*While **SAFEX International** selects the authors of articles in this Newsletter with care, the views expressed are those of the authors and do not necessarily represent the official position of **SAFEX International**. Furthermore, the authors and **SAFEX International** cannot accept any liability for consequences arising (whether directly or indirectly) from the use of any advice given or opinions expressed in this Newsletter*

CONTENTS

Watch this space for news about the next Congress in 2020.

From the Secretary General's Desk

Another year, full of good and bad events has rushed by. I hope that the past year was filled with events we could learn from and make the coming year the best ever from a Safety, Health and Environmental perspective in our industry. During the last year SAFEX has actively participated in various industry organization's events that have similar goals to us like the ISEE , IME , EFEE ,IGUS and NIXT .Experiences and learnings were shared that will hopefully assist the industry on various levels to remain the best industry on the Globe.

SAFEX has taken the next step in all its learning platforms. Translations of eLearning Modules and Good Practice Guides have been generated in various languages and will soon be published on the respective portals.

Organization of the next SAFEX Congress has commenced and will be discussed at the Board of Governors Meeting in San Antonio at the end of January. The next issue of the Newsletter will reveal a lot more detail, so members can start making the necessary preparations.

In this Newsletter, John Rathbun our Chairman , also publishes his New Year message to the industry .Your support for his efforts and that of the Board is what makes SAFEX such a successful organization and all your input and effort is highly appreciated.

We received a large number of articles for this issue and thus will regrettably not publish all of them .The ones not published in this issue will be carried over to the March 2018 Newsletter .A wide range of topics are covered from modeling of the generation of fragments from explosions to IMESAFR and slate tiled roofs in our QRA Corner.

There was only one incident reported since the last Newsletter :

IN 17-12 Atomized Aluminum Deflagration.

I hope this is an indication of higher safety awareness in the industry-**please remember to report your incidents and near misses, remember what you report can prevent another incident somewhere in the world!**

All that remains for me to say is **THANK YOU** to each and everyone for your support in 2017 and I wish you and your families a prosperous 2018.

SAFEX Chairman's Message

John Rathbun

As we wind down 2017, we should take time to reflect on how well the past year was from the perspective of SAFEX. In my

view, it was a great year with the biggest highlight being the Helsinki congress. With the steady hand of our Secretary General Dr. Piet Halliday guiding us through his first congress, we enjoyed a great collection of papers and solid workshops focused towards the unique needs of our industry. This is no small feat and one that deserves several rounds of applause and genuine appreciation for managing macro as well as last-minute details. Saying that however, it is not a one-man show, we also need to recognize other key contributors such as Andy Begg, Dr. Martin Held, Dr. Noel Hsu, Colin Wilson, and Mervyn Traut and their teams who all devoted countless hours of preparation to ensure that the workshops and papers presented were content worthy, of proper length and focused to the topic. The congresses are dependent upon such individuals to ensure that they are a success and in the case of Helsinki, it clearly was. Saying that, we did receive some important feedback on how we can improve, and this will be taken into consideration in preparation for the congress in 2020.

But this theme of volunteerism for SAFEX is more than just for the support of the congress: SAFEX is essentially an organization that is founded upon the principal that it will be supported by volunteers. These range from entire organizations that get mobilized to support the activities of SAFEX to individuals who feel this is their way to give back to an industry that has given them a livelihood, knowledge and skills. The quality and high standards that SAFEX strives to uphold, is based upon this belief and fortunately, we are currently seeing solid support from many international organizations. Specifically, in 2017, OY Forcit, based in Scandinavia, provided a tremendous amount of support not just to the congress this past May, but they have also volunteered to lead the revamping of SAFEX's website. This is no small undertaking but when Forcit learned of the need when expressed by the Board, they shared their willingness to accept this responsibility! We are very thankful and will look forward to the fruit of their efforts. Similarly, when Peruvian based EXSA learned of the desire to have our Good Practice Guides (GPGs) translated, they volunteered to translate all seven (7) into Spanish. This was a tremendous task and we are very grateful!

Fortunately, they aren't alone. MAXAM, has also made a meaningful donation of time and energy this past year with the Spanish translation of our E-learning Basis of Safety (BOS) module. AO AZOT – VZRYV, based in Russia, has translated the same module into the Russian language and for Portuguese, ENAEX –Britanite has made the translation. Finally, EPC, based in France, is now working on transforming it into French!

These efforts are wonderfully appreciated as they leverage some of SAFEX's tools to share knowledge, so they can be easily utilized by more and more members from around the world. With two modules completed to-date and five in the pipeline, this will be a great addition to help educate any willing member who wants to take the time to learn. It is SAFEX's mission to share knowledge with the goal of saving lives and property and preserving what lessons our industry has learned. We are forever grateful for the contributions of our members in helping us grow and continue to support the organization and we are always looking for more volunteers. If you feel you or your organization have something to offer, please reach out to any one of the Governors and let us know. The key to SAFEX is to share – whether it is time, efforts or knowledge.

Have a great 2018!

Welcome to the SAFEX e-Learning Portal

Following on from our Chairman's note, Martin Held, the SAFEX Governor responsible for the management of the SAFEX eLearning Portal ,reports on the current and future initiatives to move the functionality of the portal forward.

eLearning's Modules available on the Portal right now are:

- BOS (Basis of Safety) in English and Spanish.
- Incident Investigation in English.

By January (or early in 2018), the following will be added:

- BOS in Portuguese and Russian.
- Incident Investigation in Spanish.
- Introduction to Explosives in English.
- Primary Explosives in English.
- Secondary Explosives in English.

To come in 2018:

- BOS in French.
- Classification of Explosives in English.
- Permit to Work in English.

The eLearning Portal currently has over 200 active users, all reporting back on the high quality of training it provides throughout the various organizations. **Please register and use the system as it is another tool in the SAFETY TOOLBOX that helps to make the explosives environment safer in the journey to a ZERO INCIDENT workplace.**

Ron Peddie reports on the 2017 ANNA Conference

The 2017 ANNA (Ammonium Nitrate Nitric Acid) conference took place at the Hyatt Regency Lost Pines Resort and Spa, Austin Texas. October 1 to 6th 2017. As usual, although this is an industrially oriented conference, there were papers covering aspects of explosive safety when handling ammonium Nitrate.

I have shown some of the main papers with technical aspects of safety below. If anyone does not have access to these papers they can contact me, and I will try to arrange copies.

ANNA 2017 Austin Explosives Safety related papers			
Paper Number	Description	Author	Organisation
AN-02	UN Classification of AN based fertilizers	Wim Mak	TNO
An-08	AN Safety Video	Jan – Petter Fossum	YARA
AN-12	The 1995 Explosion in an Ammonium Nitrate Handling plant	S Yuwono	MNK Indonesia
AN-14	Fire in the product conveying Section CAN plant	N Vogels	OCI
AN-19	Fire followed by explosion with trucks carrying Ammonium Nitrate	R Peddie M Braithwaite R Brogden	Peddie Engineering Uni Cambridge Queensland dept. of Natural resources and mines

For those interested in changes in regulation of Ammonium Nitrate as per paper AN – 02 all the documentation is available at :

http://www.unece.org/trans/danger/danger.html

Also feel free to contact Wim Mak himself wim.mak@tno.nl.

AN-12 The lessons are over control of pH and the avoidance of contamination

AN-14 The lessons are using non – flammable materials where possible and having robust hot work procedures

An-19 Many lessons on the handling and avoidance of fires in transport.

The main theme from the conference is the need to continually remind the audience of the safety parameters in handling Ammonium Nitrate. There are always new participants and the things that are obvious to the old heads may not be known to them.

The 2018 ANNA Conference, September 16th to 21st, 2018 at Hyatt Calgary Downtown Hotel This is an inexpensive and very open conference and is worthwhile for anyone with an interest in the safe handling of AN to attend.

MODELING THE DANGER OF INJURY WHEN FRAGMENTS OF MATERIAL RESULT FROM THE DETONATION OF EXPLOSIVE CHARGES

by
Gabriel D. VASILESCU-PhD.Adviser[1], Doru ANGHELACHE-Eng.[2],
Victor G.VASILESCU-Eng.[3]

1 - National Institute for Research and Development in Mine Safety and Protection to Explosion–INSEMEX Petroșani, 32-34 G-ral Vasile Milea Str., 332047 Petroșani, Hunedoara County, Romania Country

2- SC NITRO NOBEL GROUP SRL, București, str. C.A. Rosetti, nr. 17, sector 2

3- SC GLOBAL CONSULTING SRL, Topoloveni, Argeș County, Romania Country

Abstract

The paper shows a summary of the results of research undertaken in the field of modelling the dangers of injury / destruction when fragments of material resulting from the detonation of explosive charges are jettisoned on workers and / or industrial objectives from the explosives testing center. So, American scientific practice from the moment is (FRMS ? type) developed to improve the performance of the specialized software from the security of explosives for civil use type IMESAFR (ex. Version 2.0) which was acquired in the NUCLEU project- PN 16 43 02 15/2016-2017, using different probability functions dedicated to this field type PDF (Probability Density Functions) in order to shape the graphic-analytical phenomenon when fragments of material resulting from the detonation of explosive charges are jettisoned.

1. Overview on the mechanisms of formation of fragments of the material resulting from the detonation of explosive charges

Detonation of explosives

Detonation is a physical-chemical process, characterized by a high reaction speed and by the formation of large quantities of gases, at high temperatures, which leads to the generation of high forces of breaking and dislocation of rocks. To interpret the physical phenomenon of detonation, worldwide were expressed various theories, one of them being the hydrodynamic theory. It was accepted unanimously, considering the similarity of its mode of propagation by explosives with the propagation of the pressurized fluid. The detonation mechanism comprises three steps: **I.** The mechanical compression of each molecule of the explosive substance carried by a dynamic pulse; **II.** The thermal decomposition of each layer in the structure of the explosive, up to high temperatures, when given the rapidity of the chemical reaction, the dynamic compression process being carried out without heat exchange in the environment (adiabatic compression); **III.** The exo-thermal decomposition of the explosive due to the action of high temperatures.

The formation of craters

In figure No. 1 is presented schematically a crater produced by the detonation of an explosive (explosive charge). Dimensions associated to a crater are the following: D_2 = the apparent diameter of the crater; D_1 = the actual diameter of the crater; h_1 = the actual depth of the crater; h = berm height.

Craters are formed when there is a detonation of explosive charges that are placed as follows: below ground level (closed space); on the ground (air-ground interface); suspended in the air. Regardless of the location of the explosive charge, the crater is the destructive effect of a detonation.. When initiating the explosive charge, in the mass, there is a violent decomposition reaction, the detonation wave which results is propagated at a speed of 2000 – 8000 m/s. In the detonation wave front is developed a pressure that can reach 10^4 MPa and it is transmitted through the environment in the form of a shock wave, having the same direction of propagation as the detonation wave.

---

[1]The explosive charge is the quantity of explosives prepared for detonation, in the view of displacement a volume of material (rack) for carrying out excavations.

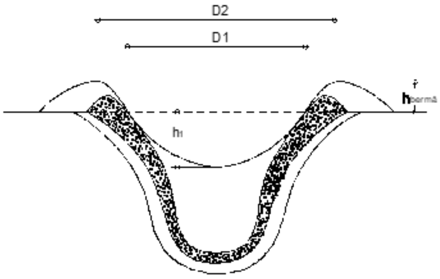


Fig.1- Defining the size of a crater

The material resulting from an explosion type event considers three types of fragments: primary, secondary and debris resulting from the crater formed. The primary fragments are coming from the body of the explosive detonated, and secondarily from the structure of the storage room if there is one(eg. roof, end walls, side and rear). Also, other residues that are generated in the impact crater formation are fragments from the ground or the foundation structure of the storage room. In the event of an explosion type event there may result a large number of individual fragments (of the order of thousands) that can be uniquely identified by mass and speed as the main parameters (and implicitly by the kinetic energy). The model type QRA (Quantitative Risk Assessment), provides opportunities for an analysis of the total volume of fragments designed, based on a dynamic model of meshing of the mass, using the distribution pattern of recurrent Bin n, (1). to provide a general overview of the 10 classes of results (Bin_i, i=1,10).

$$Bin\ n{:}DAM_n = RM_n + \left(\sum_{i=1}^{n-1}(DM_{[i,n]})\right) + \left(\sum_{i=2}^{n-1}(B11DM_{[i,n]})\right) \quad (1)$$

where:
DAM – dynamic adjustment of the mass of the material fragment
n – the order of meshing of the fragment mass of material
RM – the residual material mass of fragment
DM – the fragment mass of material dispersion

Class (Bin_{in} n=1,10)	Bin_1	Bin_2	Bin_3	Bin_4	Bin_5	Bin_6	Bin_7	Bin_8	Bin_9	Bin_{10}
Minimum kinetic energy (m-Kg)	100K	30K	10K	3K	1K	300	100	30	10	3
Average kinetic energy (m-Kg)	173K	54K	17K	5K	1,7K	547	173	54	17	5
The maximum kinetic energy (m-Kg)	^{3}300K	100K	30K	10K	3K	1K	300	100	30	10
The average weight of fragments of steel (Kg)	16,19352	6,75864	2,875824	1,206576	0,512568	0,214553	0,090266	0,038647	0,017191	0,006441
The average weight of concrete fragments (Kg)	34,20144	14,2884	6,07824	2,544696	1,079568	0,4536	0,190512	0,081648	0,036288	0,013608

Table 1

Thus, Bin_1/Bin_{10} represents the fragments with the high / low mass and level significant / low of damage and / or destruction of the human component and / or structures.

Table 1 shows the results obtained for the ten classes ($Bin_1 \div Bin_{10}$) corresponding to level of damage / destruction (via kinetic energy) at maximum, medium and minimum, and average weight of each fragment designed depending on the type of material.

Description of the primary fragments

The primary fragments result from explosive destruction and its packaging after detonation, and their design mechanism by modelling are based on the number of fragments, by their mass and by the maximum range of throw. (Figure no.2).

The number of explosive products (N_w) is determined by the relation (2):

$$N_w = \frac{W_1}{NEW \times QD_1} \qquad (2)$$

where:

W_1 – amount of explosives of the explosive product No.1

NEW – net explosive quantity of a single product (V. Table 2)

QD_1 – distance depending on the amount of explosives

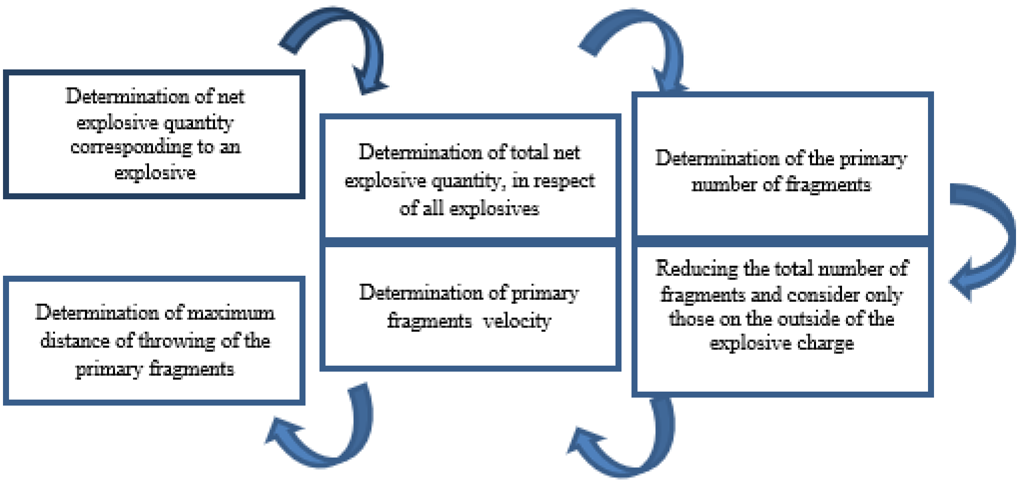


Fig.2-Process diagram for primary fragments projection

Explosive charges	NEW specific for a single type of explosive	Fragments derived from a single product									
		Mass Bin_n, n=1÷10									
		1	2	3	4	5	6	7	8	9	10
Explosive charges with small frag-	0,4536	0	0	0	0	0	0	0	1	5	10
Explosive charges without primer	0,4536	0	0	0	0	0	0	0	0	0	0
metallic container with explo-	4.536	0	0	0	0	0	0	80	4.111	796	319
Explosive charge confined in the	3,901	0	0	0	0	0	0	4	19	44	79

Table 2

Further are displayed in tables the maximum range values of action / projection of the primary fragments (R_{max}), which is determined for each fragment, according to the average weight, of the suitable bin and the initial rate (v. Table 3).

explosive charges	V (m/s)	R_s(m)	R_M(m)
explosive charges with small fragments	1219,2	569,976	683,9712
Explosive charges without primer fragments	NA	NA	NA
metallic container with explosive charge	1219,2	569,976	683,9712
Explosive charge confined in the metal pipe	1219,2	569,976	683,9712

Table 3

The value R_{max} is set at the maximum value for the projection, whether for one explosive product (R_S) or for multiple products (R_M), depending on the amount of explosives considered, W_1. In case of W_1 lower than the net quantity of explosive from the explosive product it is used the value of R_S, and where W_1 is greater than this quantity, then the value of R_M is used.. Usually, the value of R_M is 20% higher than Rs, taking into consideration the known spraying debris.
In the event of an explosion type event, product within a potentially explosive structure type PES (for storing explosives for civil uses), results a very large number of primary fragments whose number and the initial speed is determined according to the data of presented in tables No.2 and 3. Also, the components of the PES structure, remaining after the explosion, can block and remove the primary fragments resulting from this event.

At the same time, it is necessary to determine the fraction of primary fragment blocked by structural components of the PES (roof, front wall, rear wall and side walls).

Thus, to determine the number of primary fragments which may be blocked by various components of the structure of the PES, they must be divided depending on the angle of projection, namely: large angular throw fragments (hitting the roof) and lower angular throw fragments (hitting the walls). The lower angular fragments are divided, further in side impact fragments and horizontal fragments displaced in a direction nearly horizontal. Also, side impact fragments have an arched trajectory, to ES-type structure (the structure exposed to explosion), but it can be blocked, ultimately by the wall of this structure or by artificial obstacles (Figure 3).

The primary fragments are divided as follows, 25% of the total number of the fragments is considered to be high angle fragments, 7.5% of the total is considered to be fragments of the side impact, and 67.5% is considered to be horizontal fragments. Setting these values are based on interpretation of test data, including high-speed video analysis. The primary fragments are divided into fragments that can be blocked or contained by each structure type PES. The side impact fragments and the horizontal fragments are potentially blocked by the front wall, sidewalls and the components of the rear wall structure type PES, while high angle fragments are assumed to be potentially blocked by the roof component (Figure 4).

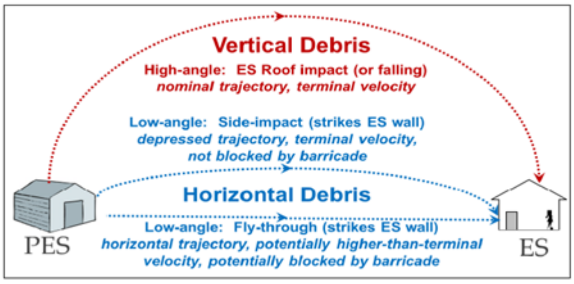


Fig.3- the design trajectories of primary fragments

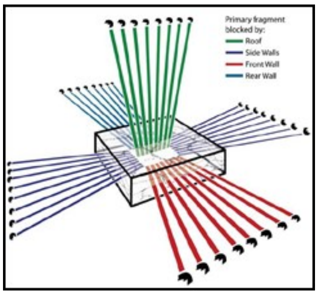


Figure 4 - Blocking the primary fragments

2. Density estimation of the material fragments projected

The configuration estimating of the path travelled by the material thrown away, can be done using the methodologies results within various research conducted in this domain and requires well-grounded scientific knowledge on the main parameters evaluated, namely: the speed of impact and the mass of material fragment projected. It would be ideal for determining the position and speed of impact, specific to each fragment of discarded material, to use physical laws based on differential equations that characterize the wave phenomena, however, at the moment, there do not exist proven scientific results for a specific scenario related to an explosion type event.

The number of fragments and individual characteristics of mass and speed are dependent both on the type of material (eg. steel or concrete), and the characteristics of explosives used to testing. Thus, the conceptual models can be developed for the production of trajectory calculations for the intervals of fragment of mass, launch angle and speed. However, Monte Carlo simulations are sensitive to present ranges assigned to each variable trajectory. Also, these models require running a series of simulations at the time of analysis, requiring extensive resources of time and the calculation result being one detailed and based only on assumptions.

Where, test results of explosives accident statistics, validated simulation data are available, then type models Fast-Running Models (FRMs) can be created for the analysis of hazards in a simplified manner, without using difficult complex physical models based on the equation of state. So, American scientific practice from the moment (type FRMs), developed for specialized software in the field of explosives for civil uses security type IMESAFR 2.0 which was acquired in the Program NUCLEU-Project PN 16 43 02 15/2016-2017, using different probability density functions dedicated to this field type PDF (Probability Density Functions) for graphic-analytical model of the phenomenon of projecting portions of the material, which result from such explosion events. This PDF is obtained by pre-processing, simulation and / or analysis of test data in a dedicated equation (closed form), after the pre-set density function can generate immediate results. Figure No. 5 shows an example of simulation test data, by a number of data-points that have been translated into a closed-form equation. This PDF serves as a contour map, almost instantaneously forecasting projected portions of the material density. To represent different types of models based on the use of probability density functions, it can be designed with different levels of complexity. Thus, PDFs are composed of elements "down-range" type and azimuth (cross-range). "Down-range" component reproduces the shape of the origin of the blast outwards in any radial direction. This essential component distance determines the design portions of the material from the original location in which the explosive charge detonation occurs, and the range of their greater density. Cross range component determines the form of the tool when moving radially at a constant distance from the origin (azimuthal direction or cross-range). In the following, there will be detailed the two components of PDFs modelling practice often used in explosives security.

The most common PDFs are the uniform distributions in all directions from the origin (that is, no azimuthal variation). These distributions may be used effectively for modelling safety are evenly distributed or random in all directions around the site of an explosion such as both pieces of material resulting from the destruction of the roof that are thrown up and scattered, as well as fragments of wall structures of the various arcuate shape. The first example is a function of the type Gauss - normal of distribution (ex. a bell-shaped curve) used as component ^{2}*down-range*^{2} without azimuthal variation, producing a distribution parameter type bi-variant Normal (BVN), characterized by the highest density at the origin which resembles a hill (Figure 6).

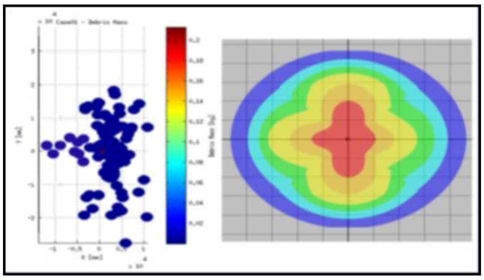


Figure 5.- Representative test transposition date in PDF

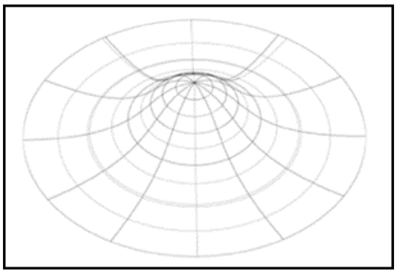


Figure 6. - Distribution type Bi-Standard version (BVN))

The shape of PDF- for the distribution of BVN is given by the following equation:

$$P_i = \frac{1}{2\pi\sigma^2} e^{\left(\frac{-r^2}{2\sigma^2}\right)} \quad (3)$$

where:

P_i - the probability of a single piece designed in a certain area

σ - the standard deviation of the distance ²*down-range²*

r - the range from the origin to the point of interest

The ISURF model

Probability density function BVN is useful for substantiating the basic scenarios, in which case is available a limited number of data and information, the danger of projecting fragments of material is assumed to be higher in the vicinity of the blast origin for the production location, as a result of the detonation of the charging material. However, there may be situations under which many of the fragments are thrown out of origin. This aspect is especially true for primary fragments, the residues from the explosive charge and secondary arising from pieces of wall. When the model ²*BVN down-range²* is used in these types of scenarios, the problem of the PDF is related to resolving over-prediction of throwing fragments near origin, in small amounts at intervals. Research conducted by the Institute of Explosives Manufacturers (IME) to develop specialized computer infrastructure for the security of explosives (IMESAFR), Research APT has developed a new function ²*down-range*² to improve the model ²*BVN down-range²*, resulting in a toroidal PDF with azimuthal variation (Figure 7).

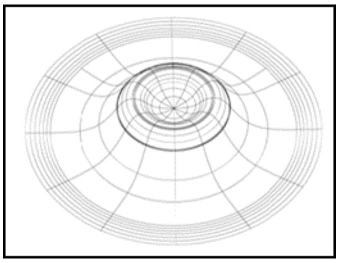


Fig.7.-PDF toroidal without azimuthal variation, type ISURF

Comparative analysis of the two established models for substantiating the scenarios of projecting the fragments of material resulting after the detonation of explosive charges, respectively: *Curve* ²*BVN down-range²* and *Curve ²PDF toroidal down-range²*, points out that the areas occupied by the two curves are identical, and declaring the approximate representation of the same amount of total mass of the projected fragments. It is also found that the model of the curve BVN is type conservative at certain intervals, compared with the curve PDF toroidal (Figure 7). The new component of the model PDF ²*down-range²* is referred to as slope (Range) and it is given by initial ascending function of the new model – ISURF, (figure no.8). The complex shape of the model ISURF is provided by the three parameters mentioned, respectively a, b and c, which may have different values depending on: size of fragments thrown away of the resulting material type after detonation by explosive charge and type of structures used \ in the scenario of the explosion (ie. the wall or roof).

The presentation chart of the model highlights the following elements of structure:

- parameter "a" is the ratio of the horizontal coordinate of the maximum likelihood (X_{peak}) and the maximum horizontal distance of throw (or "full-throw") the density of fragments (X_{MT}), it is used to determine the maximum range;
- parameter "b" the relation between probability density at origin (Y_0) and the maximum probability density (Y_{peak}) is used to determine the maximum magnitude;
- parameter "c" is used for controlling the shape of curves which are joining the set points and represents the percentage of probability generated by the surface under the curve, which is bounded by the horizontal distance from the origin to the maximum value of the curve, determining the percentage of the area under the curve.

Knowing the percentage by calculating the area under the curve will result in the determination of both the inner face of the slope and the slope of the outer surface.

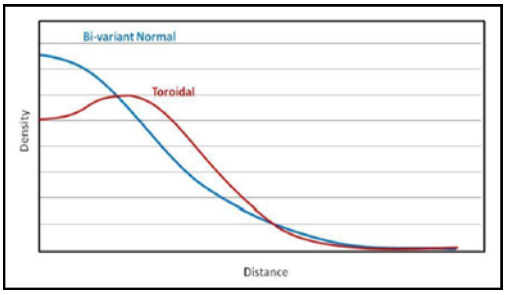


Fig.7.-Graph of curves *BVN down-range* and *PDF toroidal down-range*

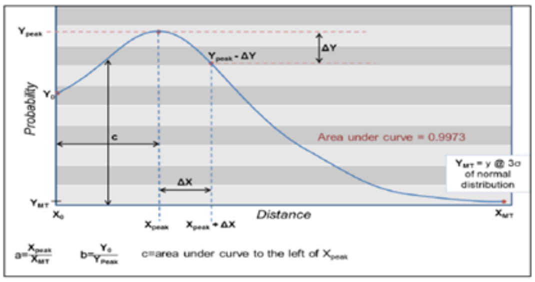


Fig.8.- graphics details of the model *ISURF down-range*

The ISURFGAD model

This model is characterized by a zero change in azimuth (they produce the same results in all directions), being used for modelling uniform of the directional hazard, both for fragments by the roof, the circular crater effect at warehouses of explosives and for scenarios of explosion where fragments are thrown in random directions. Because, in the case of centrally located loads in rectangular buildings, it has been observed that the density of the thrown material is strongly affected by the azimuth (debris of material tend to “move along the normal” and not in the “corners”) generating an effect type Cloverleaf (PDF with azimuth zero – transversely range) shown in Figure 8, Figure No. 9 presents a new type of PDF (ISURFGAD) based on a model range transverse that take this type of effect into account.

PDF derivation type ISURFGAD is performed independently for functions ²*down-range*² and the transverse radius. The function is represented for one dial of 90^0, probability density of the portions of the material characterized by independent parameters, respective interval of the range (r) and the throwing angle (θ), thus:

$$PDF = f(r) * g(q) \qquad (4),$$

in which:

$f(r) = f_1 = A' + B'r + C'r^2 + D'r^3$, out of range $[0, R_{P+}]$,

$f(r) = f_2 = k_1 exp[k_2 * (r - R_{P+}]$, out of range $[R_{P+,} R_{max}]$

$g(q) = [1/(2pR_c s_q)]exp[-0,5(q/s_q)^2]$

where:

R_{p+} - peak value of probability density

R_{max} - the maximum radius of the throwing portions of the material

R_C - the centroid radius

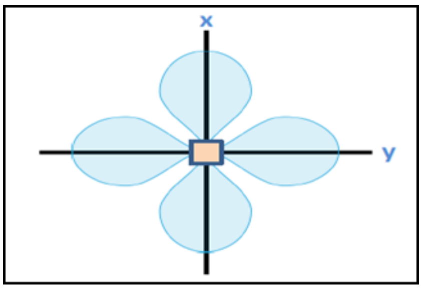


Fig.9- The model Cloverleaf of the dispersion of the fragments of material

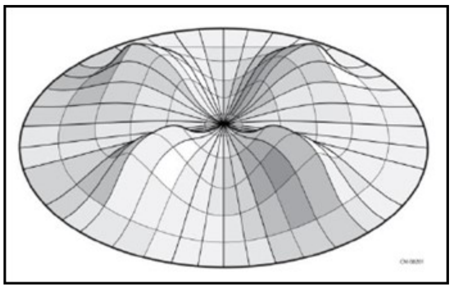


Figure 10. New PDF-type ISURFGAD

3. Human vulnerability assessment under the action of portions of the material resulting from the detonation of explosive charges

In previous sections were presented technical aspects of modelling portions of the material resulting from the detonation of explosive charges from structures type PES (for the storage of explosive materials) which can destroy structures exposed to explosion type events ES (for specific activities), with serious effects on the health and integrity of staff, and the population in surrounding areas. For modelling the degree of damage to the human component using probability equation (of the impact between the human body and thrown fragment) configured based on Poisson probability distribution (5), respective:

$$P_{impact} = 1 - e^{-EN^*} \quad (5)$$

where:
E - It is the human exposure (0.278 m^2)
N* - is the number of fragments which may damage the integrity of the human component

For solving the equation of probability, the model provides the estimation possibility of fatality areas with major and minor injuries based on the kinetic energy of the fragments projected (6), respectively:

$$P_{f(d)} = Valoarea\ de\ mortalitate \times P_{impact} \quad (6)$$

The lethality value is obtained from the curve shown in Figure No. 11, highlighting the likelihood of fatality for an event $P_{f|e}$ compared with the kinetic energy of the fragments projected. Finally, the model calculates the overall probability of fatality caused by projected fragments, $P_{f(d)}$, by summing the projecting path, corresponding to the angular projection, of the large fragments and to the displacement of small angular, and the total probability of death is obtained by using the additive rule applied in the case of events which are not mutually exclusive (7), respectively:

$$P_{f(d)} = P_{f(d)unghi\ redus} + \left(1 - P_{f(d)unghi\ redus}\right) \times P_{f(d)unghi\ mare} \quad (7)$$

where:
$P_{f(d)}$ - probability of death of a person due to the impact with a projected fragment,

Completely analogous is determined the likelihood of major damage / minor injuries $P_{maji(d)}/P_{mini(d)}$.
To substantiate the danger of the mechanism of thrown fragments is using a pattern type SCIFM (Simplified Cose-In Fatality Mechanism) all scenarios specific to this phenomenon (Figure No.12).

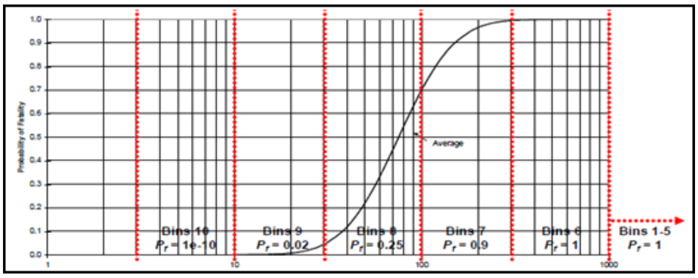


Fig.11- The probability of exposure of the human component by kinetic energy

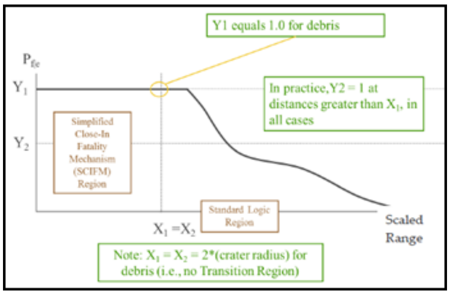


Fig.12- The Model SCIFM for fragments projected

4. Examples of application of the presented models

An example of surface PDF with the following characteristics: a = 0.330, b = 0.038, c = 50%, d = 10%, maximum range extender = 579 m and σ = 20^0,and it is presented in Figure No.13.

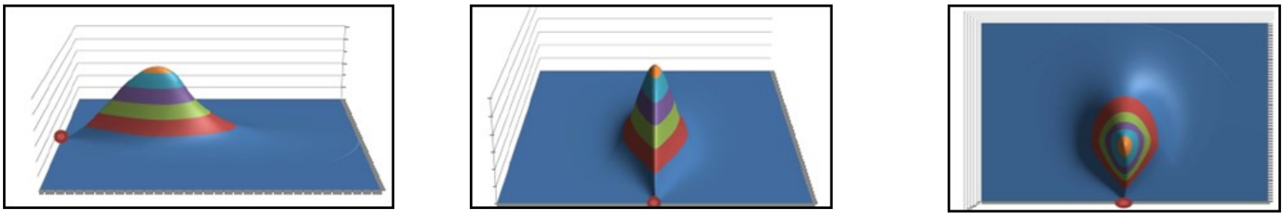


Fig.13-PDF surface - ISURFGAD PDF

The results obtained after modelling the risk of injury from projected fragments of the material resulting from an explosion type event, can be highlighted graphic-analytical, both through the associated diagrams of the contour maps of the destructive capacity, specific to the thrown fragments (kinetic energy of impact from fragments of the material), shown in Figure No. 14, and on the histograms of probability values of damage on the human component that define the following areas of interest, respectively: the area of fatality (the degree of mortality), area of major injuries (the extent of damage irreversible) and area of minor injuries (the extent of damage reversible), shown in Figure no.15.

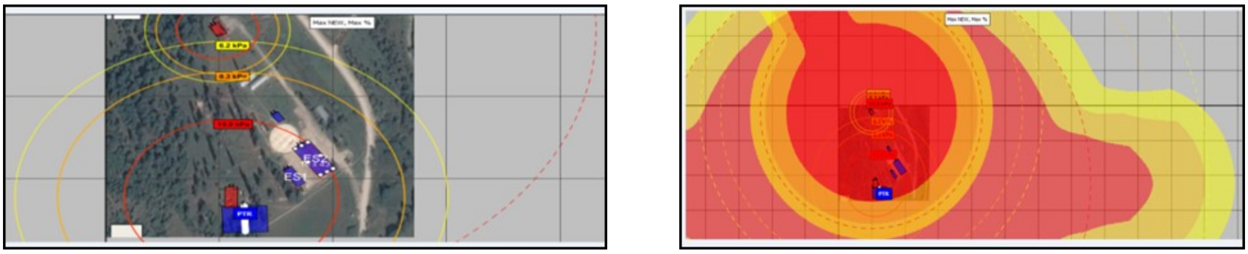
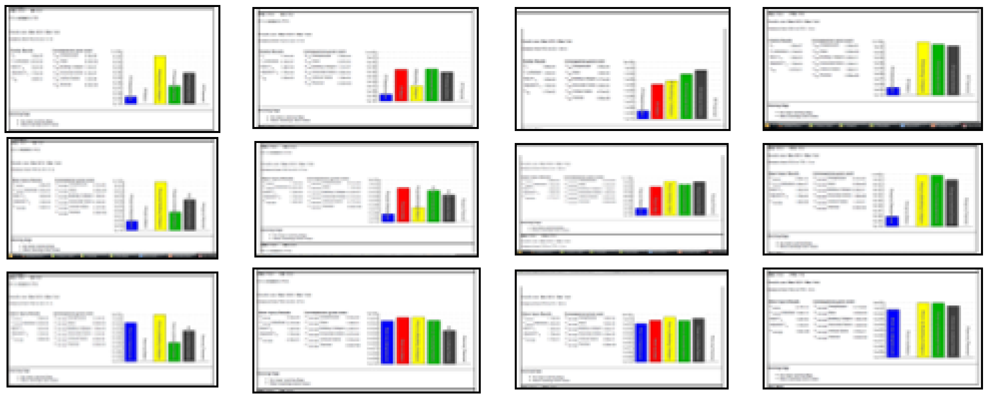


Fig.14-contour map for a deposit of explosives with a capacity of 1220 kg ETNT



Histograms of the fatality curves

Histograms of the curves of major damage

Histograms of the curves of minor injuries

Fig.15- Histograms of areas of damage on the human component and structures

The results shown in Figures 14 and 15 are needed to establish the areas of interest, in the case of an explosion type event as a result of detonation of explosive charges, resulting in the following planning areas: **area of high mortality**, defined as the area in which it accrues the death of approx. 50% of the exposed population; **the area of irreversible injuries,** defined as the area in which the exposed population is suffering serious harm to somatic level and lung, serious illness, first and second degree burns. Light buildings, suffer major damage becoming unusable. Heavy structures may undergo minor damage; **attention area,** defined as the distance that the effects of the accident can be felt and can cause a mild illness, of short duration, or superficial burns easily curable. When explosion accidents occur, light buildings existing in the area of attention, may suffer minor damage.

5. Conclusions

5.1. Estimating the route configuration of the fragments of material projected can be achieved using model type Fast-Running Models (FRMs), created for hazard analysis in a simplified manner, using different functions for probability dedicated to this area (ex. model type ISURFGAD with the azimuthal variation), for graphic-analytical modelling of the phenomenon of projected pieces of material resulting from explosion type events.

5.2. The model of projecting the resulting material after an explosion considers three types of fragments: primary, secondary and scrap resulting from the area of the crater formed. Thus, primary fragments come from the detonated explosives body, and the secondary ones are coming from the structure of the storage room (ex. roof, front, side and rear walls). Also, the other debris of impact which are generated in the area of crater, are fragments coming from the ground or from the foundation structure of the storage room.

5.3. This paper has presented the technical aspects of material fragments modelling resulting from the detonation of explosive charges coming from potentially explosive structures, type PES (for the storage of explosive materials) which can destroy the structures exposed to explosion type, ES (for specific activities), with the serious effects on health and integrity of the working staff, and the population from surrounding areas.

5.4. The final results of modelling the risk of injury from projection of the material resulting from an explosion event, may be highlighted graphic-analytical, through the associated diagrams of the contour map and histograms of probability values of damage of the human component (death, major injuries and minor injuries).

6. Bibliography

1. Hardwick, Meredith, Hall, John, Tatom, John, and Baker, Robert, "*Approved Methods and Algorithms for DoD Risk-Based Explosive Siting*," DDESB Technical Paper 14, 21 July 2009.
2. Arnauld, A. and Nicole, P., *Logic or the Art of Thinking*, 1996.
3. Pfitzer, T., "*Use of Fatality as the Measure of Risk*," Tech Memo E1-00300, A-P-T Research, Inc., Huntsville, AL, May 8, 2002.
4. Institute of Makers of Explosives Safety Analysis for Risk - User's Reference Manual, Version 2. October 2014.
5. IMESAFR P(e) Matrix Tech Memo, APT Report CM-07400, May 2006.
6. RCC Standard 321-00, Common Risk Criteria for National Test Ranges; Inert Debris, published by Secretariat, Range Commanders Council, US Army White Sands Missile Range, New Mexico 88002-5110, April 2000.
7. "RBESCT Technical Issues Regarding Injury Modeling," APT CE3-00300, 26 February 2004.
8. Copes WS, Sacco WJ, Champion HR, Bain LW, "*Progress in Characterizing Anatomic Injury*," In Proceedings of the 33rd Annual Meeting of the Association for the Advancement of Automotive Medicine, Baltimore, MA, USA 205-218CE3-00200 SAFER Injury Model Sources.
9. Swisdak, Michael, "*DDESB Blast Effects Computer Version 5 User's Manual and Documentation,*" DDESB Technical Paper 17, 10 March 2005.
10.
11. *** Program PNCDI – NUCLEU, Proiect PN 16 43 02 15/2016-2017„*Cercetări privind creşterea gradului de securitate la infrastructurile tehnice destinate depozitării explozivilor de uz civil²*, INCD INSEMEX Petrosani.
12.
13. *** Raport de expertiză tehnică privind *Evenimentul produs în data de 26.05.2008 la SC SPAROMEX SRL Victoria,* INCD INSEMEX Petrosani.

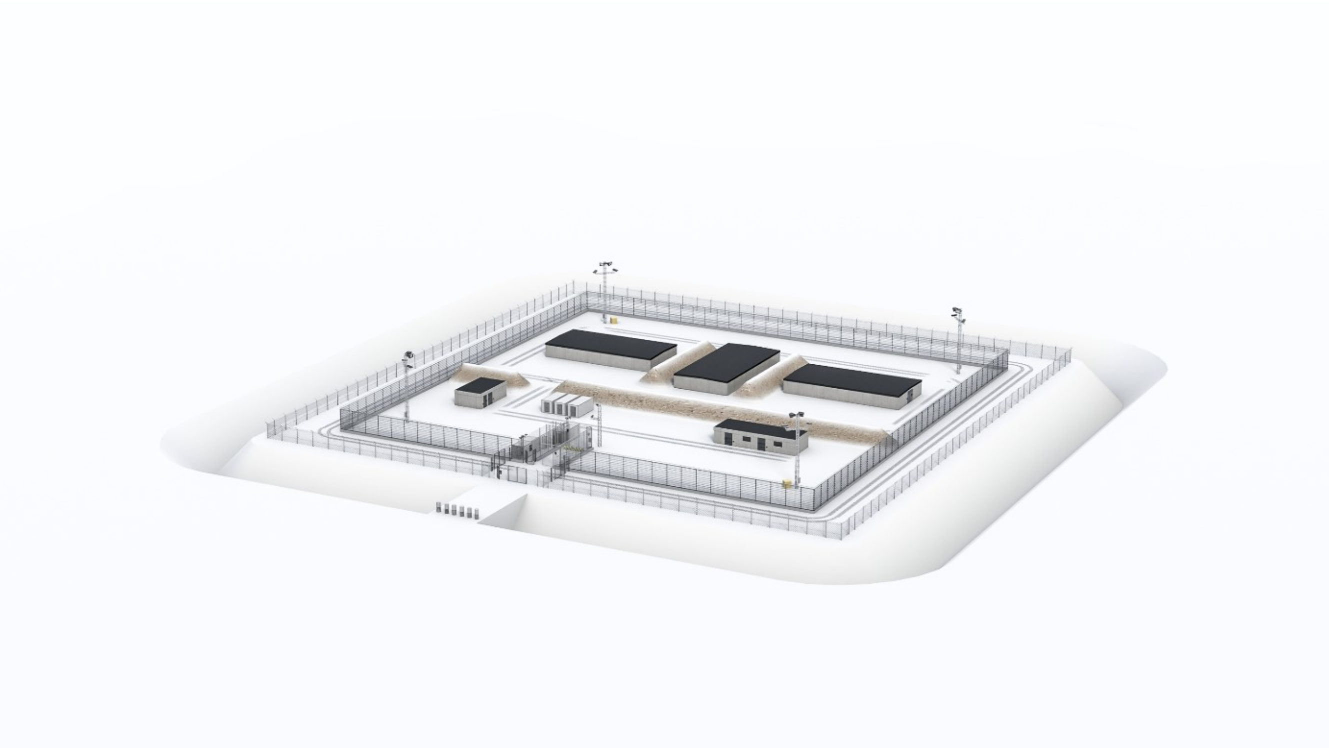
Ashley Haslett provides this different view to the perceived loss of experience in the industry:

"*Within our industry, we often hear that we are facing a significant problem due to the age profile of our workforce. Many are retiring and that results in an inevitable loss of corporate, systems and explosives knowledge, experience and skills. I've been in the industry over 30 years and have heard this concern raised throughout those 30 years. This is a risk to the industry and I'd like to take this opportunity to say that we are in the business of managing risks. I'd argue that as an industry, we manage the range of risks now better than at anytime in the past. We have applied and developed technology at an ever increasing rate that when implemented adequately, reduces our risks. We communicate better, in part through technology, but also through a greater understanding of the importance of good communication. That can be seen in part through the work of SAFEX and all that it does to share knowledge and lessons that we all have the opportunity to learn from. We have significantly improved how we develop people within our industry, not only in the level of information available to progress, the methods of learning and the structured approach to learning and development that wasn't there to prior generations. SAFEX's e-learning is in the early stages of development, but this in itself is a huge step forward for us and further generations. We have learnt the lessons from the past, we've used those lessons to develop and apply new systems to reduce our risks further. Who within our industry had robust management of change processes 30 years ago, or hazard and operability studies across the various stages, or human failure analysis? We certainly don't want to be complacent, but we're better prepared now to pass on the mantle than at any time in the past. I for one am confident in the people following behind me, knowing that they have been better prepared for the future than I was 30 years ago*."

Safe and Secure Storage and administration of Weapons and Ammunition

"Stockpile Management and Physical Security"

Hans Wallin MIExpE. Cesium AB Sweden
www.cesium.se
Ken Cross MBE CEng FIExpE. PICRITE Ltd
www.picrite.co.uk



References
ATT Arms Trade Treaty
https://www.un.org/disarmament/convarms/att
IATG International Ammunition Technical Guidelines
https://www.un.org/disarmament/un-saferguard/guide-lines/

Background

Millions of tons of commercial explosives are used each year to get minerals and metals out of the ground that we all use in our daily lives. These are minerals that make our food tastier, precious metals that our computers and cell phones need to function properly and materials used to build buildings and pave our roads.
Explosives engineers, the people who work with these commercial explosives, are skilled, highly trained workers who take every precaution to ensure the safety of those in a blasting area and the surrounding communities.
However, Commercial Explosives can also be used as weapons by terrorists and criminals. Therefore it can be of interest for readers of the SAFEX Newsletter to read a short orientation of what is going on within the United Nations concerning storage and administration of Military Weapons and Ammunition.

Most, if not all, States have a legislative or regulatory regime for the storage, movement, handling, processing, use and/or disposal of explosives. All these regulations are in place to achieve the three pillars of explosives safety:

Safety OF the explosives (to prevent accidental initiation)
Safety FROM the explosives (to mitigate damage and injury in case there is an accidental explosion)
Security of the explosives (to prevent loss, theft or diversion of ammunition and explosives)

Many explosives companies have plants in multiple States. Others, such as providers of blasting services, work in a number of different countries, moving from one to another sometimes many times per year. It would be useful if there was a common framework or benchmark against which the different national regulations could be compared.

UN SaferGuard Program

The United Nations has, since 2009, been working to develop Guidelines for storage and administration of military Weapons and Ammunition called the International Ammunition Technical Guidelines or IATG.

The guiding principles of the IATG recognise that: all the United Nations Member States have the right to determine the size of their stock of ammunition and weapons that best suits the country's national defence and security purposes; and that each nation also has the right to design the laws and regulations applicable in the country itself.

Trade across national borders with weapons and ammunition is governed by the Arms Trade Treaty ATT. It is also a commitment to store weapons and ammunition under safe conditions that prevents them from being stolen or otherwise diverted. You will understand, therefore, the ATT requirement to have auditable and transparent management and storage systems and to maintain a system of traceability throughout their lifetime

It is also advisable to keep technical data and technical specifications until the ammunition is destroyed. You should also consider archiving these details for a sensible period just in case there are complaints or further finds of the same type of explosive article.

Finally, it is the State's responsibility to demilitarize any excess of
Weapons and Ammunition by environmentally correct and long-term sustainable methods.

The United Nations Office for the Disarmament of Conventional Weapons (UNODA) is responsible for the development and publication of both the ATT and IATG.

International Ammunition Technical Guidelines (IATG)

The IATG provide basic and more comprehensive knowledge and education material of how to manage stockpiles with an auditable and transparent management system (compare for example different ISO systems).

Anyone reading the IATG will recognise that they have been written with a military application in mind, predominantly to support States that are conflict-affected, and which have a large stockpile of ammunition that needs to be managed effectively and efficiently. Although the IATG talk about 'ammunition' and 'munitions', it is fairly easy to see that commercial/civil explosive substances and articles (to use the UK Explosives Regulations generic terms) can also be managed using the same guidelines… after all, the physics and chemistry are the same, as are the classification testing regimes for transportation and storage.

The IATG are, first and foremost, guidelines, not legislation, but they are governed by a multinational Technical Review Board and a Strategic Coordination Group. This level of governance gives us the confidence to suggest that the IATG could be used by commercial organisations as a benchmark when comparing different regulatory regimes.

IATG Implementation Support Toolkit
This toolkit is suite of web-based applications that support the implementation of the IATG. Ammunition and Explosives experts are invited to use the resources on this website to implement best-practices that will improve the safety, security and efficiency in conventional ammunition (or explosives) stockpile management. These tools may also be used to communicate safety and security requirements to policy-makers and other stakeholders.

Arms Trade Treaty (ATT)

The landmark Arms Trade Treaty (ATT), which regulates international trade in conventional weapons - from small arms to tanks, fighter aircraft and warships - entered into force on December 24, 2014.

Member States are also committed to avoiding national and transboundary consequences due to theft or forgery from poorly managed stocks of ammunition and weapons.

Dissemination of ATT and IATG knowledge over the Internet

All information, guidelines and training materials can be accessed via the Internet and are already translated into many languages and the number of languages is constantly growing. The IATG are currently in their Second Edition and are due to be re-published in their Third Edition by 2020.

The situation in Sweden

Sweden is also affected today by illegal automatic weapons, ammunition and hand grenades that mostly come from poorly-managed ammunition stores in mainly former conflict zones.
Currently, the weapons are used for internal gang war , but escalation of use leads to increasing risks for civilian and police personnel. Shots against a villa owned by a police force have already occurred and are classified as assassination attempts.

Sweden must quickly reverse developments before violence escalates.

Improved High Security Storage Buildings(HSSB) introduced

The picture below shows High Security Storage Buildings (HSSB) made from reinforced Concrete.

The Buildings below are tested and have Certified Burglary resistance in accordance with EN 1143-1 Grade VI and higher.

HSSB combined with electronic Burglar Alarm, which can also be operated with satellite communication, so its Physical Security is strongly enhanced.

CESIUM
CESIUM SWEDEN
INNOVATION COMPANY

CESIUM
CESIUM SWEDEN
INNOVATION COMPANY

An International problem

Today's problem with terrorists and advanced criminals using military weapons underlines the need for improved storage space and improved burglary resistance combined with advanced perimeter protection. Military weapons and ammunition must be kept in such a way that they do not get into the wrong hands.

Commercial Explosives must also be kept out of the hands of all types of criminals and terrorists.

Risk of mass detonation in ammunition stockpiles

From a global perspective, several accidental mass detonations of military stockpiles occur annually, often with catastrophic consequences for employees and residents, such as at the Evangelos Florakis Navy Base in Cyprus on 11 July 2011, when 98 containers of explosives that had been stored for 2½ years in the sun self-detonated. One of the reasons for these explosions is often decomposition of nitrocellulose when the stabilizers are consumed.

The risk of self-ignition increases at higher outdoor temperatures. This is a different issue and should be addressed initially by the manufacturers.

It follows that some form of protective technology for control of ammunition is necessary, and ideally, such technology will provide all three pillars of explosives safety – safety OF the explosives, safety FROM the explosives and security of the explosives.

Each state should establish routines for the lifetime inspection of military ammunition stockpiles in order to reduce the risk of self-ignition and malfunction of the stored ammunition.

About the Authors
Hans Wallin has a lifelong experience from handling of Explosives. He is now Project Director at Cesium AB and focused at Physical Security and Stockpile Management. He is a Member UN SaferGuard Strategic Coordination Group

Ken Cross is an independent consultant explosives engineer, working in the field of explosives safety management and with a particular interest in the UN SaferGuard programme.

https://www.un.org/disarmament/un-saferguard/guide-lines/

http://www.legislation.gov.uk/uksi/2014/1638/regulation/2/made

https://www.un.org/disarmament/un-saferguard/toolkit/

Tales of explosives-contaminated land management
By Dave Griffith

Management of contaminated land can take many directions. The first option is always to do nothing – but only if there are no impact or safety issues. This doesn't often apply to explosives contamination.

Much of the work that I've done has been to remediate dumps of material, often from burning grounds. In some cases the material was buried in trenches, which may have seemed a good idea at the time, but it complicated the remediation. On-site dumping is now banned, so at least we only have past sins to deal with these days.

The good old dig and dump option may sound the easiest, but this really only moves the problem to somewhere else. Legislation is tightening, so this option is gaining less favour lately. With explosives, I've done a number of variations of sorting and sieving to remove explosives before disposing of the bulk of the material. Sorting was done by hand and sieving by hand or mechanically. The explosives were then usually destroyed by burning, but getting permission for this is also becoming more difficult.

Obviously the materials of interest present their own specific challenges. For example, the presence of Mercury in the soil around old Mercury Fulminate plants led to the development of flux chambers to measure the vapours emanating from the soil.

On-going impacts can require interventions over a number of years after removal of the contamination. A site on which water-based explosives had been buried required management of both groundwater and surface water, with the interventions being modified as time went on. Sometimes what you expect to be effective just doesn't work and so you have to continually innovate.

Similarly, the area downslope of an AN store required water management and planting of appropriate vegetation over a few years. However, before effective management could begin, contaminated sand, bricks and water had to be removed from the store. The sand was sent to a company that used it as a growing medium in their nursery for dump rehabilitation plants, the bricks were sent to a licensed landfill, and the water was pumped out onto the ground. The local troop of baboons used the derelict store as sleeping quarters and as a toilet. We had fleeting thoughts of mixing the resultant mess with the bricks and sand and selling it as Baboonex. (We thought Apex might be a bit presumptuous.)

Destruction activities have also left their impact in the form of exploded, partially exploded and unexploded detonators, etc. The use of metal detectors was problematic on the first site we tackled because the sensitivity/setting of the devices was difficult (depth cf. size).The ground was graded down 200mm at a time and put through a mechanical sieve to remove the detonators. The detonators were then sent to the burning ground for destruction as per standard practice.

Destruction in situ has been used on a number of sites. Decontamination burning using a gas lance was effective on drains in two NC plants and decontamination blasting was effective on NG plants on three sites.

PETN containment areas (soakaways and ponds) have been remediated on two sites. On the first site (larger areas) the PETN was slurried and pumped to an adjacent incinerator.

Recent, current and proposed remediation work includes:

- PETN was dug out from a containment pond by hand into plastic drums containing some soda ash solution. The drums were then taken to the nearby plant, and the contents mixed with sawdust, paraffin and broken paraffin briquettes. This mixture was then taken and burned on a burning ground.
- The ground around destruction facilities was excavated with a backhoe loader and loaded into a rotary sieve.
- Decontamination blasting is going to be used on an LS French drain.

For all these projects, repeated Risk Assessments were undertaken.

Of course, before you can start remediating an area, you have to know if there is anything there to remediate. Characterising sites comes with its own challenges, not always of an explosive nature. In Southern Africa, and no doubt elsewhere, monitoring wells are a favorite haunt for snakes. (I recall a big, strong hydrogeologist leaping backwards into the arms of a female colleague on seeing a cobra. At least, that was his excuse.) Bees are also not uncommon.

Sampling ground contaminated with explosives requires appropriate precautions, so let me share two of those.

We developed a remote-controlled drilling rig to investigate an NG soakaway. This was in the days before computerizing everything and telemetry and drones, etc. so we set up cameras at the rig and TV monitors and controls in a caravan some distance away. And we had a beach buggy to run between the two. Come the first attempt to drill, and the driller says he can't work like this – he has to hear the drill! So, we set up microphones and then all went well and the drilling programme was completed without incident. There were those who then asked why we bothered with remote drilling seeing nothing went bang. And if it had?!

When developing a methodology to sample ground contaminated with primary explosives we discovered that you can get PPE to protect every part of your body except the soles of your feet. So, I stood on a wooden pallet so as to get a degree of separation from any potential initiation. All rigged out in a demining apron, Kevlar gloves and sleeves, extra strength face shield, hard hat, hearing protection and steel toe-capped boots. I used a long-handled wooden scoop to take the samples and put them into a sample bottle. My assistant stood behind a nearby mound/barricade with his eyes closed and his fingers in his ears. Again, repeated Risk Assessments were undertaken.

Risk Assessments were undertaken for all these projects as per standard practice, but I can only remember the recent ones. For many of these we used an independent facilitator with all the required registrations and credentials. Less complex ones were led by internally qualified practitioners.

I hope this has given you a taste of (and for?) explosives remediation.

Did you know that - - - ?

Did you know that trucks loaded with explosives and other dangerous goods on long distance deliveries require to park enroute to enable drivers to take rest stops regularly? Your safety guard can be let down during these situations that can lead to incidents that could endanger the safety and security of the truck and its load. Here are some points for truck drivers to consider at truck rest stops:

Safety:

- Upon entering the vehicle park, watch out for pedestrians.
- Drive slowly and observe any speed limits.
- Always use your turn signals, even at low speed.
- Observe safety distance between trucks.
- Take note of non-compatible vehicles (including combustible and flammable). Avoid these and maintain the required safety distance.
- Observe safety distance between trucks.
- Use a spotter to aid your parking if required.

Security:

- Park in well-lit areas if possible
- Lock your cabin and tool boxes when the vehicle is unattended.
- Activate electronic engine immobilisers to prevent vehicle from starting.
- Use a steering wheel lock or similar device whenever you leave your vehicle.
- Activate vehicle alarm to deter theft.
- Don't leave items of value on display.

Remember: A load at rest is a load at risk! Look out for good parking areas that enable drivers to take rest breaks safely and securely. This will enable drivers to continue their journey fully refreshed and not fatigued and thereby deliver the explosives load safely to its destination. Look out for safe entry and exit for trucks. Avoid hotspots for crime. Ensure you can communicate with other truck drivers in the vicinity. Look out for suitable amenities and services for drivers.

Submitted by Brian Devaraj

For further information on Truck Safety Procedures you may contact the Expert Panel.

QRA CORNER ARTICLES

Bricks, Mounding, IMESAFR and Slate Tile Roofs

By

Bill Evans

Chairman , IMESAFR Subcommittee

Institute of Makers of Explosives

This note is written in response to – possibly inspired by is more appropriate – Tony Rowe's excellent article in SAFEX Newsletter No. 61. Amusing and thought provoking is a combination I have always admired. In full disclosure, I am not writing this note as either a member of the SAFEX Expert Panel or as Orica's Senior Explosives Technology Consultant (except for the slate tile roofs part, which is straight Orica), but in my IME role as Chairman of the Institute of Makers of Explosives' (IME) IMESAFR Development Team and the IMESAFR Subcommittee, as well as the Co-Chair (along with Kevin McNeill of the Bureau of Alcohol, Tobacco, Firearms & Explosives) of the IMESAFR Science Panel.

Quantity/Distance (Q/D) is a nice, simple tool to determine the difference between "too close" and "far enough away" when explosives inventories are present. But the simplicity means that important detail is not considered – and the construction of both the PES (Potential Explosion Site) and ES (Exposed Site) is one of those important, sometimes critical, factors that Q/D does not consider. I always like to ask whether you would rather be in a reinforced concrete building 100 m on the diagonal from a 10 te all-glass magazine (the new showcase style) or in a glass house facing a 10 te concrete magazine 500 m away. One meets Q/D, the other is a catastrophic fail, but the catastrophic fail is orders of magnitude "safer", i.e. at lower risk. Change that from concrete to bricks and you get the same relationship. So yes, materials of construction are important for both the PES and ES, far more so than Q/D would indicate.

Q/D, as suggested by the name, considers exactly two factors – Quantity and Distance. But neither all Qs nor all Ds are constant. I have walked by 1000 te stores of 1.5 ANEs without even thinking of risk; 100 kgs of lead azide or styphnate would, on the other hand, give me significant pause. Because while Q/D treats the ANE as being the much bigger risk, we all know that while that may be true at 500 m, it is entirely wrong close in. A Quantitative Risk Assessment (QRA) can – and should - consider many other factors. IME's QRA software tool, IMESAFR, which is inarguably the most powerful such tool available to the commercial explosives industry, tries to incorporate a great many key variables into determining the 'real' risk, some of which are:

Explosives/Activity
- ◊ Quantity
- ◊ Actual TNT equivalence
- ◊ Event frequency based on explosives classification and activity

PES
- ◊ Construction (floor, walls, roof)
- ◊ Size and positioning
- ◊ Mounding
- ◊ Hours of activity

ES
- ◊ Distance
- ◊ Positioning
- ◊ Construction (walls and roof)
- ◊ % and type of glass
- ◊ Occupancy

Hazards
- ◊ Low angle/high velocity horizontal debris
- ◊ Mid angle horizontal debris
- ◊ Vertical debris
- ◊ Fireball
- ◊ Pressure/impulse
- ◊ Glass failure
- ◊ Structural failure

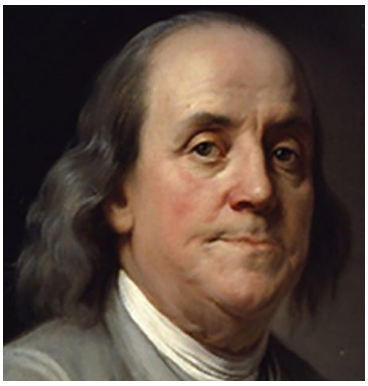
So IMESAFR does consider both Q and D, which are undeniably important factors, but also considers a great many other factors, which often are more important than Q or D. But what has this to do with the original premise, i.e. that bricks are a non-optimum construction choice for a PES? The answer to that is that IMESAFR allows one to model just how bad that choice is versus other options, e.g. concrete, metal, or even open (which clearly was not viable in this specific process). If the differential risk is great enough (and I would recommend reviewing documents from the UK HSE, who are much less squeamish than most regulators when it comes to risk to help quantify that determination), then making changes must be considered. If it turns out, for example, that the relatively low loading of these buildings means that bricks are not going to be propelled at high velocities for long distances, then bricks may be a non-ideal choice but not an unacceptable one. So IMESAFR can tell you whether that nagging concern needs to be dealt with or whether it can be lived with. It is worth noting that the next version of IMESAFR (v2.1), which will have a full release in 2018, will handle this type of case even more accurately – at higher explosives loading concrete and bricks, and to a lesser extent metal, will be broken into more and more sub-lethal fragments, mounding can be more/less effective than the current default 50% (removes all low angle, no mid angle). The IME is to be commended for not settling just to be best, but to continue to make the best even better.

Now to slate tile roofs, my equivalent to bricks. Many of our older buildings in Latin America, in particular Brazil, had heavy tile roofs, sometimes slate. Not a necessarily poor choice overall given the climate, but a poor one for explosives plants as it turns out. Our plant outside Rio was in its last week of operation before site closure when we had a serious explosion, overnight/off-shift, in the Packaged Explosives Plant. So no fatalities, no injuries and damage only to equipment that was, with the exclusion of one Filipac cartridging machine, going to be scrapped anyway. Orica learned some valuable lessons in electric heat tracing control and gasser handling that remain integral parts of those BoS documents. But we learned one more lesson as well. The actual event was essentially a 2-4 kg pipe bomb going off between a vertical PC pump and the Votator gasser blender, both of which acted as detonation traps. But every single one of those heavy roof tiles, except those directly above the thermal explosion site which had been thrown significant distances in some cases, was in pieces on the floor of the building. I led the investigation and we did the free fall velocity calculations for those tiles at 1.8 m height above the floor and came to the conclusion that, had this occurred during operating hours, the explosion would have killed 2-3 operators, the tiles another 6-7. No more heavy roof tiles for Orica process buildings. But much better to use IMESAFR to determine the potential risk than wait for an explosion to demonstrate the actual one.

Quality Assurance: Ounces of Prevention

By

Dr Jackson Shaver



"An ounce of prevention
Is worth a pound of cure."
Benjamin Franklin

Introduction:

One of my college professors frequently noted that safety and quality go hand-in-hand and that many successful management practices can be applied to both disciplines with an equivalent level of success. Several authors have noted that Safety, Health and Environmental systems and Quality Management Systems share some common tools and techniques. Typically, a successful quality management system will establish processes that a safety management system requires, such as management of change, analysis of data, corrective action, preventive action, process assessments, and, internal audits. I always appreciate the calls, emails and notes from our quality team when they encounter a situation in the manufacturing process or share information from a F.M.E.A. that has safety implications. The cross-functional exchange is certainly welcomed and valued.

Lessons Learned

Some management teams have discovered the implementation of traditional safety action plans intended to augment the ongoing safety management system can be replicated to favorably impact the quality management system. For example:

- Independent, external monitors to review quality practices
- Company quality hotline
- Daily/weekly quality meetings
- Internal compliance and regulation posting system
- Global system to report and monitor quality incidents
- Third-party audits of products and services
- Independent review of product development
- Quality Assurance Panel or Council to review policies, practices, procedures, structure and personnel to achieve best practices

One company that invited independent auditors to examine the quality management system found that two of the recommendations; 1) promote and respond to quality-related concerns in a manner similar to safety concerns (e.g., Quality Committee managed similar to a Safety Committee; Quality Minute at the beginning of the work shift); and, 2) monitor how quality was designed into the products and company processes, were highly effective. Both recommendations improved quality performance and were similar to safety management practices at the company so there were few difficulties with implementation. The manufacturer found the enhanced safety and quality activity (ounces of prevention) so effective they describe the safety and quality as part of the company DNA.

The American Society for Quality (ASQ) suggests quality assurance is planned, systematic activities implemented in a quality management system to ensure that quality requirements and expectations will be fulfilled. Many quality management system elements like those described by ISO standards are not revolutionary or new and they match up well with safety management systems. Combining safety and quality management practices can be the ounces of prevention needed to obtain and sustain successful safety and quality management systems.

References:

Hoffman, Rebecca L.; Morris, Jon B.; Kelz, Rachel R.; The "Quality Minute" – A New, Brief, and Structured Technique for Quality Improvement Education During the Morbidity and Mortality Conference. JAMA Surg. Published online July 12, 2017, doi:10.1001/jamasurg.2017.2229

McNeely, Steven C., Safety Management System: Quality and Safety Management, Flight Safety Information, Published February 12, 2010

Nemtzow, Andy, QC, QA, and Cost of Quality, 15 April, 2015 Accessed via the internet, 31 August, 2017.

Wylie, Cathy; What is a Quality Minute? 30 May, 2017, Accessed via the internet, 19 September, 2017

PHOTOS OF GOOD AND BAD PRACTICES

INCOMPATIBLE MATERIALS

BRUSH AND MOP USED IN EXPLOSIVES ENVIRONMENT WITH METAL FITTINGS

NO GUARDING

GOOD GUARDING

TONY'S TALE PIECE

HATS OFF TO THE SHE PRACTITIONERS

By

Tony Rowe

Working safely with either explosives or pyrotechnics, especially those manufactured within the commercial sector, should be easy. Nearly all have well established histories and even the latest offerings are well regulated, thoroughly documented and have been the subject of intense testing regimes and the most searching scrutiny. Workers are provided with excellent training, are environmentally aware and are encouraged to know more. Despite all of this, accidents and incidents continue to plague the industry.

So, what is it about the manufacture and use of energetic materials that turns the operation of an essentially mundane series of processes into such a complicated issue for any **SHE** practitioner?

It's not a difficult question to answer. Let's begin with the oldest known explosive, blackpowder also known as gunpowder. The names are totally interchangeable. I will use both terms randomly throughout the article.

These days the main commercial application for blackpowder is in the blasting of granite, where its slow heaving action, doesn't result in hairline cracks becoming visible in the quarried stone after polishing.

From the earliest of times up to around the 1880's, blackpowder was the only available explosive. There was nothing else. Blackpowder itself was first used in China more than two thousand years ago. As an explosive, it is not deemed to be particularly powerful, in fact gunpowder is better characterised as a weak or low explosive, one that does not detonate in the truest sense of the word, but rather 'fast deflagrates'. It is, however, either delightfully easy to ignite or on occasion, frustratingly difficult. For reasons not quite understood it is also an excellent igniter for other explosives and pyrotechnics.

Blackpowder was probably first used in fireworks and in noisemakers intended to scare away demons and other creatures of the night. It didn't take long before other uses were found. Applications like rocket propelled arrows, incendiary firepots and simple grenades. Later on it was used not only as a blasting explosive, but also as a propellant in guns (large and small) and even as a bursting charge for both common and shrapnel shell. By around 1840 blackpowder also provided the central core in commercially manufactured safety fuse.

In the absence of anything better, gunpowder soon had its grubby little fingers into a wide variety of pies. The statement that, "In the land of the blind, the one-eyed man is king" was rarely more true. It became the active component of early time-delay type fuses and as mentioned earlier, in the years to come, even commercially manufactured safety fuse. It was used in rockets, flares, railway signals and anti-personnel mines. Hollywood absolutely adored Blackpowder. John Wayne even used it to blow up a variety of wicked wooden bridges and rioting railroad tracks.

Gunpowder has had a long and chequered history, but don't be misled, gunpowder has probably killed more people than any other energetic material. It has burned and mutilated them, burst their lungs, blown them apart and blasted miscellaneous projectiles and shrapnel into and through their bodies.

With such a record I have to ask, can gunpowder really be your friend?

Gunpowder is in all probability also the most studied explosive. There are literally mountains of technical literature on the subject and every year researchers make more available. You would think that after around two thousand years together we'd have it all down pat. We'd know, chapter and verse, exactly how to manufacture, handle and use gunpowder in absolute safety. You'd think so, but sometimes I wonder.

I can recall an explosion that took place way back in 1995 or 1996. It occurred at a blackpowder plant in South America and resulted in a number of fatalities. I think it involved a total of some fourteen metric tons of gunpowder. Around four buildings were totally destroyed and a further three or four were seriously damaged. I remember it because I had actually been there once. Modderfontein too has had its issues with gunpowder, losing its safety fuse manufacturing plant and gunpowder lofts when a series of explosions ripped through the facility. People died.

Again in South Africa, this time at a facility not far from Rustenburg, a nautamixer filled with a thick and viscous, water-based, blackpowder paste exploded, blowing part of the roof off the particular production house. There were no injuries, but it goes to demonstrate that even in the form of a water-sodden paste, blackpowder should never be underestimated. It still has teeth and can bite.

Blackpowder is a mechanical mixture of just four ingredients. On its own, each one is fairly benign. The first is a water soluble and fairly commonplace oxidizer. The second ingredient, while insoluble in water burns to produce a pungent and potentially toxic gas. The third is obtained by burning wood in an oxygen deficient atmosphere. The fourth, involves certain unmentionable portions taken from a specific variety of toad. These, we cannot talk about. All we can say is that part of the tradition involves candles at midnight and a brass-bladed knife.

When all four raw materials are combined together in the right proportions, the songs and chants well-voiced and the esoteric rituals correctly performed, a true monster emerges. Glazed with graphite it appears lively and flows well. With the merest flick of a flame or strike of spark it can hurl a suitable projectile at velocities in excess of the speed of sound. If confined within a strong container, it will, upon ignition, transform that container plus any other objects in the immediate vicinity into large chunks of high-velocity shrapnel. An orange flash, a loud bang and lots of white smoke are its calling cards.

Given gunpowder's inherent tendencies towards death, destruction and the maiming of the unwary I am sure that the mechanisms that resulted in its unexpected or unforeseen ignition were identified pretty quickly. Flame, high temperatures and impact were most likely among the first ignition mechanisms to be confirmed and I am pretty sure that attempts were made to eliminate them. This though was a time when neither gas nor electric lighting existed. Gas lighting would only become available at the beginning of the nineteenth century and electric lighting just before the beginning of the twentieth. Before then, oil lamps and candles were the only options. Pouring gunpowder by the light of a naked flame sounds to me like a recipe for disaster, yet for at least nineteen hundred years what choice was there? If you made or used it inside a structure, light was a practical necessity.

Gunpowder is hygroscopic. This means that it doesn't like water very much. Because of this property it can be unstable in storage and measures must be taken to protect it. For military purposes it was often stored in barrels made from thoroughly seasoned, best 'Quebec' oak. The casks were bound with copper bands.

As for the properties of gunpowder my memory is less comprehensive than I might wish. Whilst I have been carefully matured, a statement that my wife translates to "old and worn out", the grey matter sometimes seems to function more like custard.

I've just given it a quick stir and seem now to recollect the following:

- When I was, but a sprightly young lad, blackpowder regularly ignited in a DTA at around 337 degrees Centigrade, but hotspot ignitions have been reported at temperatures around 130 degrees Centigrade. Blackpowder is clearly never to be trusted.
- Loose blackpowder burns at about 100 meters a second, but if confined can reach up to 600 meters / second.
- The temperature of burning blackpowder probably lies in the region of 1200 - 1300 degrees Centigrade.

- Blackpowder is extremely sensitive to ignition by flame and hot sparks.
- Blackpowder is highly friction sensitive, perhaps just a little less sensitive than lead azide under similar test conditions.
- Blackpowder is highly sensitive to ignition by electric and electrostatic spark. The author can personally confirm ignitions at 20 mJ.
- Blackpowder can be ignited by impact, (2 kg from 32 cms about 6,5 J) is a typical figure.
- Blackpowder doesn't much like heat.
- When gunpowder burns, a lot of the reaction products are solids. Upon one rather memorable outing I can recall sitting in the 'hot rain' as these once molten particles returned to earth.
- Gunpowder can be effectively desensitised by leaching with water, a process which dissolves the water soluble component.

***

But there is still more to understand.

It is not only the explosive nature of the final product that the **SHE** practitioner must take into account, in addition are all the other hazards associated with a typical industrial workplace.

Danger is inevitable and the Grim Reaper (GR for short) mounted on his favourite pale horse constantly lurks in the shadows looking for mistakes. He can't be everywhere of course which is lucky for us. The horse is called Poppins by the way. According to some he's called Binky, but that's silly.

It's a waiting game with life as the prize, but GR has many lifetimes of patience. He knows that in any factory environment there is the ever present possibility of trips and falls and there are always electrical hazards. Operators, even the most experienced ones, make mistakes with electricity. Adding extra spice to the mix is a host of miscellaneous hazards resulting from the operation of powerful and heavy machinery. Some of it may be electrically operated, but there may also be pneumatic and hydraulically powered machines running alongside. There may be a source of compressed air or a connection featuring an air hose. GR just loves an air hose. Even better, personnel may have to work at height. Then there are water sources, taps and hoses and therefore the potential for leaks and pooling water. There is the ever present threat of fire.

There are chemicals, noise, vibration and best of all boredom. GR does enjoy a spot of boredom. There are fire exits and – Oh I see! GR's giving me his best toothy grin - escape routes that can be blocked with clutter or product. There are sharp edges to consider plus a wide range of impact hazards. There are the 'good housekeeping' standbys of dust and spillages, even better if the dust or spillage has combustible or explosive properties. When they're not cleaned up promptly GR always rubs his bony hands together and chuckles. Nobody knows why.

There are the buildings themselves, its floors, stairs and perhaps even the odd confined space or hidden area to consider. Small rooms locked with a padlock are ideal places for storing contraband. It is even better when the door opens out onto a walkway. Such rooms provide a perfect place for temporarily storing soon to be stolen goods intended for later collection by some practiced accomplice with a duplicate key.

Then there are the people. There are those who should be there and maybe even a few who shouldn't. Work areas should be forbidden to anyone not actively employed there. Personnel from other areas, friends and family or any other people not physically required to be there must be actively excluded.

Remember too that it is the demands of production that become the drivers of worker activity. Compelled to work quickly and under pressure is when people take shortcuts. It's a fact.

Experienced people move upwards, downwards, sideways and onwards. They may leave altogether, retire or even pass away. They may be replaced, but in that process critical knowledge may be lost forever.

The printed word has lost both its authority and its magic (I was going to say gravitas, but that's a bit posh). Books and manuals are no longer seen as important. Knowledge is no longer a necessity and counts for little. Operating manuals and other documentation may be discarded because the folders or manuals haven't been accessed for a while and they're looking a bit dusty. Worse, they may be simply labelled as 'clutter'. It is rare to get such information back. Once it has gone it has usually gone for good.

There are typos and errors contained within important documentation. The author has personally seen 'sodium nitrite' become sodium nitrate and what should be standard dilute acid concentrations fluctuate. The errors were contained within a document detailing with how to destroy a certain primary explosive. If not corrected quickly such errors soon become entrenched and rapidly multiply.

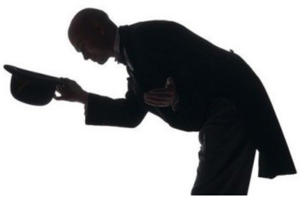
Think about training? Are all your employees properly trained and is that training properly documented? Can they tell the time, read and do they follow work instructions as required or only when the boss is walking by?

Think about unguarded machinery. Do you have any? What about that new equipment on the roof? Are there guardrails in place? What about noise and vibration hazards, scaffolding and the ever present bogeyman 'The Permit to Work'?

Finally, for now at least there is the issue of type testing. If you are a manufacturer of bulk safety fuse, do you know what happens if a reel of semi-fuse catches fire? How large is the fireball, if any? Can it be extinguished easily? What happens when you try? Can it propagate by any mechanism that can be identified?

- Do you know if your spacing between stations is adequate?
- Can an unforeseen event propagate by any mechanism to other buildings nearby?
- Is all shielding fit for purpose?
- Is the proper PPE available and do the employees wear it?.
- Are your emergency escape routes and exits clear and immediately accessible and can all doors can be opened quickly in an emergency?
- What happens if there is an incident at night that cuts power to the lights. Can employees find the exits safely in the dark?
- Can you account for all your explosives?

This has not, by any stretch of the imagination been a comprehensive document. To tell the truth it doesn't even begin to scratch the surface. It simply attempts to highlight a few of the issues that beset our **SHE** practitioners every single working day.
Hats off to them all.



***

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 March Newsletter is 10 March 2018 and I look forward to your support** .

SAFEX thanks all the authors and contributors for their for their valuable support.