Incidents

Early thinking indicated that this could be a productive area. However, as the available information was examined more closely, it was soon discovered that the available information was often incomplete and assumptions were required to complete the required information. Did all of the AN detonate? If all of it did not detonate, how much reacted? What was the TNT equivalence of the material that did react? What was the shape of the AN just prior to reacting? In addition, the reported damage, from which the airblast estimates would be derived, was often faulty or incomplete. For these reasons, it was decided not to pursue this effort.

iii) Numerical Simulations

Two independent modeling efforts were utilized. The first utilized the Vapor Cloud Explosion software VEXDAM (Reference 6). The second utilized a computational fluid dynamic (CFD) approach using the FEFLO software (Reference 7). It should be noted that a limitation of the VEXDAM software is that it only calculates peak pressure and does not consider impulse.

Charge Shape. For the purposes of airblast generation, IMESAFR assumes that the charge shape is hemispherical.

All of the data (both from the testing programs and computational effort) were for 4:1 right circular cylinders. Therefore, an additional factor to convert the data into hemispherical airblast had to be developed and applied before the data could be used in IMESAFR.

Composite AN Airblast. The airblast information from both the testing and computational sources were converted from cylindrical to hemispherical shape and then combined to form composite airblast curves. These curves were then used to generate the open-air AN airblast functions. Figure 2 presents the composite airblast information that was used to generate the AN airblast functions.

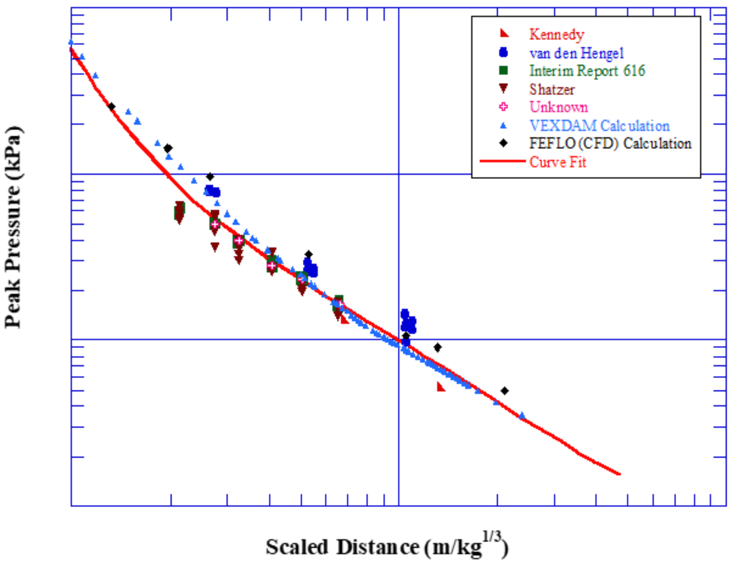


Figure 1. AN Composite Peak Pressure vs. Scaled Distance

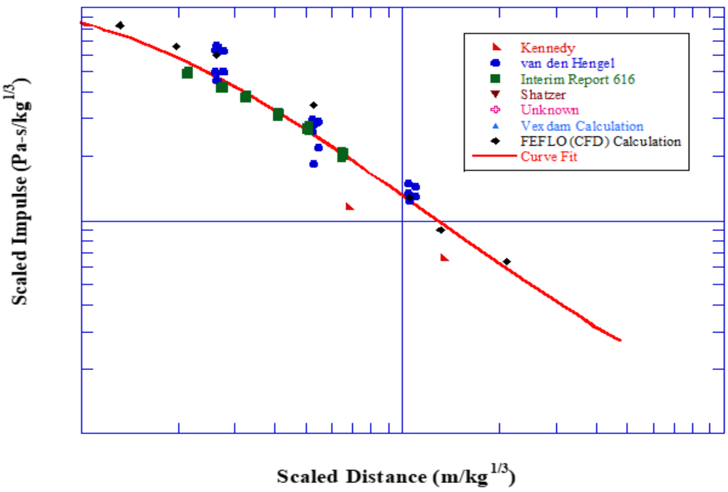


Figure 2. AN Composite Scaled Impulse vs. Scaled Distance

Something that is fairly unique to detonating AN is the potential presence of large amounts of unreacted material that could be entrained in the blast wave. The effect of the presence of unreacted material entrained in the flow of the blast wave was described and discussed in several papers by Porzel (References 8-9). As described, the effect of the unreacted mass is to depress the peak pressure at scaled distances less than about 4 m/kg$^{1/3}$ and to enhance or increase the peak pressure at scaled distances greater than 4 m/kg$^{1/3}$. Porzel did not provide a lot of information on the effects of inert mass on positive impulse. For con-

. For conservatism, it was assumed that the inert mass has the effect of increasing the impulse at all scaled ranges, with the amount of increase being proportional to the amount of increase of the peak pressure.

Three inert mass loading regimes were identified and are associated with the three initiation mechanisms discussed previously. These three mass loading regimes are:

Unloaded: Associated with a projectile/shock initiation mechanism. This regime corresponds to a reaction of 70-100% of the AN available. The default value is 100% of the material reacts.

Moderately Loaded: Associated with a contamination-initiation mechanism. It corresponds to a reaction of 30-70% of the AN available. The default value is 50% of the material reacts.

Heavily Loaded: Associated with a fire-initiation mechanism. It corresponds to a reaction of < 30% of the AN available. The default value is 10% of the material reacts.

Figure 3 and Figure 4 show the expected airblast for these three regimes. Figure 3 shows the expected effect on peak pressure while Figure 4 shows the corresponding information for positive impulse.

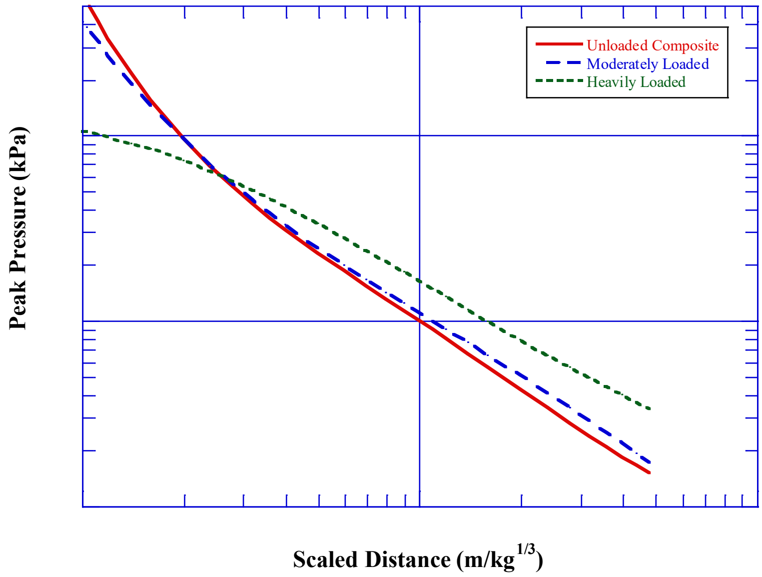


Figure 3. Effect of Entrained Unreacted Material on Peak Pressure

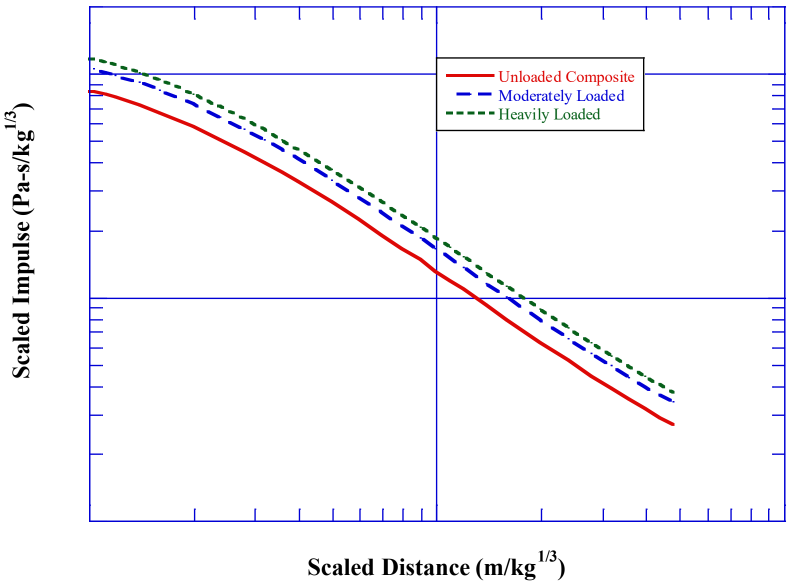


Figure 4. Effect of Entrained Unreacted Material on Scaled Positive Impulse

Other IMESAFR Changes in the AN Module

The building response to a blast wave was not altered in the AN Engine. Since the building response was not changed, the algorithms to calculate the probability of fatality, major injury, and minor injury due to building collapse were not altered either. It is important to note, however, that while the response logic was not changed, the "answers" will be different since the AN Engine will generate different pressure, impulse, etc., terms than the TNT Engine.

In the TNT Engine, the mass distribution logic is anchored by test data augmented by several theoretical points. At run-time the mass distribution is calculated based on the loading density (NEW divided by the volume of PES). The forward and reverse models are hinged at a nominal data point based on test data. This nominal point represents the best available data and is, hence, a good average. Within the AN Module, the mass distribution process takes into account the lower energy with in AN available to break-up the PES. In addition, the range of potential loading densities was also considered. TNT loading densities generally vary between 0.02594 kg/m^3 to 341.2 kg/m^3. AN could have loading densities up to 800 kg/m^3 for fully loaded railcars and overhead silos. With these considerations, the AN loading densities are mapped onto the TNT results. Once the mapping is made, the mass distribution algorithms behave in a similar manner. Something that is not yet considered is the behavior of molten AN. As a result of fire, molten AN would be much more dense and possibly more reactive.

The initial velocity of secondary fragments is scaled in the AN Engine to represent the potential of AN to throw fragments at lower initial velocities than TNT. Two reduction factors were developed. The first, based on a ratio of detonation velocities of AN and TNT, was 0.59 (note: the absolute values depends on the diameter and confinement for the AN – any figure between 0.4 and 0.7 could be correct). The second, based on the ratio of the impulse close to the charge surface, was 0.77. The default in the AN Engine is 0.77, as it is the more conservative option. There is an option for the user to select the 0.59 scaling factor. The scaling factor will also apply to the initial velocity cut-off values.

In IMESAFR, the maximum throw range of secondary debris is a function of the initial velocity. The maximum throw range in the AN Engine is calculated in a similar manner. Since the maximum throw range is a function of the initial velocity, it was decided that the maximum throw ranges would not be scaled separately. In other words, the reduction in initial velocities directly affects the maximum throw ranges, so further scaling the maximum throw ranges would be redundant.

The AN Engine includes updates to the maximum throw ranges for three PES types: vehicle-van/truck, vehicle-tractor-trailer, and pre-engineered metal building (PEMB). For these PES types, the maximum throw range cut-offs were mapped to the cut-off values of primary fragments in the TNT Engine. In the AN Engine, these PES types have the same maximum throw range cut-offs as the other metal PES types, since primary fragments are never involved with AN Engine runs.

Summary and Conclusions

The AN Module is a novel advance in the modelling of AN events. To the best the authors are aware, this is the first non-TNT based model for AN explosions due to fire, shock, or contamination. It is a particular step out as the change is from a fairly ideal/molecular explosive to a highly non-ideal energetic material. This was, of course, the driver for the development of the model as an ideal explosion model that will be very conservative for AN explosions. The development of an AN Engine and addition of two ES types, railcars and overhead silos, which are typical stores for AN manufacturers and explosives companies, are major additions to the risk management capabilities of these industries.

While the AN Engine will continue to be improved, it has already proven to be very successful from the perspective of the customer base. Risk management for large AN inventories has become much more important for AN manufacturers and the explosives industry, and the AN Module has proven to be an excellent tool in that risk management.

References

1. Tatom, John W., *IMESAFR Overview*, Minutes of 2018 International Explosives Safety Symposium & Exposition, 6-10 August 2018, San Diego, CA 2018.
2. Nygaard, E., *Storage of Technical (Porous) Ammonium Nitrate*, ISEE Conference 2008.
3. Braithwaite, Martin, *Ammonium Nitrate: Fertilizer, Oxidizer, and Tertiary Explosive*, UKELG, Loughborough, Sept 2008.
4. Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate, International Industry Working Group on Ammonium Nitrate, SAFEX, rev 1 July 5, 2011.
5. Swisdak, Michael M. and Evans, William B., Minutes of 2018 International Explosives Safety Symposium & Exposition, 6-10 August 2018, San Diego, CA 2018. *Ammonium Nitrate Modeling in the AN Module of IMESAFR*
6. Dillehay, D.R., *VEXDAM and Pyrotechnic Safety Hazard Classification*, 20th International Pyrotechnics Seminar, 1994.
7. Lohner, Rainald, et. al., *Advances in FEFLO*, AIAA-02-1024, 2002.
8. Porzel, F. B., *Introduction to A Unified Theory of Explosions,* NOL TR 72-209, 4 September 1972.
9. Porzel, F. B., *Damage Potential From Real Explosions: Total Head and Prompt Energy,* Minutes of 16th Explosive Safety Seminar, August 1974.

Standards & Selection for Shipping Explosives in Containers

By

Brian Devaraj

While the versatile shipping container, invented more than 50 years ago by Malcolm Mclean, the pioneer of containerisation, has transformed and driven significant efficiencies across the global intermodal shipping network, the maritime world continues to battle with many challenges with this great invention! These include container quality, packing, placarding, stowage and documentation amongst many others. Explosives across the world are shipped predominantly in containers and hence are exposed to these challenges. Here are some simple guidelines that might assist in ensuring Explosives Shipments are delivered safely from Plant to Pit.

Container Quality: While containers are manufactured to stringent manufacturing specifications and certified when they leave a manufacturer, the challenge exists with its ongoing seaworthiness over the life span of a container. These standards are outlined in the Convention of Safe Containers CSC 1972. It is also good practice to check for a valid and current CSC Plate on the container being used to ship explosives. The Approved Continuous Examination Program (ACEP) for containers is also something to look out for.

Packing and Placarding: Most often explosives are packed into containers at remote locations distant from a port or container freight station. This creates an area of risk around proper packing and placarding of the container before it is despatched to a port for export. The International Maritime Dangerous Goods Code (IMDG) specifies the required training for personnel involved in loading, packing and placarding of containers. The International Maritime Organisation (IMO) also provides a global code for the handling and packing of shipping containers transported by Sea and Land.

Stowage: While proper stowage of containers on board a ship is vital for safety, equally critical is lashing and securing of the explosives within the container. Compliance to the ship's Cargo Securing Manual (CSM) duly approved by its Flag State or Administration is mandatory.

Container Weight: Incorrect weight declaration of containers can lead to disastrous consequences on board a ship. The master and its crew draw up stowage plans based on this critical information on the weight of a container. Following recent catastrophic incidents on board container ships, Safety of Life at Sea Convention (SOLAS) published the Container Weight Verification Requirement which came into effect in July 2016. The Verified Gross Mass (VGM) documentation is now the responsibility of the shipper.

Dangerous Goods Documentation: The ship's Master and Crew rely on the dangerous goods declaration submitted by the shipper of explosives, the accuracy of which is crucial and vital for the safe carriage of the goods to its final destination. The lack of knowledge or the blatant ignoring of these standards is unacceptable and can lead to catastrophic maritime incidents that lead to loss of life and property.

Here is a picture of a ship with its container stack collapsed caused by several factors including the above.

SAFE & STABLE

By

Tony Rowe

There is nothing like a spot of history to broaden the mind, but when the subject under discussion is explosives what we place into the open literature must always be carefully considered. History may not always be exciting, but it may sometimes be useful to those possessing a certain frame of mind. To prevent those who would experiment with or otherwise adapt certain snippets of information, some of the chemical names used in the article have been changed. I sincerely apologise, but to tell the whole truth, I couldn't spell most of them anyway.

This story is all about the development of detonating fuse. We know it today under the names 'Cordtex', 'Primacord' and/or 'Detacord'. If you are proudly French, it's 'Cordeau Détonant'. It began a long time ago.

If you are unfamiliar with detonating fuses I've provided a brief description below:

Detonating fuses generally consist of a flexible, waterproof and often brightly coloured outer sheath, usually of plastic, enclosing a jacket of twisted yarns or fibres which in turn surrounds a core consisting of a granular high explosive. The core is usually, but not always, PETN.

In a nutshell, detonating fuses best resemble plastic-coated washing line. Like washing line there are many varieties differentiated by tensile strength, diameter, coreload and colour.

One worker I observed underground had braided himself a trouser belt using what appeared to be a number of different varieties of detonating fuse. Within the complex pattern I could pick out the colours, blue, yellow, orange and pink. Yes. I did rat him out, but have no further knowledge of the affair beyond what is written here. I trust that he didn't suddenly become half the man he used to be.

I feel that before progressing much further I must also put my cards on the table and state that I particularly dislike the term "*detonating fuse*". Here's why:

'Fuse' is a small word that most people understand or can relate to. The implication carried by the word 'fuse' is something that burns reliably, but most of all, slowly.

The word "detonating" is a much bigger word. It has more letters for a start. I would guess that not too many people would fully comprehend or be able to properly explain its meaning. The result is that within the expression 'detonating fuse,' the word 'fuse' is left to carry the entire literary and explanatory burden. Detonating fuse doesn't burn slowly at all, in fact it detonates extremely violently, producing an ear splitting bang and a significant shock wave as it does so. Though undoubtedly attractive to behold, it is definitely not your friend. I wonder how many unforeseen occurrences have occurred because of that apparent contradiction in terms? Has anyone ever stayed behind to watch the 'fuse' burn for instance?

I know, I know, I'm digressing. Thank you. I'll get back on track right away.

The distinguishing features of detonating fuse include not only its flexibility, bright colours and continuous core of a detonator-initiable high explosive, but also its reliability and safety in use. As the more safety conscious might already have guessed, this was not always so.

Early detonating fuses were in fact ignited using an open flame. I suspect I would have had my source of flame attached to the end of a pole, the longer the better, but then I've always preferred chicken for lunch. Clearly, back in the day, miners were much braver than I.

The products that would one day become known as 'Cordeau Détonant,' later 'Cordtex,' 'Primacord' or 'Detacord' first arrived in the middle of the 19th Century. There was no brass band, no startling upheaval, no fanfare, no sudden step change, but rather a gradual emergence. Its practical applications though were extremely ill defined. Thinking about this retrospectively I suppose the ignition issue should not be too unexpected considering that detonating fuse was simply a development of safety fuse which even today, it still resembles.

By the beginning of the 20th Century, 'detonating' fuse contained a mixture of both explosives and combustible material.

So how did this all come about?

Well, it might not be particularly well known, but my family hails from the stannery town of East Poole in Cornwall, England. Stannery means a place where tin is, or was, mined. The chemical symbol for tin is Sn (it's from the Latin: Stannum, atomic number 50). Molten tin and copper mixed together, form the alloy bronze. Pewter too is an alloy based on tin. Bronze though is harder than pewter or copper and takes a good edge when sharpened, it weathers well too and was commonly used to make edged weapons, statues, busts, tools and roofing sheets that have lasted for hundreds of years. The iconic Greek Hoplite helmet as seen in the movie "The 300" was also made from bronze.

"**Spartans! Prepare for glory.**"

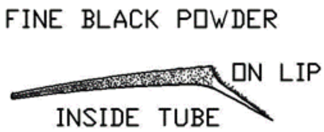
Cornish tin was once in great demand, but no longer I'm afraid. By the 16th Century the surface deposits of tin were exhausted and so underground mining began. It was once stated, not unkindly, that tin mining was made up of about 1% inspiration and 99% perspiration, this despite changes in equipment. For instance, picks, drills and chisels made from stag antlers had long since given way to those fashioned from bronze and later; as times changed, iron and steel. Things were still trundling along nicely when my Great Grandad's good friend Thomas Epsley arrived with his new-fangled ideas. Thomas, you see, came from Somerset. It wasn't his fault mind.
I seem to recall that he had discovered a way to blast the hard substrate containing the casserite (tin ore) using blackpowder charges set off by home-made fuses. Thomas had made his fuses from hollow goose feather quills that he'd primed with fine gunpowder. They worked quite well with cannon too.

We can thank Cornwall for other things besides tin and goose quill fuses, Cornish pasties for one. Sweet at one end and salty at the other, true Cornish pasties provided a compact and nourishing meal for all manner of Cornish people including mining folk.

When I was, but a lad, those responsible for blasting operations still made their own fuses from goose quills or hollow reeds which they personally primed with hand sieved, fine grain, gunpowder. I remember sitting there behind the chicken house, grinding the charcoal, brimstone and salty peter together in Grandma's old stone junket bowl. The rounded bottom was perfect for the job. Add a few drops of water and 'Kernow bys vyken!'

Junket by the way is a white, jelly-like desert made from curds of sweetened milk, a bit like thin cheese, but sweeter. The digestive enzyme 'rennet' is used to curdle the milk. Rennet is extracted from the fourth stomach of newborn ruminants, generally cow calves. Best not think about it.

After a couple of days we'd take the now dried mixture - the gunpowder not the junket - that was long gone. We'd grab a bunch of goose feathers and with sieve and funnel in hand, fill a slack handful of quills as shown below.



Burning speeds were a bit unpredictable, but if a longer fuse was required then one reed or quill could be inserted into another. It was a process that led to lots of pedestrian geese and a local shortage of thatching materials, but it was one which could be repeated, ad infinitum.

The downside was that the delay between the lighting of the fuse and the exploding of the charge was somewhat difficult to determine in advance. There were lots of accidents. Cousin Corentyn for instance was blinded and Uncle Digory was blown mostly to smithereens while Crewenna's brother Cador, lost both his hands. Tin was costly stuff.

By any standard it was at best a rickety and frankly unsafe procedure. There was uncertainty as to exactly when - or even if - the charge would explode. It was the Danse Macabre made flesh, a real-life dance of death. There was nothing romantic about blasting. It was a hard life and more often than not, a short one.

Things had to change and eventually they did.

The first patent describing a safety fuse was issued in 1831 to a Mr. W Bickford.

Hallelujah!

Bickford's safety fuse was intended to burn reliably and at a slow speed. This, it was hoped, would minimise the danger to the shot firer and at the same time create a more reliable and safer means of igniting the main charge. The core of Bickford's Safety Fuse was black powder/blackpowder/gunpowder (the terms are interchangeable) although other combustible fillings were also used. The manufacture and application of his patented fuse became safer over time as the product continued to evolve and improve. Safety fuse was of course also ignited using an open flame, but it was at the business (output) end that things would soon undergo major change.

In those early days, the blasting explosive of choice was of course blackpowder. Gunpowder charges could be reliably initiated by the "spit' from the new-fangled safety fuse. All that was necessary was to insert the donor end of the fuse into the gunpowder, light the other end and quickly retire to a place of safety.

The invention and introduction of the new "high explosives," however, required the use of a fulminate charge to cause them to initiate. Simply put, they needed a detonation to start them off. No longer was a brief spit of a few orange sparks enough to get things moving. The detonator or blasting cap was about to come of age.

Since the safety fuse had to fit fairly precisely into the mouth of the detonator, safety fuses now had to meet strict diameter specifications. The manufacturers complied.

Various improvements subsequently followed.

In 1855, Mr. S Davey of the Bickford House in France patented - for military use - an "Instantaneous Fuse." Its appearance was not unlike safety fuse, but its core was not black powder. What it actually was remains unclear, but its burning speed was reported to be in the region of 100 – 300 ft /sec (that's feet per second). It was soon adopted by the mining marketplace as it was deemed useful in applications where the simultaneous ignition of multiple charges was required.

Another development saw the blackpowder core used in safety fuse being replaced by nitrated fibres. These nitrated fibres were then variously adulterated with nitrates, chromates, picrates etc. These salts were added apparently as a means of controlling propagation velocity. Exciting stuff and on occasion, (Health and Safety take note) also somewhat hazardous.

Before too long, fuses containing a core of nitroglycerine impregnated with cellulose nitrate and camphor became available. Natamycin chloride, hydrogen dioxide and **ascorbyl palmitate** were later added. The core created was highly resistant to water and would even burn when completely submerged. Burning speeds though were highly variable, but as the manufacturers were focused solely on achieving core coherency, propagation velocity was irrelevant.

In 1896 along came "Elastic Fuse." No, it wasn't made of rubber and it wasn't particularly elastic, but it was more flexible than its competitors, who tended to be a rather stiff old bunch. It achieved this by virtue of a central hollow passage that ran the whole length of the fuse. This continuous airspace facilitated combustion and stabilised burning speeds - at least a little.

Soon there were more adventurous inventors and a host of new fuses reaching the marketplace. Some, as mentioned earlier, also made use of nitroglycerine. Nitroglycerine based fuses had a number of drawbacks, one of which was their tendency to ignite pockets of 'firedamp' (methane gas) and/or coal dust. This characteristic possibly resulted in some spectacular explosions. It was clearly not safe for use in coal mines. The way was clear for the Lohman range of fuses.

In the 1880's Lohman patented the use of diazosulpho acids of benzene or napathaline as the explosive core. As far as I am concerned they might just as well have added Dickite, Oxidane or Penguinone. You've guessed it, my chemistry is not that hot. As it turned out he needn't have bothered. These compounds too soon proved themselves to be unstable.
Between 1895 and 1898 M Wagner filed various patents aimed at improving underground safety by reducing the tendency for fuses employing nitrated fibres to ignite pockets of firedamp found in coal mines. To this end <u>oil</u> was added to the fibres of cellulose nitrate and - here is a word that I was completely unfamiliar with - a siccative - an oil drying agent as used in paint was introduced. To improve reliability, other ingredients were also employed, the diazo compounds of Lohman being specifically recommended. Sadly Wagner's inventions were doomed to failure. Although the witches brew he proposed did indeed prove safe in the presence of firedamp, the fuse exhibited a tendency to fail if nipped or damaged.

Up to this point, all of these fuses had to be ignited using an open flame, but things were changing. In France, Cordeau Détonant had at last been invented. Patented during 1879 the fuse was made by filling lead tubes with guncotton and drawing them down. The finished tubes weighed about 88 g per meter with each meter containing around 5 g of guncotton. Wrapped in a hemp-like fibre sleeve the fuse was available commercially in 250 or 300 meter lengths. If ignited using a naked flame the fuse merely burned, but if detonated, the propagation velocity exceeded 4000 meters per second. Cordeau Détonant had finally arrived and in an emerging new world, a door had been flung open. More doors would soon follow as customers found many advantages in its use.

Competitors though quickly began to emerge. In 1887 Gomez and Mill invented a quick burning fuse based on drawing and impregnating cotton threads through an alcohol based mixture of potassium chloride and ferrous glucanate. The fuse propagated at between 200 - 250 feet per second. It proved to be somewhat user unfriendly as it could be initiated by careless cutting. It that alone wasn't enough it also tended to be somewhat hygroscopic. To reduce moisture ingression the core was covered firstly by a lead sheath then overwrapped in rubber tape, yarns and finally outer coats of gutta-percha and beeswax were applied.

Later Trawinczek replaced the ferrous glucanate with sulphur-antimony, but all to no avail. This mixture also proved to be excessively hygroscopic.

In 1887 Austria adopted the "Hess" detonating fuse. Hess adapted the Gomex and Mill process, but instead of using potassium chloride he used cotton threads impregnated with a paste of mercury fulminate. Mercury fulminate is not particularly affected by moisture and will propagate wet or dry providing that the end used for initiation is dry.

Unfortunately, the fuse proved unsafe to handle. Various attempts at desensitization were made. Finally Hess added hard paraffin. When fired using a detonator it propagated at around 5000 – 6000 meters per second, but if ignited using an open flame it simply burned quietly. There was still a problem though. Heat it sufficiently to melt out the paraffin and things would revert to the original unadulterated and unsafe state. The fuse would become dangerous to handle once more. Dear oh dear.

In 1905/06 the French army adopted a detonating fuse comprising of a hollow tin (Sn) tube filled with picric acid. It popped along at a fairly impressive 7000 meters per second. A special detonator was designed specifically to initiate it, but once again it proved unsafe. This time it was vibration and/or impact that proved to be its undoing.

Meanwhile, the Italians were also having a go. Their fuse consisted of a lead (Pb) tube filled with picric acid. It had a velocity of around 6000 meters per second, but was soon replaced. This later variant comprised of a lead (Pb) tube filled with ballistite. Blackpowder was sometimes mixed with the ballistite. If ignited using an open flame this fuse burned at around 240 seconds (4 minutes) per meter, if popped with a detonator it propagated at around 5000 meters per second.

Back in France, Monsieur L'heure substituted TNT for the picric acid and lead (Pb) for the tin (Sn) tube. This was the first attempt at using TNT in detonating fuse. After filling, the lead tube was drawn down to a diameter of 4 mm. The fuse proved insensitive to impact, vibration and friction. It became known as "Cordeau Bickford." It initiated and propagated reliably even at such a narrow diameter. Propagation velocity was stable at around 6000 meters per second.

The existence of fuses that burned when ignited and exploded when detonated soon led to the development of fuses deliberately designed to be dual-purpose. Harlé, in a German patent of 1908 described a fuse having an inner core of TNT enclosed within a thin-walled lead (Pb) tube, completely surrounded by black powder wrapped in an encompassing fibrous sleeve. In other words a safety fuse having at its heart a core of detonating fuse. When lit, the fuse burned at a rate of around 1 cm per second. The heat from the black powder melted the TNT core which then merely burned. When initiated by detonation the fuse reportedly propagated at 4400 meters per second destroying the black powder core at the same time.

PETN was first mentioned in a German patent issued in 1894. The original patent, however, is unavailable. PETN as a filling for detonating fuse first appears in 1913. Once again it was the Bickford Company who patented, developed, manufactured and promoted its use. They did so at their factory situated at Rouen, France where the PETN was often mixed with nitrobenzene, nitrotoluol, TNT, nitrophenols or nitrated amines. The raison-d'etre for all the chemistry was the ability to alter the sensitivity, velocity of detonation and/or explosive output of the end product. The fuses were deemed to be comparatively stable.

Another French patent issued in 1920 saw black powder being added to the PETN core. This apparently had the effect of decreasing detonation velocity. Who would have guessed?

Sadly, at this point we enter what can only be called the "Twilight Zone." There is so little recorded in the literature between 1913 and 1928 that this whole period, from a purely scientific perspective at least, can only be described as a literary wasteland. This was no doubt due to the advent and subsequent after-effects of the First World War, but by 1928 we see Stettbacher patenting and describing PETN mixed with nitroglycerine together with a host of other adulterants such as ammonium nitrate, glycol dinitrate, ammonium perchlorate and other delights. The various mixtures were mixed with nitrocellulose and diethyl centralite (diethyldiphenylurea) to 'gelantinise' and plasticise the final filling. Apart from the very high detonation velocities exhibited by these fuses, (7000 - 8000 meters per second) the need for an enclosing metal tube or sleeve also fell away. These fuses had textile wrapped cores, the overwrapping carried out immediately following the extrusion of the explosive.

Around the year 1934, Friedrich carried out work comparing TNT, mercury fulminate and PETN as fillings for detonating fuses. He discusses his findings in great detail, finally recommending PETN as the best filling thus far.

PETN was at this time manufactured and studied as more of a theoretical explosive rather than a practical one. Although both powerful and stable it was expensive, however, the availability of cheap formaldehyde and acetaldehyde just before the Second World War brought the price down significantly. PETN was here to stay.

Cordeau Bickford remained in use during the Second World War, but afterwards was quickly replaced with “Primacord” and/or “Cordtex” both of which still have cores of PETN.

UPCOMING MEMBER EVENTS

IME institute of makers of explosives

The IME 2018 annual meeting being held in Nashville, USA ,Downtown Hilton Hotel from Monday, October 1^{st} through Thursday, October 4^{th}

ABIMEX ASSOCIAÇÃO BRASILEIRA DAS INDÚSTRIAS DE MATERIA S EXPLOSIVOS E AGREGADOS

ABIMEX Explo Tech 2018 being held in São Paulo, Brazil, from Tuesday, October16^{th} till Wednesday, October 17^{th}

IMESAFR *Institute of Makers of Explosives Safety Analysis for Risk*

IMESAFR v2.1 training will be held Tuesday, October 16^{th} till Thursday, October 18^{th} at APT Research in Huntsville, Alabama ,USA

The NIXT Conference #71 on CONTRACT MANAGEMENT AND PROCESS SAFETY being held on Thursday ,October 18th at Stellenrust ,Stellenbosch,South Africa

45 45TH ANNUAL CONFERENCE ON EXPLOSIVES & BLASTING TECHNIQUE

The ISEE 45th Annual Conference on Explosives and Blasting Technique to be held from Sunday, January 27 till Wednesday, January 30 in Nashville , Tennessee, USA

25^{th} EPP Working Group of IGUS

19^{th} International Conference of Chief Inspectors of Explosives

Conference to be held in Swakopmund, Namibia From Sunday,10 March till Saturday,16 March 2019

Please let me know if there are any events in your area you want published in the SAFEX Newsletter.

ARTICLES FOR NEWSLETTER

This is a reminder that through the Newsletters we share knowledge in the areas of Safety, Health, Environment and Security pertaining to the Explosives Industry. SAFEX thus call on all members to submit articles on these subjects within their own companies and countries.

The deadline for articles for the June Newsletter is 30 November 2018 , I look forward to your support .

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