



SAFEX NEWSLETTER

No. 33, 2nd Qtr. 2010



CONTENTS

This is your Captain Speaking

– Mr Jose Sanchez-Junco: MAXAM Group

Incident performance

– Scoring our performance

Know the Expert Panel

– Martin Braithwaite

Boardroom Feedback

– SAFEX Mission

Research notes from CERL

– Quantifying the friction sensitivity of energetic materials

Our Regulatory World

– Explosives classification in Canada

Explosives Eco-talk

– Carbon footprints

Congress Commentary

– Call for Papers

Inbox

– Readers' contributions

Safety Snippets

– Pump protection for MMU's

BOARD OF GOVERNORS

Claude Modoux (Poudrerie d'Aubonne);
Enrique Barraincua (MAXAM);
Andy Begg (Associate);
Jean-Yves Canihac (EPC);
Stephen Connolly (Orica);
David Gleason (Austin Powder);
Rahul Guha (Solar);
Dr. Piet Halliday (AEL);
Tom Hethmon (Dyno Nobel);
Karl Maslo (EXSA)

This is your Captain speaking

Jose Fernando Sanchez-Junco Mans – MAXAM Group



Jose Sanchez-Junco was born in Madrid in 1947 and qualified as an Industrial Engineer. He is also an ISMP graduate from Harvard Business School. During the 80s, he worked in different positions for the Spanish Ministry of Industry & Energy between 1985 and 1990; first as Managing Director of Iron, Steel & Shipbuilding Industries and then as Managing Director of Industry. During this period he was responsible for the main restructuring processes undertaken in Spanish industry as a result of Spain joining the European Union.

In November 1990 he was appointed Chairman and CEO of the MAXAM Group (formerly Grupo Unión Española de Explosivos, S.A., UEE); the position he currently holds. He is also a non-executive director on several Boards of companies listed on the Madrid Stock Exchange. Mr Sanchez-Junco is active in cultural affairs and serves on the Board of Trustees of the MAXAM and ONUART Foundations and is Patron of Honour of the Mining and Industry Museum Foundation. In January this year he was awarded the Encomienda de número de la Orden del Mérito Civil (the civil merit award) by the King of Spain for services to MAXAM.

When I assumed the responsibility as CEO of MAXAM 20 years ago, I also accepted a heavy burden: the commitment of taking any necessary measures to guarantee the well-being of all the people working within our company as well as the users of our products.

In this regard, my main concern during this time has been to develop an organization whose strength clearly lies in the training and education of our employees at all levels. In order to achieve this goal, MAXAM has developed two main courses of action. The first has been to ensure our recruitment policies are oriented to enable MAXAM to access the best available professionals. I do believe the cornerstone of any Occupational Health and Safety (OHS) programme is unequivocally made of people with the necessary knowledge to carry out the ambitious programs that are devised by upper management. The other is to ensure that the Policies and Management Systems are fully integrated in each of our Companies throughout the world. This must be done in such a way that the safety and protection of our customers and employees' health as well as the environment have top priority in our work.

view and making considerable efforts today so that in future it will be possible to have the desired results. More often than not the future is further away than we wish. Some of my managers have adopted the motto: "today we are sowing the accidents that will take place in three year's time". I could not agree more. However, I would prefer to say: "today we are taking measures to avoid those accidents". By selecting and training the right people is how we plan to do it.

Only by fulfilling the previous commitment will it be possible to perform successfully the vital tasks of assessing and avoiding the risks of processes and detecting anomalies in everyday work. Therefore, the multi-task assessing teams that carry out the Risk Analyses and the Investigation of accidents need that technical preparation to do their job. Thus, what I expect from managers in my organization is that they lead by example, showing that they are well-prepared professionals in their respective fields of expertise and asking their collaborators to be the same. It goes without saying that they should be provided with the necessary means to achieve this goal.

In this way we can live out the MAXAM slogan: "Occupational Health and Safety concerns all of us".

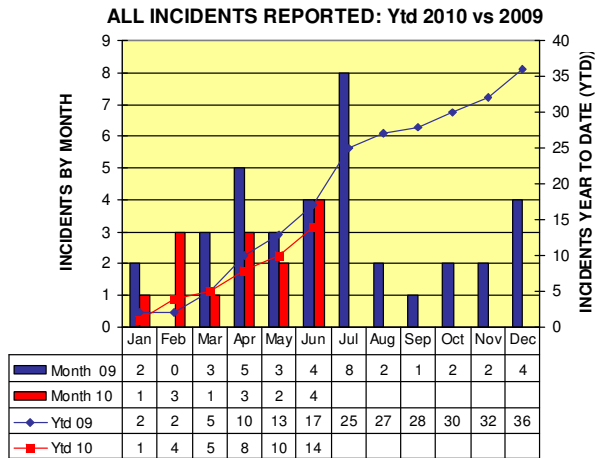
Unavoidably it means taking a long-term

Incident Reporting

Monitoring our Reporting Performance

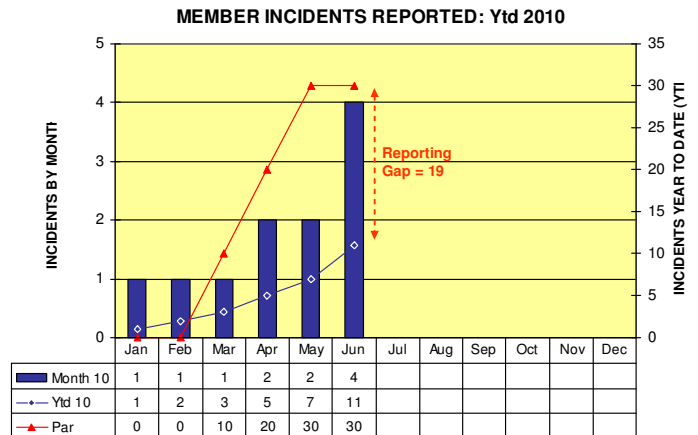
“Every incident that is reported may prevent another from occurring. You can save a life by reporting an incident - including a near-event.”

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

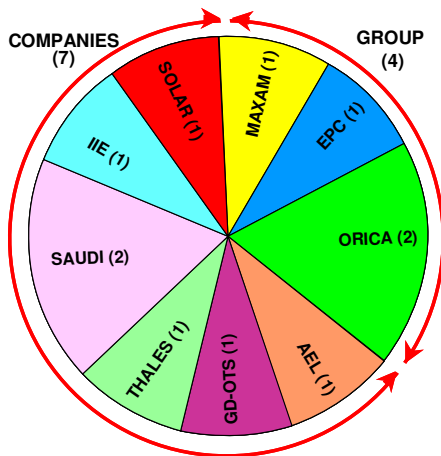


All the incidents reported. This chart compares the sum of non-member and member incidents reported to SAFEX every month this year to the previous year. Are we having fewer incidents or are we not reporting the incidents we are having? Every incident not reported is a lost learning opportunity. Remember, it’s never too late to report an incident.

Member incidents reported. Because they give us the best learning opportunities, we track member incidents (MI’s) separately in the chart on the right. PAR is an estimate of how many MI’s are occurring based on the severity of the MI’s reported. The gap between the number of MI’s reported and PAR is our Reporting Gap. The Reporting Gap suggests only 30% of our MI’s are being reported.



MEMBER INCIDENTS CONTRIBUTORS: Ytd 2010



Contributors of member incidents. This chart identifies those members who reported their incidents. It shows the number of incidents each of these members have reported in the context of the total number of MI’s received. The chart distinguishes between Groups and Companies merely to indicate the performance of the two membership categories. Each of these categories has about the same number of operating units

Know the Expert Panel

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

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

Martin Braithwaite

PERSONAL

Position: Professor
Company: Imperial College and
M. Braithwaite Ltd
Location: London, UK
Education: BSc Chem Eng (Hons)
- London (1971); PhD
- Cantab (1975)
Affiliations: FICHEM, FRSC, SCI
Languages: English; French (written)



CAREER OUTLINE

**Universities of British Columbia,
Southern California and Colorado:**
Research Fellow
With ICI Corporate Laboratory:
Senior Research Scientist
With ICI Explosives:
Company Research
Associate
With ICI Group Technology:
Company Research
Associate – Safety
With Cranfield University:
William Penney Professor of
Chemical Physics
With Imperial College: Professor of
Chemical Engineering

EXPERTISE

- Safety in Explosives Plants and Ammonium Nitrate handling
- Computational Modelling as applied to explosions and detonations
- Condensed phase, gas and dust explosions – avoidance and containment

TYPICAL ASSIGNMENTS

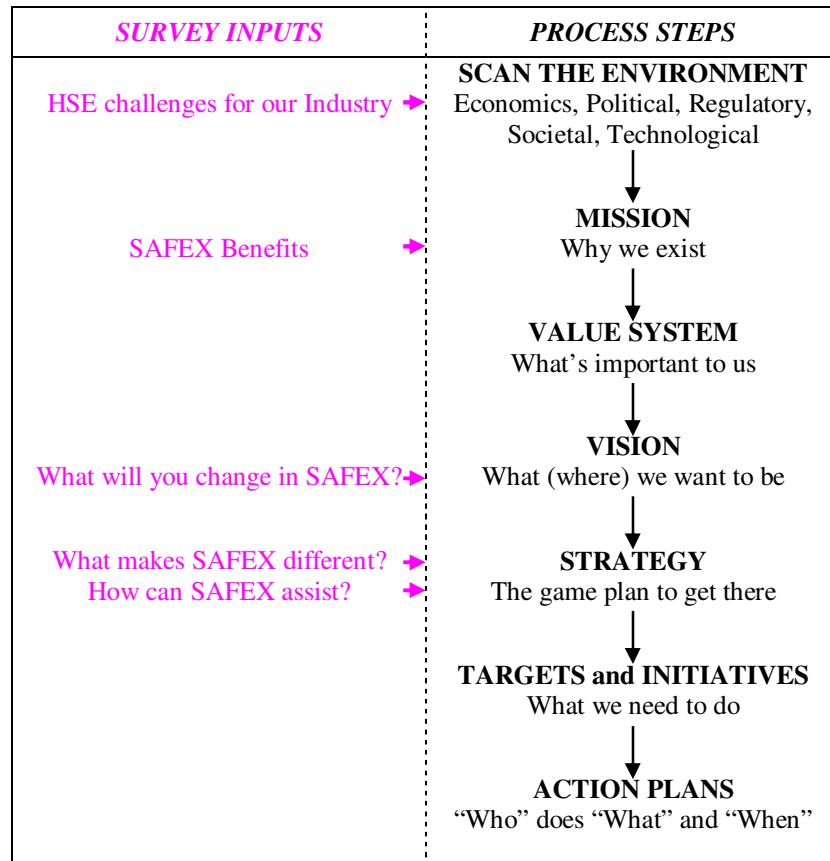
2003 Mine clearance issues – disposal of energetic materials - UN
2000 to 2006 Safe handling of waste energetic materials - AWE
2005 and 2010 Safety review of an emulsion plant - SEC Portugal
2000 to 2003 Dust Explosion Research – TU Delft, ICI
2007 Ideal detonation computer code issues - Orica
2000 to 2009 Detonation Physics – HSBM: AEL, De Beers, Rio Tinto, Dyno
2007 to 2010 Ammonium Nitrate Safety Issues – AEISG, Orica
2007 Issues with improvised explosives – CPS, UK
2002 to 2006 Hazards research – UK MOD
2005 Safety consultancy (internal) – Imperial College
2003 to 2005 HCN plant explosion/ safety consultancy - Lucite
2002 to 2006 SAFEKINEX – Gas Explosion Safety – EC
2008 Transport of Explosives – Hong Kong rail Tunnel Study
2010 Expert Witness, Industrial Court, South Australia

Feedback from the Boardroom

The SAFEX Board of Governors met in Orlando, FL early in February this year. The focus of the Meeting was a review of the SAFEX Strategy. In the last Newsletter we summarised the results of the Strategy Survey in which members participated and whose inputs were used throughout the Strategy Review process. While there are many approaches to developing strategy, the Board decided to use concepts such as MISSION, VALUES and VISION with which member companies are familiar. Future editions of the Newsletter will share some of the Board’s views on what each of these mean for SAFEX. Readers are, of course, welcome to comment on the Board’s thinking. In this Newsletter we outline the Framework the Board has adopted and discuss some aspects of the **SAFEX Mission**.

A Road Map for reviewing SAFEX Strategy

The overarching MISSION (Purpose) of the organization provides the starting point in defining why the organization exists. The MISSION and VALUES that accompany it should not change that much in the short term. As VALUES on their own can be quite abstract and difficult to grasp, SAFEX has decided to incorporate the Behaviours we expect from Members in what we shall term our VALUE SYSTEM. The organisation’s VISION paints a picture of the future and determines the direction the organization wishes to take. It helps individuals understand why and how they should support the organization. In addition the VISION sets the organization in motion moving it from the relative stability of the MISSION and VALUES to the dynamics of STRATEGY. STRATEGY is developed and evolves over time to meet the changing conditions posed by the external environment and internal capabilities. We viewed STRATEGY as how



SAFEX will differentiate itself from similar organisations and

create value for its Members. The process the Board adopted is outlined above.

SAFEX Mission as an arrow

If we look at the SAFEX Mission as an arrow in flight, the arrowhead seems to be the most important part of the arrow. It is, after all, the part that is meant to do the work when it reaches its target. How can we describe the “arrowhead” in the SAFEX Mission? The Board agreed that the following elements should be part of it:

- *What is SAFEX about?* It wants to eliminate explosives incidents that cause harm. (Previously we looked at “minimising” them but now believe we should raise our sights and not stop till we “eliminate” them)
- *How does SAFEX plan to do it?* SAFEX should be

instrumental in developing and adopting appropriate practices to prevent such incidents. (In our earlier Mission statement we merely wanted to “help members learn” from reported incidents and leave it to them to interpret it in their own practices.)

- *What will SAFEX use to do it?*
The obvious resource is the cumulative knowledge and

experience of its members who will be encouraged to support each other in this

endeavour. (This is a broader focus than merely sharing incident information which is how SAFEX saw its task previously)



There is more to an arrow than an arrowhead

This is very clear from the picture above. The flights at the back of the arrow stabilise it in flight on its way to the target. Without the flights the arrow cannot fly true. In the same way the SAFEX Mission “arrow” needs the following four flights to fly true:

- **Domain.** If you will permit me to change the metaphor, the Domain describes *the game SAFEX intends to play*. Previously our Domain was the Health, Safety and Environmental impacts of explosives. As result of members’ inputs, it was agreed to extend the SAFEX Domain to include Security. However, SAFEX’s Security involvement will be limited to “eliminating explosives incidents that can cause harm” (true to the SAFEX mission). SAFEX will not “trespass” on regional Security issues which are more than adequately addressed by corporate Associate Members like FEEM, IME, AEISG, NIXT, etc. Instead, SAFEX can add value for its members and the industry by getting involved in

explosives Security issues where international harmonisation may be required. The Board is sensitive that SAFEX should not be deflected from its traditional focus: the sharing of knowledge and experience as, for example, in the reporting of incidents. SAFEX’s Security focus will be selective. It is likely to concern issues requiring harmonisation of local practices in order to develop international standards. Therefore, it is not foreseen that Security will become a significant part of SAFEX activities.

- **Members.** *Who will play in this game?* – who can be members of SAFEX? The previous position is unchanged in that SAFEX members are manufacturers of commercial and military explosives. Associate Members may include industry associations and individuals that contribute to our Mission
- **Scope.** *What will we play with*

– the products, activities, etc that interest SAFEX? This is defined in our Articles of Association (Constitution) and involves the life cycle of explosives. Explosives encompass both Commercial and Military explosives as well as explosive initiation systems and pyrotechnics but no fireworks. The Articles also makes provision for raw and intermediate materials dedicated to the manufacture of explosives such as technical grade ammonium nitrate (TGAN).

- **Ambit.** *Where will we play?* Ambit describes “where” SAFEX does its work – its location. This also remains unchanged and can be simply put as: Worldwide

These are the guidelines the Board has accepted. It now remains for these ideas to be formulated in a document which can be distributed to the SAFEX community for its comments. This task has been given to an editorial group that will formally capture these and other ideas in due course.

Research Notes from CERL

Quantifying the Friction Sensitivity of Energetic Materials

Dr Phil Lightfoot

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2010.

The contents of this report may be based on work in progress or may contain speculative comments by the authors. Readers are cautioned to rely on their own judgment in assessing the correctness of the contents. CERL does not warrant the quality, accuracy or completeness of the contents and is not responsible for any errors or omissions, or any technical inaccuracies. CERL disclaims liability for any injury, damage, or other loss resulting from any use of or reliance on the report or its contents

Introduction

Instantaneous friction events, such as those caused by two hard surfaces rubbing against each other for a short time, are a major cause of accidental ignitions in the explosives industry [1]. As a result, many small-scale empirical tests have been devised to evaluate the sensitivity of energetic materials to friction. These tests have been of value in providing guidelines for the safe manufacture, handling, and transport of sensitive energetic materials. However, most of them have only been used to assess relative sensitivity to instantaneous friction [2]. Such results are therefore of little value when a quantitative hazard assessment methodology is required.

In a quantitative approach, probabilities must be evaluated. In particular, the probability of initiation, under specific friction mechanical doses and for particular energetic materials, must be measured. For this purpose, a friction test capable of simulating typical friction events encountered in manufacturing processes and offering a good control of the essential parameters had to be developed. Such a test was developed at C-I-L Inc. in the late 1970s [3]. The corresponding Sliding Block Friction (SBF) apparatus was designed based on the principle of the Hercules Allegany Ballistics Laboratory apparatus [4]. The C-I-L apparatus was recently renovated, upgraded and commissioned at CERL as part of a joint research program on explosives hazards with Orica Mining Services.

Experimental

In the SBF test (Figure 1) a stainless steel test plate is covered with a uniform film of energetic material. This plate is clamped on top of a sliding platform. A fixed stainless steel disc is forced vertically against the plate by a hydraulic cylinder. The sliding platform is set in motion by the impact of a pendulum equipped with a heavy weight. A pure friction event is thus created at the contact surface of the disc and the plate. The mechanical friction dose can be varied by setting the hydraulic load (0-8000 N) and by varying the plate velocity (up to 4 m s^{-1}), which is mostly controlled by the pendulum drop-angle (θ).

An indexing system is used to rotate the disc and push it along the shaft axis in order to bring a fresh area of the disc with a fresh area of the plate before each test. In this way a series of 12 tests can be readily performed on each plate at various combinations of applied vertical load (f) and pendulum drop-angle (θ).

Two physical quantities need to be quantified in the test: the friction mechanical dose and the degree of reaction induced in the energetic material.

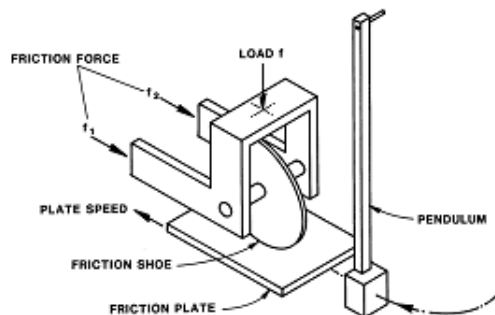
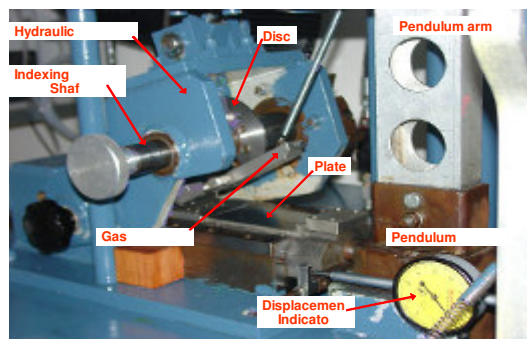


Figure 1: Schematic diagram (bottom) and photograph (top) of the SBF apparatus

Following the method of probit analysis [5], a dose parameter had to be found that would give a straight line when probability of ignition was transformed and plotted against the logarithm of the dose parameter. In a study at C-I-L Inc. [3], the dose parameter $D = P l v^2$ provided the best overall correlation over a wide range of energetic materials. In this product 'P' is the contact pressure, 'l' is the length of the contact area of the disc with the plate in the direction of movement, and 'v' is the average friction velocity.

In order to use the above dose parameter, D, the friction apparatus must be equipped with transducers capable of measuring the various quantities. The vertical force can be readily calculated from the hydraulic pressure and the diameter of the hydraulic piston. In order to calculate the contact pressure (i.e., the vertical load 'f' divided by the contact area) the contact area of the disc with the plate was measured by making ink imprints of the contact area for various loads and by measuring the area under optical microscope using image analysis software. Typical imprints and the resulting calibration of the apparent contact area (A_a) and average contact length (l) are shown in Figure 2 on the next page. Note that the greater the load, the greater the deformation of the steel and the bigger the surface area. The last parameter required to evaluate the dose parameter D is the average velocity of the sliding platform. In order to

monitor the velocity of the test plate, a series of closely-spaced reflecting strips was installed at the back of the sliding carriage. The position-time history of the sliding carriage can be observed using a reflective object detector positioned in front of the reflecting strips. A typical velocity profile obtained using this method is shown in Figure 3. It can be seen that, depending on the load 'f', and the pendulum drop angle, the velocity profile can be non-linear. In this

Figure 2a: Typical ink imprints of the contact area of the stainless steel disc against the stainless steel plate, as photographed under an optical reflectance microscope; **Figure 2b:** Calibration of the contact area and contact length as a function of applied vertical load

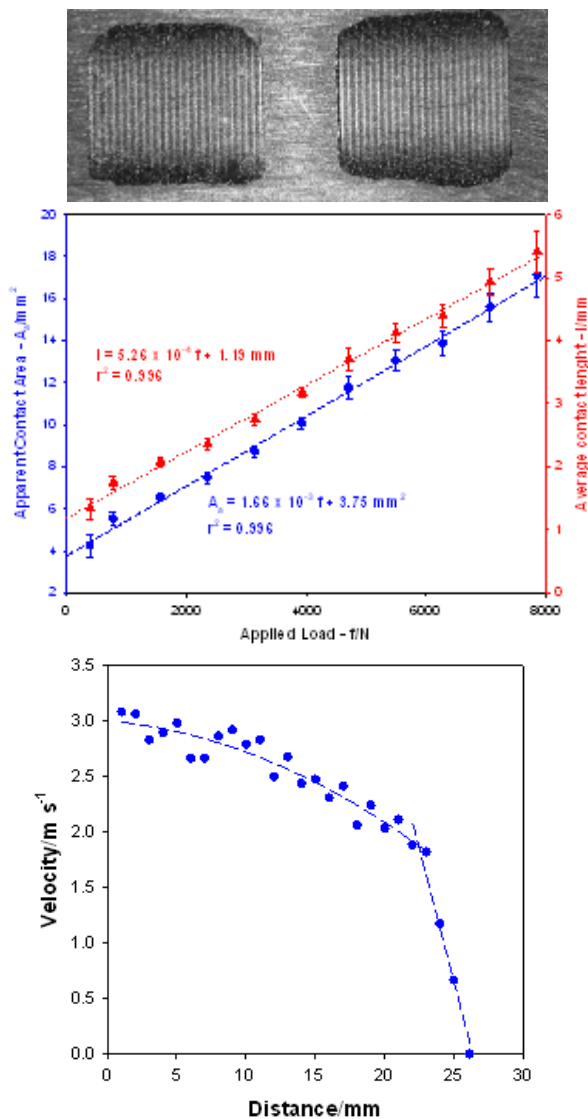


Figure 3: Typical velocity profile obtained using the reflective object transducer used in the present work

example, the velocity is seen to decrease from about 3.0 m s^{-1} , initially, to 1.8 m s^{-1} at which point, around 22 mm, the sliding carriage hits a shock absorber and quickly comes to rest. The procedure to compute an average velocity must therefore take this non-linear decrease into account.

With the SBF apparatus, even the most sensitive secondary explosives (e.g. PETN, HMX, RDX) produce only relatively mild reactions. These cannot be detected reliably by human senses. The reason for this is that, since very thin explosives deposits are used, the reaction does not propagate away from the friction site and, therefore, less than a milligram of sample material takes part in the reaction. For this reason, sensitive instruments must be used to detect the reactions objectively and to quantify the degree of reaction induced in the sample. In the current version of the test, two gas analyzers are used: an infrared CO analyzer and a chemiluminescence NO-NO₂-NO_x analyzer. The two are mounted in parallel so that both gases can be detected simultaneously. They are coupled to the friction apparatus using flexible tubing connected to a gas collector unit which has been designed to collect the reaction gases in the vicinity of the friction event (see Fig. 1 on the previous page).

With such sensitive instruments, very faint reactions can be detected. Therefore, the following problem is introduced: how does one distinguish between a localized reaction where the material is slightly decomposed by the heat of the local friction event and a more serious exothermic reaction where the decomposing material is generating enough heat for the reaction to become self-sustaining? Throughout the literature, people using such instruments for sensitivity testing got around this problem by adopting an arbitrary minimum detection threshold to assign positive events. For example, a threshold of 25 ppm of NO_x has been used to assign positives in the BAM friction tests performed at Lawrence Livermore National Laboratory [6].

Three facts should be mentioned about the use of such threshold: Firstly, the chosen thresholds are arbitrary and could lead to subjective interpretation of the data. Secondly, the gas thresholds are held fixed for all energetic materials being tested. This is clearly untenable as it implies that all energetic substances would produce different gases in identical ratios. Thirdly, only the amplitude of the detected signal is used to assign positives while the time evolution of the signal may vary appreciably from one sample to another.

To obviate these inconsistencies it was proposed to define a reaction index, R, proportional to the extent of reaction that can be monitored as a function of the friction dose parameter [7]. Such a reaction index can be easily defined if one makes the following assumptions: (i) the amount of reacted sample is proportional to the detected gas volume, (ii) the width of the disc, the thickness of sample deposit, and the density of the deposit are approximately constant. Under these assumptions a proper reaction index can be defined as:

$$R = \frac{\Phi}{L} C_{output}$$

Where ‘ Φ ’ is the measured gas flow through the gas analyzer, ‘L’ is the length of the slide (length of the track left by the passage of the disc on the test plate), and ‘ C_{output} ’ is the measured concentration of gas (CO or NO_x) adjusted for ambient CO or NO_x concentration. For each test, the reaction index is computed by integrating the gas concentration vs. time profiles (typical profiles shown in Figure 4), using the measured gas flow through each analyzer and normalizing using the measured length of slide (L).

Typical Results

In a typical measurement, 12 tests are performed at each chosen combination of ‘f’ and ‘ θ ’. This series of 12 tests is repeated for six to eight different combinations. For each series, the average dose parameter <D> and the average reaction index <R> are computed and <R> is plotted as a function of log <D> as shown for a typical example in Figure 5 on the next page. Such graphs have been obtained for several other energetic materials and they all show similar characteristics, with two distinct reaction regimes. Similar behaviour was also reported when observing the light emitted by explosives and propellants subjected to drop-weight [8] and projectile [9] impact. Using high-speed photographic techniques, the inflexion point between the two regimes can be interpreted as the point where the reaction mechanism changes from initial/local to combustive/propagative reactions. We therefore use the inflexion point as a threshold to assign positives when generating friction probit curves. This threshold is measured (rather than arbitrary) and would be different for every energetic material tested. Moreover, sensitivity ratings derived using the above thresholds would not be altered by the introduction of even more sensitive gas analyzers.

When constructing the friction probit curve, the computed reaction index for each of the 12 tests within each series is compared to the measured threshold. If it is lower than the threshold the result is assigned as

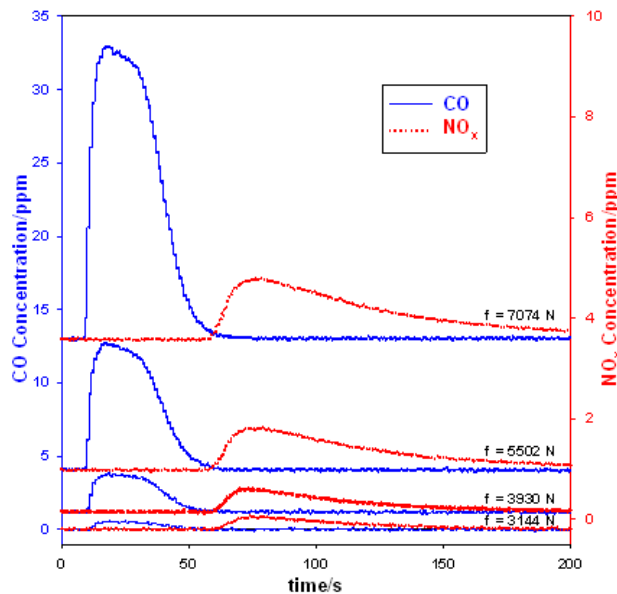


Figure 4: Typical CO and NO_x records obtained for ground TNT at various vertical loads ($\square = 90^\circ C$). The CO and NO_x are produced at the same time by the friction event. The delay in the NO_x signal is due to a long residence time in the detector.

negative; if it is greater or equal to the threshold, the result is assigned as positive. Therefore, for each of the series, the probability of ignition may vary from 0/12 to 12/12. The probability for each series is then plotted, on a probability scale, as a function of the logarithm of the average dose parameter ($\log \langle D \rangle$). The friction probit curve for the example of Figure 5 is shown in Figure 6 (also on the next page). Note that the probability scale on the Y axis is very unusual, as it represents a normal (bell-curve) probability distribution that has been transformed to make it linear. The advantage of using such a scale is that it can be used to extrapolate to very low probabilities and very high probabilities while still emphasising the range in the middle (10 – 90% probability) where most measurements are taken.

Application of Quantitative Friction Data to Practical Problems

For hazard quantification, probit curves such as those of Figure 6 can be used to estimate the probability of ignition for instantaneous friction events that could occur in process equipment (a broken blade against bowl in a mixer, or a foreign object in a blender, for examples). In general the probit curve is extrapolated linearly to the low mechanical doses that can happen in explosives manufacturing processes. It is generally felt that this assumption is conservative. In practice, the friction dose (D) is evaluated based on other

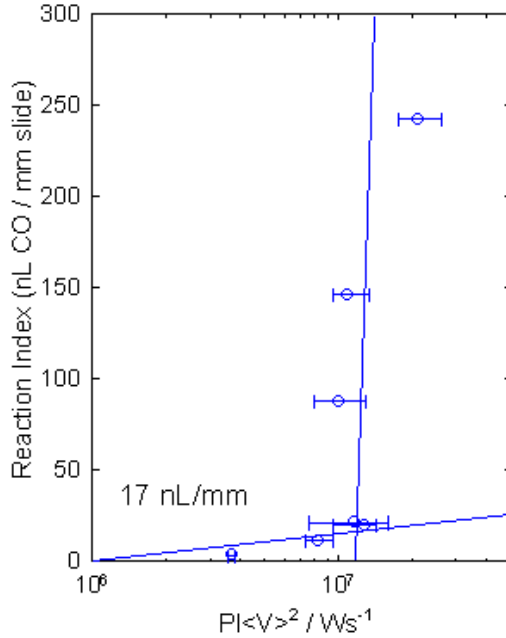


Figure 5: Reaction index as a function of average dose parameter with inflexion point at 17 nL/mm. Largest reaction index is near saturation and not included for estimation of the two regimes

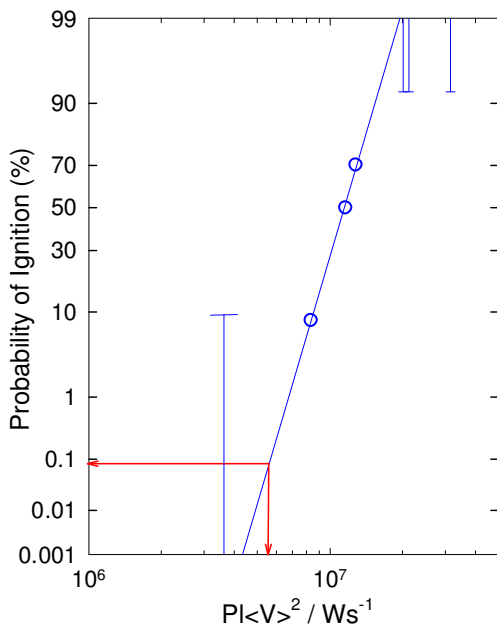


Figure 6: Example of a friction probit curve for ground TNT. Vertical lines indicate upper and lower bounds. Red arrows indicate probit example

conservative assumptions. Generally, the pressure ‘P’ exerted on the explosive during a strike cannot be easily calculated or measured for practical cases. Thus, it is conservatively assumed to be the yield strength of the weaker (or softer) material involved. The velocity ‘v’ is the relative velocity of the rubbing surfaces, which generally can be calculated with good accuracy. The length of contact ‘l’ is difficult to determine for a practical case: it is the instantaneous length of the contact region between the two surfaces in the direction of movement. In experiments with the SBF apparatus, for which high plastic deformation of the disc can be produced, the maximum contact length is about 5 mm (Figure 2 on p. 7). This latter value was therefore suggested as the maximum that is likely in a piece of equipment. Lower values may be more appropriate for equipment with low masses and/or velocities. A nominal value of 1 mm is often suggested in these cases. Selection of the ‘l’ value is often a matter of engineering judgement. One technique for estimating ‘l’ in existing equipment is to measure the width of visible scratches and use this as the ‘l’ value for similar events.

Once the process dose has been estimated, the probit curve is used to provide an estimate of the probability of ignition. The latter has to be inserted in the standard equation expressing the expected frequency of a fatality resulting from the event considered in the analysis [10].

To illustrate the use of the technique, let’s suppose TNT is being mixed with other ingredients in a blade blender and that a foreign object (screw or nut) accidentally enters in the blender and gets stuck between one of the blades and the blender wall for a short time.

Diameter of foreign object: 3 mm (3.0×10^{-3} m)
 Foreign object material: Stainless Steel (Stainless steel (yield strength = 6.2 to 10.0×10^8 N m⁻²))
 Blade tip tangential velocity: 1.5 m s⁻¹

1. calculate the friction process potential (PP) in W s⁻¹:

$$PP \text{ (W s}^{-1}\text{)} = P \text{ (N m}^{-2}\text{)} \times l \text{ (m)} \times v^2 \text{ (m}^2 \text{s}^{-2}\text{)} = (8.1 \times 10^8) \times (3.0 \times 10^{-3} \text{ m}) \times (1.5)^2 = 5.5 \times 10^6 \text{ W s}^{-1}$$

Where ‘P’ has been taken as the average yield strength of stainless steel and ‘l’ has been taken as the diameter of the screw.

2. From the probit curve (Figure 6) determine the corresponding probability of ignition (I_p) at the PP value calculated in step 1. From the probit curve of Fig. 6, we get an $I_p = 0.08$ % or 8×10^{-4} .

Conclusions

A Sliding Block Friction apparatus has been recently installed, instrumented, and calibrated at CERL. In its present state, the apparatus offers good reproducibility of the essential parameters which control the mechanical dose and allows realistic and conservative friction probit curves to be generated for hazard quantification. We already have a long line-up of materials we plan to examine and are hopeful that this new long-term capability

will contribute to the improvement of process safety for our stakeholders.

The present apparatus has been calibrated for stainless steel surfaces and data for other materials would require calibrating and testing with parts made out of these materials. An alternative would be to use a dose parameter that is numerically scalable for different materials. In this regard, it was recently discussed that the friction temperature would be a

more realistic and physically meaningful dose parameter to utilize [11]. At CERL, more research will be performed to study the use of the friction temperature as a dose parameter.

Acknowledgements

Thanks to our partners Orica Mining Services, for permission to publish this work. PL would like to thank Dr. Shanti Singh, Dr. Richard Turcotte and M. Dominique Laniel for producing a draft of the article, which is based on their work.

References

- [1] Wharton, R.K., and Harding, J.A., 'An Experimental comparison of Three Documented Test Methods for the Evaluation of Friction Sensitiveness', *Journal of Energetic Materials*, **11** (1993) 51.
- [2] Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, 5th revised edition, United Nations, 2009, Series 3 type (b) tests, pp. 104-115.
- [3] Chan, S.K., 'Quantitative Hazard Testing Techniques for Water-Based Explosives', Proceedings of the International Symposium on Pyrotechnics and Explosives, Beijing, October 12-15, 1987.
- [4] Richardson, R.H., Smith, D., Kristoff, F.T., Treadwell, L.S., and Heere, D.K., 'Hazards Analysis Through Quantitative Interpretation of Sensitivity Testing', *Annals of the New York Academy of Sciences*, 152, Art. 1, pp. 269-282, 1968.
- [5] Finney, D.J., 'Probit Analysis', Third edition, Cambridge University Press, England, 1971.
- [6] Moody, G.L., 'Hazard Characterization of Explosives by Use of the Friction Sensitivity Test'. Lawrence Livermore National Laboratory, Report UCID-21052, 1987.
- [7] Turcotte, R., 'A Scheme for Quantifying the Friction Sensitivity of Energetic Materials', Proceedings of the 15th Symposium on Explosives and Pyrotechnics, Philadelphia, USA, April 1994, pp. 12-1, 12-23.
- [8] Buntain, G.A. McKinney, T.L., Rivera, T., and Taylor, G.W., 'Decomposition of Energetic Materials on the Drop-Weight-Impact Machine', Proceedings of the 9th Symposium (International) on Detonation, Portland, Oregon, USA, 1989, Volume II, pp. 1037-1043.
- [9] Ho, S.Y., 'Response of Rocket Propellants to Projectile Impact', Proceedings of the 9th Symposium (International) on Detonation, Portland, Oregon, USA, 1989, Volume II, pp. 1052-1059.
- [10] Macdonald, L., Koniaris, E., Bauer, A., Simpson, J.D., and Sterling, T.S., 'A Risk Assessment Methodology for the Explosives Manufacturing Industry', Prepared by Mining Resource Engineering (Kingston, Ontario) for the Department of Supply and Services Canada, Science and Professional Services Directorate, Contract No. OSQ83-00080, April 27, 1984.
- [11] S.K. Chan and R. Turcotte, 'Probit Analysis of Friction Sensitivity of Explosives', Proceedings of the 35th International Pyrotechnics Seminar, July 13-18, 2008, Fort Collins, Colorado, USA.

Our Explosives Regulatory World

Explosives Classification in Canada

Ben Barrett

Ben Barrett, an Expert Panel member, is an independent consultant specializing in regulation of explosives. DG Advisor, Ben's consultancy, is dedicated to participation in the development and modification of international dangerous goods regulations and helping clients comply with US and international regulations. Ben also provides training in the handling of dangerous goods including that required by ICAO.

Disclaimer: The opinions expressed in this article are solely those of the author and not the Government of Canada

The Canadian Explosives Research Laboratory (CERL) is one of the foremost scientific laboratories in the world dedicated to research and testing of commercial explosives. CERL and its sister organization, the Explosives Regulatory Division (ERD), make up the Explosives Safety and Security Branch (ESSB) of Natural Resources Canada. The Branch has the advantage of closely integrated regulatory and scientific divisions focusing together on all non-military explosives activities for Canada. CERL supports ERD's policy initiatives with development of test methods, classification testing and recommendation, product analysis and research to support regulatory decisions. They also serve industry in safety research. Overall, close to 50% of CERL's funding is derived from commercial sources.

CERL is headed by Dr. Phil Lightfoot, who also serves as Vice-Chairman of the IGUS Working Group on Explosives, Propellants and Pyrotechnics. He directs four managers in charge of the focal points including Richard Bowes, Explosives Certification; Bill Ridley, Explosives Analysis; Bert Von Rosen, Explosion Effects; and Dr. Richard Turcotte, Explosives Research.

One responsibility of CERL's Explosives Certification group is UN testing and classification recommendations. Obtaining a transport classification is part of the authorization process. The procedure for obtaining authorization for an explosive in Canada is as follows:

- Contact ERD
- Submit detailed information on the products to ERD utilizing Form 31
- ERD determines if testing is required; testing is frequently not required for known products and variants. If testing

is required -

- Applicant contacts CERL
- CERL prepares a test plan and quote
- Test plan is agreed to by client and approved by ERD
- CERL contracts with client
- Client obtains import permit from ERD
- Client sends samples to CERL
- CERL assigns unique identifiers to samples
- Allocate work to scientists / technologists
- Perform testing in accordance with CERL procedures
- Record results
- Secondary review of results by supervision
- Results consolidated with classification recommendation into a report
- Report sent to ERD
- ERD determines if other factors apply which could affect the recommendation, report is finalized
- ERD provides authorization and CERL report to client

Note that CERL is ISO 17025 certified and the above steps are done in compliance with that standard. When determining a test protocol, it is important to note the introductory paragraph of the UN Manual of Tests & Criteria:

1.1.2 It should be noted that the Manual of Tests and Criteria is not a concise formulation of testing procedures that will unerringly

lead to a proper classification of products. It therefore assumes competence on the part of the testing authority and leaves responsibility for classification with them. The competent authority has discretion to dispense with certain tests, to vary the details of tests, and to require additional tests when this is justified to obtain a reliable and realistic assessment of the hazard of a product. In some cases, a small scale screening procedure may be used to decide whether or not it is necessary to perform larger scale classification tests. Suitable examples of procedures are given in the introductions to some test series and in Appendix 6.

CERL and ERD are adept at achieving safety without requiring an overly burdensome test plan. They exercise their authority with competence to waive, add or modify tests as indicated in the particular case. Generally speaking the UN criteria are applied. Product families are not necessarily bracketed by the high and low characteristics. Instead the samples are chosen based on expected behaviors or where variations will have unknown effects.

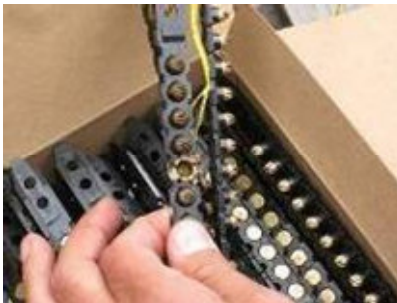
Both CERL and ERD have noticed that the work pool is shrinking for employee candidates with seasoned explosives experience. They now must usually hire competent candidates and train them up within the organization. Less expertise could result in more rigidity of enforcement of regulations and criteria, so it is fortunate for stakeholders that Branch employees still have a wealth of experience. However CERL's standards layered with ISO documentation ensure that procedures are documented and repeatable. ERD has also been working hard to document their standards.



Don Cox (above) – Senior Technologist at CERL. 27 years experience is not easy to replace.

The Branch is known for its contributions to testing methodology which are used in Canada and shared with the global explosives safety community. Projectile impact tests have recently been conducted on heated AN emulsions to try and understand why these products occasionally progress from fire to detonation. A minimum burning pressure test has been developed in partnership with industry to determine maximum safe pumping pressures for emulsions. This test is used in the issuing of Canadian explosive manufacturing licenses, with license requirements based on the particular pump specs used by the company. In 2008, the UN adopted the 6(d) unconfined package test to augment the 6(c) bonfire test to fully implement the definition of Division 1.4S. This 6(d) test is becoming considered by air mode regulators as a definitive criterion for passenger aircraft eligibility.

Recently I had the opportunity to visit CERL to observe testing on power device cartridges. I was particularly interested to see the 6(d) tests for this product and the methodology for igniting the samples. As stated in the Manual of Tests & Criteria, "The competent authority may wish to take into account the expected effect of the initiator when assessing the results of the test, if these are expected to be significant when compared to the articles being tested." Explosives designed to function within equipment, e.g. power device cartridges and ammunition, can be very difficult to ignite when not using the equipment. In this case CERL used a voltage-controlled electrical short to ignite a single article. With experimentation the proper voltage can be determined which is not excessive. Too much or too little voltage can input more than the



CERL technologists used a variable voltage controller to apply electrical heat just adequate to ignite the sample.

necessary heat into the sample; too high a voltage inputs excessive energy; too little voltage takes longer to ignite the target device and spreads heat into the adjacent materials.

In 2009 the air regulations infringed on competent authority discretion by requiring the 6(d) test for passenger air eligibility, whereas they don't specifically require other tests which are equally fundamental (Series 3, 4 & 6). The proper method is to require that an explosive meet certain criteria and let the competent authority choose the test plan. For the eight affected UN numbers, the 6(d) test is now required for air shipments regardless of whether the competent authority determines that conducting the test is unnecessary. For example, the test was never intended for small power device cartridges, but nonetheless is now necessary for compliance. The product in the photograph can pass the 6(d) in its inner package alone without the

benefit of an outer package. Therefore to avoid over-regulation and unnecessary costs, the decision whether or not to apply a certain test should be left to competent authorities adhering to the UN Manual of Tests and Criteria and not "hard-wired" into the regulations.

CERL provides all the tests necessary for a UN classification. This includes thermal stability and sensitivity testing. Sensitivity test equipment include BAM friction, BAM impact, BOE impact and the CIL Modified Type 12 impact tester. In addition to UN testing, CERL provides testing for other standards such as NATO, and sensitivity testing which is incorporated into manufacturing hazards analyses to ensure equipment does not ignite explosives. Although Canada does not have a system similar to Seveso or Process Safety Management, many Canadian companies pursue it voluntarily. Manufacturing or analysis may require more sensitive equipment than normally used for UN testing; for example CERL employees also use a highly sensitive BAM friction apparatus to characterize developing formulations.

CERL's Explosives Analysis group has been constantly upgrading their equipment to keep up with the state of the art. Explosive compositions are verified against declared formulae during the authorization process. Accident investigations are conducted at the request of ERD, and high tech services are provided to industry.

To quantify specific ingredients in explosive formulations, samples are first prepared for analysis. This typically involves extracting the ingredients from the formulation based on their individual chemical

and physical properties. Sequential extraction of an explosive composition with a series of solvents is the most commonly used technique to prepare an explosive composition for analysis. For example, the potassium nitrate in black powder can be dissolved in water and the sulfur and charcoal removed by filtration. Organic species are typically dissolved in non-polar solvents and metals are dissolved with acid. The sample extracts are then analyzed with various instruments to identify and quantify the analytical species of interest. Examples of the instrumentation used at CERL to analyze explosive samples include ion chromatography (IC) for water soluble salts (e.g. nitrate), gas chromatography (GC), high performance liquid chromatography (HPLC) with Ultraviolet or Visible spectrophotometric detection and Fourier transform Infrared spectroscopy for organic ingredients or explosives (e.g. TNT), inductively coupled plasma spectrometry (ICP) for metallic fuels, oxides or carbonates, and x-



Bill Ridley (above) alongside a High Performance Liquid Chromatography (HPLC) system



Dr. Richard Turcotte (above) with the Simultaneous Differential Scanning Calorimeter (DSG) and Thermogravimetry(TG) calorimeter.

ray fluorescence spectroscopy for general elemental analysis CERL is also equipped with a scanning

electron microscope (SEM) which is used to examine the morphology and size of explosive particles at up to 10,000 times magnification.

The thermo-chemistry lab, operated by the Explosives Research group, offers an impressive array of calorimetry equipment to measure endotherms and exotherms, in general giving sophisticated data on heat ignition sensitivity which, for example, can be used in manufacturing hazard analyses. Differential scanning calorimetry is augmented by thermal gravimetry, i.e. measuring weight gain and loss as a corollary to heat gain and loss to define endotherms and exotherms. One piece of equipment even combines these techniques simultaneously. A heat-flow calorimeter and three accelerating rate calorimeters provide data on increased sample sizes but at lower temperatures. Each method has advantages and disadvantages based on temperature limit, speed, accuracy and sample size. An isothermal nano-calorimeter is available for studying shelf life characteristics at static temperatures up to 100°C.

Explosives Eco-talk

The impact explosives and explosives manufacture has on the Environment falls squarely in the SAFEX domain. We are as interested in the experiences Members, Associates and Expert Panel members have in minimising explosives' environmental impact as we are in safety and health. While most of our explosives incidents concern the safety and health impact, we are eager to learn about the environmental side of our activities. By way of this Feature we want to encourage readers to let us have contributions which create awareness of this facet of our operations as well as assist our industry to behave with environmental sensitivity and responsibility.

Carbon Footprints Dr. Michael du Plessis

Michael du Plessis is a member of the SAFEX Expert Panel and Director of Greenice Pty Ltd, an independent consultancy based in Australia. Michael has more than 20 years experience in R&D, Innovation and Sustainability having worked in AEL (South Africa), ICI (UK), IES and Orica (Australia). His particular expertise in explosives includes non-electronic detonator and electronic blasting systems. More recently he was Innovation and R&D Manager for Sydney Water Corporation. Michael has a PhD in chemistry and is passionate about helping organisations improve the return on their investment in R&D and Sustainability.

Given his interest in Sustainability and the profile enjoyed by global warming and carbon footprints in particular, we asked Michael to outline his approach to the topic in the following article.

What is a carbon footprint?

A carbon footprint is the total amount of carbon dioxide (CO₂) and other greenhouse gases (like methane, sulphur dioxide etc) emitted over the full life-cycle of a product or service. Greenhouse gas (GHG) emissions are tracked from the point where raw materials are mined or grown, through to consumption or disposal. All other types of greenhouse gases are converted into the equivalent impact of CO₂ on global warming (“CO₂-e” designates CO₂ equivalence)

How does the carbon footprint model work?

The model Greenice™ uses takes your company’s expenditure and revenue (sales) data and onsite data for consumption of fuels such as LPG, petrol/diesel and processes it through a computer model to produce a comprehensive carbon footprint. To put it simply, the computer model works out the amount of CO₂-e “embodied” in the \$ value of your purchases plus CO₂-e emissions that come from burning of fuels onsite (this includes fuel in company owned vehicles). This model was developed by Centre of Integrated Sustainability Analysis (ISA) at the University of Sydney and uses Input-Output analysis (IOA). IOA is an internationally accepted accounting procedure that tracks all monetary flows to and from 344 economic sectors in the Australian economy. Input-Output theory was pioneered by Nobel Prize winning economist Wassily Leontief in the 1940’s. It is governed by UN standards on IO tables which are published regularly by the Australian Bureau of Statistics (ABS). The methods used by ISA integrate the structure and function of the financial economy (as described by the national IO tables) with other national physical accounts such as energy, greenhouse emissions, water, land disturbance,

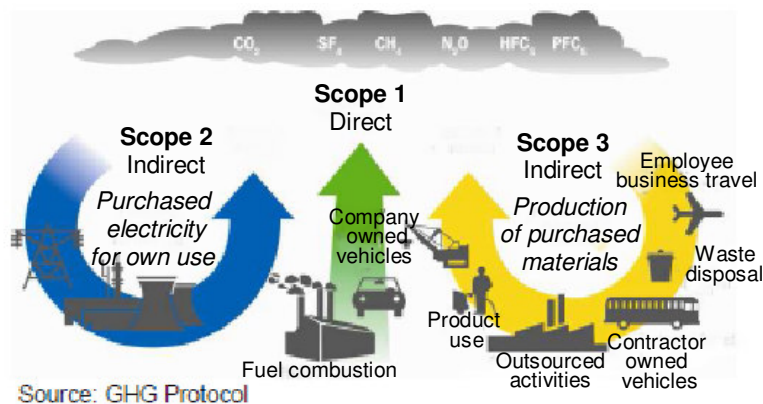


Figure 1: Schematic representation of the full supply chain life-cycle

employment and so on to account for the social and environmental, as well as the economic impacts of operating a business. The analysis determines the total greenhouse gas emissions for each sector of the Australian economy and then allocates a portion of the emissions commensurate with a particular business’ expenditure in each sector. The model effectively calculates a business’ “CO₂-e budget” that makes up your carbon footprint. The carbon footprint analysis can be undertaken for an entire business, a project or a product/service using only two sets of inputs – expenses/revenue and fuel usage.

Full supply chain life-cycle analysis (LCA) – See Figure 1.

The model automatically calculates the greenhouse gas emissions throughout the entire supply chain. This covers:

- **Scope 1** emission (onsite impacts such as company owned vehicles and combustion of fuel)
- **Scope 2** emissions (indirect emissions like purchased electricity for won use) and
- **Scope 3** emissions (also indirect emissions in the entire upstream supply chain like the production of purchased materials - business travel, waste disposal, contractors’ vehicles, outsourced activities, use of products, etc).

Full Scope 3 Supply Chain Analysis

Reporting Scope 3 emissions would normally require businesses to survey their entire supply chains – and the supply chains of their suppliers. This is a complex, expensive and virtually impossible task for most businesses. The Input-Output Analysis developed by Centre of Integrated Sustainability Analysis (ISA) provides a solution to this problem and carries out a complete upstream supply chain life-cycle assessment (LCA) of your business’ greenhouse gas impacts.

Hybrid-LCA

The ISA methodology used by Greenice™ also allows a Hybrid life-cycle analysis (Hybrid-LCA) to be carried out. This is the combination of two approaches with life-cycle perspective: a top-down Input-Output analysis and a bottom-up process analysis. A process analysis has advantages when looking at a particular process, a product (e.g. recycled paper) or a relatively small group of products. The Hybrid-LCA approach allows organisations to “drill down” to the appropriate level of process or product detail. It saves time and costs over traditional audit-based life cycle assessments.

Shared responsibility for emissions

Another problem with accounting for Scope 3 emissions in the supply chain is the potential for double counting of emissions. This problem arises because it is likely that at least some of the emissions have already been captured in someone else's reporting as Scope 1 or 2 emissions. The ISA model gets around the double accounting problem by apportioning emissions along the supply by allocating greenhouse gas emissions on a 50%-50% basis between the supplier and the recipient at each step in the supply chain. The ISA's framework allocates a 50:50 split of all impacts, so that they cascade along the supply chain. This means that, for example, the portion of greenhouse gas emissions retained/accepted by your business is 50% of the onsite total plus 50% of your allocation of the upstream impacts embodied in the goods and services that you purchase. The other 50% gets passed on to your customers *pro-rata* to the amount of goods that each customer purchases. This approach means that all parties in the supply chain, including final customers and consumers have a shared responsibility for greenhouse gas

emissions generated during the production, delivery and consumption of a product or service.

What does a carbon footprint deliver?

A carbon footprint analysis according to the approach I have described provides a full GHG inventory for onsite emissions from fuel and energy consumption, purchased electricity and in the supply chain. It provides a powerful tool to measure and drive a business' GHG reduction efforts. The type of information provided in such a carbon footprint report includes:

- Total GHG emissions in tonnes of CO₂-e (full Scope 3 calculation)
- A breakdown of emission sources in the supply chain and amount from each source. This allows you to focus on efforts aimed at reducing emissions in the supply chain (e.g. reducing travel and freight costs, saving paper)
- A breakdown of Scope 1, 2 and 3 emissions.
- The carbon intensity of the business. This shows the total

GHG generated per \$ of revenue. This data can be used to benchmark your business against other organisations. Our model can also provide a broader report on economic, social and environmental (triple bottom line—TBL) indicators under the Global Reporting Initiative (GRI). This allows you to measure and benchmark a full suite of sustainability indicators.

Standards and endorsements

The ISA methodology complies with international standard ISO14044 which addresses the methodological framework and reporting of an LCA. The methodology has also received endorsement from the Federal Government. ISA provided input to the Department of Environment and Water Resources Climate Clever on-line greenhouse gas emissions calculators. The ISA methodology has also been endorsed by the Australian Conservation Foundation - ACF. Its methods have been incorporated into ACF's on-line carbon footprint calculator.

Congress Commentary

The XVII SAFEX Congress in 2011 will be held from **Wednesday, 25 May to Saturday, 28 May 2011 in Istanbul, Turkey**. The pre-Congress activities will commence on Monday, 23 May and run through to Wednesday, 25 May 2011. The planning framework for the Congress was communicated to members in Congress Bulletin No.1 which we distributed in March. At the end of April we issued Bulletin No.2 in which we called for Congress Papers and requested prospective authors to submit Abstracts by the end of June. Please contact the Secretariat for copies of the Bulletins if you are interested in them.

Two days of Plenary Sessions

The Papers will be presented during the Plenary Sessions of the Congress which extend over two days:

- The first day (Thursday) is an **Open Day** at which SAFEX invites specific outside visitors with whom we collaborate to join us. It consists of 4 plenary sessions each with a Theme.

- The second day (Friday) is a **Closed Day** reserved for SAFEX members and associates. There will be 3 plenary sessions on the Closed Day. During these Sessions SAFEX members will be invited to review incidents and extract valuable lessons from them.

While Bulletin No.2 requested authors to submit Abstracts of their proposed Papers by 30 June (see Author Deadlines below), we can still receive late submissions from anyone who wants to present a Paper on any of the two days.

Author deadlines

- | | | | |
|-------------------------|--------------|----------------------------|------------------|
| ➤ Indicate interest – | 30 May 2010 | ➤ Draft Paper submission - | 31 October 2010 |
| ➤ Submit an Abstract – | 30 June 2010 | ➤ Final Paper submission - | 31 December 2010 |
| ➤ Abstract acceptance - | 31 July 2010 | | |

Possible themes for the Plenary Sessions

Based on inputs received from readers after inviting suggestions from readers in the last Newsletter, we are working with the following Themes:

For the *Open Day*:

- **Behavioural Based Safety**
(Convener: *Stephen Connolly*)
We encourage Papers to focus on effective, practical tools that minimize unsafe behaviour and reinforce safe behaviours. It will be useful to hear what member companies are currently doing that works in this area. What have been the experiences in industry and what learning might be shared about good methodologies to employ?
- **“Green” Explosives Manufacture**
(Convener: *David Schelbach*).
The recent SAFEX Strategy Survey indicated members want SAFEX to be more proactive with regard to “green” issues. Devoting a Session to this topic is one way of doing so. Some thought starters for Papers are: The disposal of explosives in waste; the role of explosives in global warming (greenhouse gases, carbon footprint, etc); customer pressure for data on members’ sustainability performance; and environment friendlier design of processes and products.
- **Risk and Regulation**
(Convener: *Noel Hsu*).
Noel, Convener of this Session,

makes the point: “Risk Assessment is a very relevant theme. Consequence-based analyses are still the norm but there is increasing interest in using Risk Analysis as well.” In addition, regulators in several jurisdictions have proposed new initiatives such as the EU “track and trace” Directive. Canada will also propose Minimum Bursting Pressure as Regulation for manufacturing as an alternate for the Vented Pipe Test. Technical grade ammonium nitrate issues also remain in the forefront.

- **HSSE Management Framework for Explosives Operations**
(Convener: *To be announced*)
A management “Framework” is to provide the global explosives industry with a version of the chemical industry’s Responsible Care (RC) initiative. Member companies may wish to suggest key elements and key success factors for an explosives operations HSSE Framework. Papers could also suggest industry-wide HSSE metrics we could use to measure our HSSE performance. (We need a “catchy” name for the Framework - one that will speak to the emotions. Perhaps you have one in mind).

The *Closed Day* focuses on actual incidents and the lessons learnt from them in the following Sessions:

- **Case Studies of Incident Investigation and Reporting**
(Convener: *Martin Held*)
The Session’s aim is to promote good investigation and reporting practices by reviewing actual case studies. A Paper that analyses trends and high-level learning points from reported incidents will demonstrate the power of good reports. It will be good if we can get Papers that review cases in which **incident investigations** were POORLY and WELL done as well as possible consequences of them. The Session can be wrapped up nicely with a paper on **incident reports** using examples of GOOD and BAD practices.
- **Incidents with initiating systems and primary explosives**
(Convener: *Enrique Barraincua*)
Incidents with initiating systems and primary explosives (lead azide, lead styphnate, tetracene etc) in the military or commercial explosives fields will be the subject of Papers in this Session.
- **Incidents involving secondary / emulsion explosives and propellants**
(Convener: *Rahul Guha*)
This Session will cover bulk and packaged explosives and members who have had incidents with these explosives will be presenting their Papers in this Session.

Inbox @ SAFEX-International.org

From time to time we receive e-mails from members of the SAFEX community on a variety of issues. It is important we share such experiences and insights and, if necessary, debate them. Our quarterly Newsletter may just be the forum for doing so.

We therefore invite ALL readers to drop us a line at secretariat@safex-international.org if they want to raise an explosives health, safety or environmental issue or comment on any of the opinions received from our correspondents.

Burning waste explosives in pans has advantages

A number of burning ground incidents have been reported to SAFEX this year.

It prompted Maurice Bourgeois (GD-OTS Canada) to comment as follows:

We do our burning in steel pans which are designed with slanted sides and a pouring spout. A possible downside of the pans is that if a detonation occurs the

shockwave is amplified. This can be mitigated by laying the explosives on a straw bed in the pan.

The main advantage of the pans is that the ashes and cinders can be dumped into a properly sealed container using a lift truck with rotating forks. Ash dumping is facilitated by the spout and the container is designed to prevent

water from leaching the ashes. Furthermore, the pan can be inspected and one can be sure it has cooled before laying out the next batch of explosives for destruction. It is also environmentally friendly because the ashes do not accumulate in the soil. The pans are stored on racks to prevent them from collecting water or snow so they are nice and dry for further use.

Probability of mass explosion with burning explosives truck

A recent SAFEX incident involved a fire in a truck transporting a large quantity of packaged emulsion explosives. The truck and its cargo burnt completely without exploding. It prompted Ardaman Singh (Visfotak) to ask: What is the possibility of hot spots developing within the emulsion explosive to cause a mass explosion? We asked two experts in the field to comment.

Piet Halliday (AEL Mining Services), a Governor and member of our Expert Panel felt:

Although emulsions are very safe, when burned in bulk it can lead to a detonation. Various factors will and can influence this e.g. contamination, type of formulation (products containing sensitisers or chlorine have a higher propensity to burn to detonation), design of vehicle and temperature of burning. Thus all these have to be considered during the transportation of emulsion.

Leigh Hart (Orica Australia), Leader of the SAFEX Emulsion Workgroup commented:

There are cases where these kinds

of fires have led to mass explosion. The mechanism that causes some of these to explode whilst others just burn is largely unknown. There are a number of theories such as the level of confinement, the heat of the fire, contamination with combustion by-products, etc. I am not aware of a definitive model that will predict with any certainty which ones will explode and those that won't. This is why we recommend that all fires involving explosives should be treated as if they will explode.

Diaphragm valves can cause problems

In an incident reported to SAFEX, an explosion occurred in the discharge lines/valves while the lines and valves were being cleared after discharging a batch of HMX. The explosion did not propagate beyond the

valves and is thought to have involved a very small quantity of material. One of the observations made was that wet materials (HMX and by-products) may not be as insensitive as normally assumed.

Maurice Bourgeois (GD-OTS Canada) commented:

Valves in contact with explosives are an element of risk not to be neglected. Air-operated diaphragm valves are preferred to hand operated ones. The hand-operated

valve has threads which can create major friction on explosives if the diaphragm cracks and explosive migrates behind the diaphragm. Hence the diaphragm should be the subject of scheduled inspections at a frequency determined by operating conditions and number

of cycles of operation per year. There are some further drawbacks to diaphragm valves. One is that they are not full bore and can clog more easily but such blockages are not easily unplugged. Also if the explosive is sticky or is melted sometimes the diaphragm sticks to

the bottom of the valves. When the actuator attempts to open the valve stress is induced which can after a certain time induce cracks in the diaphragm. There are sleeve valves which are full bore but require sufficient head (pressure) to open them.

Role of water in an explosive reaction

After the same incident Bill Evans (Orica USA Inc) picked up on the observation that wet materials may not be as insensitive as expected and felt:

In a friction or impact event, the presence/absence of water is not a significant factor in the initiation probability of molecular explosives. What the water does is minimize the probability of a sustained reaction/propagation. So I suspect that the water did exactly what it was supposed to in this incident and prevented a serious incident from becoming a catastrophic one.

Bill was asked whether water (and perhaps other liquids) can act as a lubricant between

particles to make initiation by friction less likely. Or, that the presence of water may dissipate the heat necessary to initiate the explosives and therefore make it less likely to initiate. He answered:

The classic Hercules/CIL/ICI definition of an impact or friction event is catching sensitive material between two hard surfaces moving relative to each other. It is the heat generated by this contact that is the actual initiator. There is no doubt that liquids do act as lubricants and will therefore reduce the probability of such an event - but if a crystal of, e.g. PETN gets directly caught between two moving metal surfaces, then any liquids around will have, at most, a

marginal effect on the initiation probability. While I agree that a liquid will dissipate the heat generated by an impact or friction event, in these events the heat generation is so localized (a few square millimeters) and the reaction time so fast (less than a millisecond), that heat dissipation can only be a secondary effect.

Any liquid will then act as both a heat sink and a separator of sensitive material. Both effects reduce the probability of propagation and, at some level, will prevent it. Note that the initial event will be less than milligram quantities so, as long as there is no propagation, the initial event will probably not even be detected.

Safety Snippets

Pump Protection Systems on Mobile Equipment

R. Tom Watts

Tom Watts is the Vice President of Tread Corporation and a loyal supporter of SAFEX and its objectives. Tread Corporation provides explosives storage, handling and delivery systems to an international customer base. Bulk explosives trucks are an elements of their product line.

This article appeared in the Journal of Explosives Engineers, May/June 2010 and is reproduced in its entirety with the kind permission of the author and Jeff Dean, Executive Director of the ISEE. SAFEX is proud of its relationship with the ISEE which is a corporate Associate Member and active collaborator in the promotion of explosives safety. We thank Tom and Jeff for allowing us to publish this article in this Newsletter.

The practice of pumping bulk blasting agents is regulated by many agencies around the world. The explosives manufacturers have done an excellent job of hazard and operability studies allowing

criteria to be established for the safe pumping of water based blasting agents. The challenge of a Bulk Trucks or Mobile Manufacturing Units (MMUs) manufacturer is to take the

objectives of the regulatory agencies and the explosives manufacturers and responsibly design and build MMUs that are safe, compliant, and cost effective without compromising serviceability.

Progressive cavity pumps used in the loading of blasting agents have inherent risk. A conscientiously administered safety program should accompany the installation of a safety system to ensure that it continues to provide the required level of protection. In order to minimize the risk involved in the use of progressive cavity pumps the following safety program is recommended as a minimum guideline.

1. Pump Safety System. A well-engineered pump safety system should be used in conjunction with all progressive cavity pump applications. The system should be reviewed and accepted by the explosives supplier.
2. Operator training. Every pump truck operator should receive annually recurrent training in the hazards of pumping emulsion explosives, and the

- operation of the pump safety system.
3. Daily checks. Each operator should verify the correct operation of the safety devices daily.
4. Responsible maintenance. The pump safety system must be responsibly maintained. Any defective devices should be expeditiously repaired or replaced. It is never acceptable to by-pass a safety device.
5. Quarterly re-qualification. The full and correct function of the safety system should be verified and signed off by a responsible company official on a quarterly basis.

These recommendations are made in consideration of the level of the hazard that may develop if either a run-dry or deadhead condition is allowed to continue unchecked. Both of these conditions can produce dangerously high

temperatures inside a progressive cavity pump, which may ultimately result in a pump-hazard event. The system stops the pump when it first detects a run-dry or deadhead condition, the trip-off action occurs well before a dangerous hazard is allowed to develop. Consequently, it is often seen as a nuisance. The nuisance trip is simply the result of a misadjusted flow switch, which could be easily corrected by a properly trained operator. However, a frustrated operator may be tempted to bypass the safety system to eliminate this nuisance. This action should be prevented.

The manufacturer of the blasting agents should always be consulted when progressive cavity pumps are used. This will assure the highest level of safety possible in keeping with their products and applications.

SAFEX International thanks the following for their contributions to this Newsletter:

- **Jose Sanchez-Junco**, Chairman and CEO, MAXAM Group
- **Prof. Martin Braithwaite**, SAFEX Expert Panel member and Individual Associate
- **Dr Phil Lightfoot**, Manager, Canadian Explosives Research Laboratory
- **Ben Barrett**, President, DG Advisor and SAFEX Expert Panel member
- **Dr Michael du Plessis**, Director, Greenice Pty Ltd and SAFEX Expert Panel member
- **Maurice Bourgeois**, GD-OTS, Canada
- **Ardaman Singh** (Visfotak); **Dr. Piet Halliday** (AEL Mining Services) and **Leigh Hart** (Orica Australia)
- **Bill Evans** (Orica USA Inc)
- **Tom Watts**, Vice-President, Tread Corporation
- **Jeff Dean**, Executive Director, ISEE

Boet Coetzee

Boet Coetzee
Secretary General, SAFEX International

REGISTERED OFFICE
SAFEX International

c/o Modoux Services Sàrl
 Route du Village 13
 CH – 1807 BLONAY, Switzerland
 Tel: + 41 21 943 0101
 Fax: + 41 21 943 0109
 Web: www.safex-international.org

CONTACT US
Secretary General

Tel: + 1 919 342 5848
 Tel/Fax: + 27 21 854 4962
 e-mail: secretariat@safex-international.org