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JOURNAL OF THE EXPLOSIVES SAFETY AND TECHNOLOGY SOCIETY (VISFOTAK) INDIA, DEALING WITH SAFETY AND TECHNOLOGICAL ASPECTS OF THE EXPLOSIVES INDUSTRY

Cover Feature : Revisiting "Explosives Delivery Regime and Public Safety : An Overview"

Explosives Technology and Public Safety are symbiotically interlinked, constantly evolving and uniquely manifested in the 'Explosives Delivery Regime', at any given juncture. The 'Cover Feature' updates and reviews the current status, last articulated in 2006.

MISSION STATEMENT

"To proactively establish a sustainable interface between all major constituents of the Explosives Industry : The Users, the Regulatory Bodies, the Manufacturers, the Academic and Research Institutions, et.al., in order to foster and promote modern concepts and practices, relating to Safety and Technology of Explosives."

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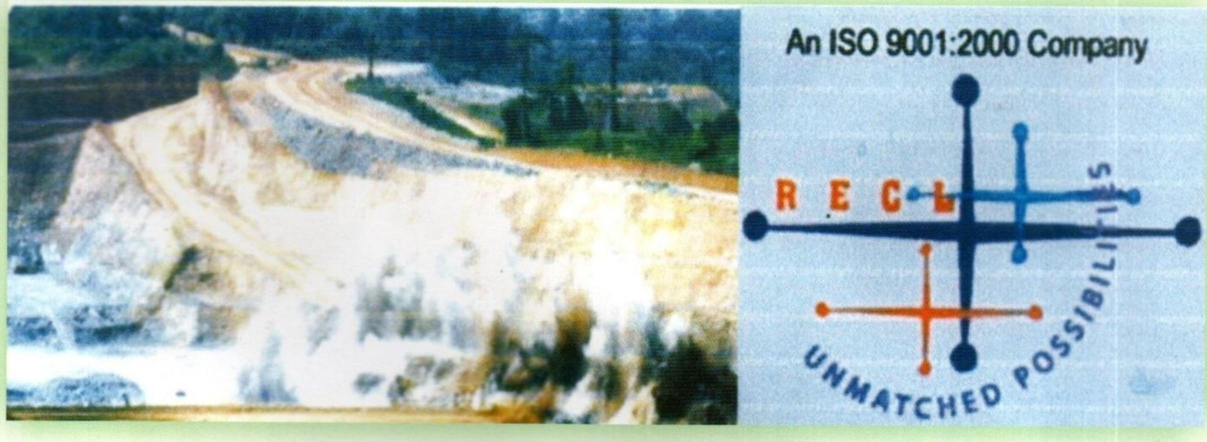

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- Super Plain detonators
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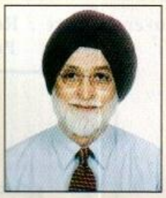
Editorial...



"We are what we repeatedly do. Excellence then is not an act but a habit - Aristotle"

New technologies bring with them new regulatory challenges; and if not met at the cusp, there are serious consequences of 'Opportunity Costs' in economic development and public safety at large ! However, this axiomatic assertion rarely gets the attention it deserves; and our explosives industry is a valid case in point ?

We have constantly drawn attention through our serial on 'Challenges and Issues' of the explosive industry, in the form of cover features in our Journal, for the need of a permanent mechanism in the public policy domain for 'Technology Information, Technology Assessment and Forecasting' in order that appropriate, more efficient and safer technologies, systems& processes, are quickly inducted into the industry.

To quote from the cover feature 'Explosives and Environment' in the 4th edition of the Journal Dec.2009, *"The stewardship of the industry is not only about prescriptive 'Control and Regulations', which task is vested with the Department of Explosives* (Office of the Chief Controller of Explosives), *but it is much more about ensuring an integrated development of the industry in close concert with the 'State of the Art' globally at any juncture. There already exists an institutional frame work of an 'Explosives Development Council', created under ID&R Act,1951"* for just such a task. *"Unfortunately, the Council has been functional only sporadically, mostly on short tenure of two years or so, whereas, the explosives industry is now much too large and complex to be dealt in such an ad hoc manner"*.

The Council is now been moribund for a long time, and should be urgently revived, restructured and accorded a permanent tenure. duly mandated to act as a Nodal Agency.

This singular requirement once again resonates through the 'Cover Feature' in this edition of the Journal, which revisits the 'Explosives Delivery Regime and Public Safety', last articulated in the inaugural edition in 2006. The cover feature updates and reviews the current status. In this context, notwithstanding some notable developments since 2006, mostly in the realm of statute and control, viz, the revised Explosives Rules - 2008; promulgation of new Ammonium Nitrate Rules, 2012 under the Explosives Act,1884; the initiatives taken by the Department of Explosives for e-Governance of explosives transactions through an online 'Explosives-Return System (ERS)', etc., there are still serious anomalies in terms of technology and safety, which have persisted, and need to be urgently addressed.

Ardaman Singh

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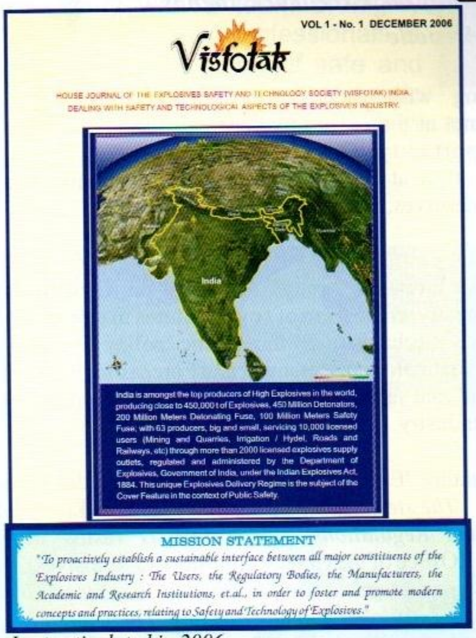

Last articulated in 2006.

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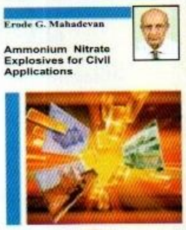

The society is proud to acknowledge the first ever exhaustive treatise from India, on modern industrial explosives, authored by Dr. E.G. Mahadevan, our esteemed Patron. Full details in the Book Review.

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Homage to Sri K.C. Vijh, Patron, Visfotak, who passed away on 31st July, 2012.

Sri K.C. Vijh
1941-2012

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COVER FEATURE AND SUPPLEMENT

COVER FEATURE

Revisiting "Explosives Delivery Regime And Public Safety : An Overview"

Every publication of the Journal is distinguishable by its 'Cover Feature'. Thus far, since inception, we have dealt with a range of contemporary 'Challenges and Issues', listed below, on aspects of safety and technology' of the explosives industry in India, simultaneously presenting the global perspective on such issues, and making appropriate recommendations for further action by all the stake holders associated with the industry.

Vol.1, Dec. 2006	*: "Explosives Delivery Regime and Public Safety : An Overview"*
Vol.2, Oct. 2007	*: "Energy Audit of Commercial Explosives"*
Vol.3, Sept. 2008	*: "Draft Explosives Rules 2006 : An Appraisal "*
Vol.4, Dec. 2009	*: "Explosives and Environment"*
Vol.5, Sept. 2010	*: "Value Chain Analysis of Open Pit Mining"*
Vol.6, Dec. 2011	*: Emerging Dividends from "Technology-Safety Interface" of Modern Industrial Explosives : Why India has lagged behind ?*

We intend revisiting these topics, one by one, over time, in order to update, review and assess the current status. For full text of these cover features, visit www.visfotak.org

Editor

1.0 PROLOGUE - 2006 :

When this subject was first articulated in 2006, it was intended to develop a 'Base Case', as it were, of the explosives industry in India from the stand point of 'Public Safety', uniquely distinguishable by the status of the 'Explosives Delivery Regime', alongside the over-arching regulatory dispensation and the state of explosives technology, at that juncture.

The profile of the 'Base Case -2006', is provided in Box-1, whereas, the relevant issues of concern and actions proposed, are summarized below for ready reference :-

Issues of concern

- *'Commoditization' of packaged explosives, due to the very large number of licensed retail outlets vis-à-vis the size of the market; and as a result, creating multiplicity of intermediate transactions before reaching the actual user, clearly a situation inimical to the cause of 'Public Safety'.*
- *Majority of these outlets are very small and, in a competitive environment, situations could arise, inadvertently or otherwise, in contravention of the statutory provisions prescribed in the licenses granted for possession and sale.*
- *Linkages between the actual users and the manufacturers, are amorphous at best, devoid of clear line of 'accountability' in the event of untoward incidents.*
- *By the same token, it is impossible to reconcile the supplies reaching the actual users with the deliveries effected by the manufacturers at any given time, and leakages if any, are hard to detect.*

Actions Proposed

i) Transition to Bulk Systems :

Besides the large opencaste mining projects where BulkExplosives Systems (BESs) are already deployed constituting 50% of the market, BESs need to be rapidly promoted where ever amenable; for example, converting the large diameter (83mm and above) packaged explosives market through appropriate administrative measures

ii) Review of Licenses for 'Possession and Sale':

In the interim, to urgently review and rationalize the existing licenses as per following criteria :-

- *Linkage with manufacturer(s) is mandated, by clearly specifying the area/ actual users, to be serviced in the licenses.*
- *Adequate holding capacity with requisite infrastructure, to properly service the demand from the designated area / actual users.*
- *The 'Qualification and Competency' of the dealer to handle hazardous goods, in full compliance with the provisions of the explosives rules.*

iii) Small Users:

It's a vulnerable sector of the market from the stand point of compliance with the provisions of the explosives rules. This sector, primarily of quarrying and civil construction, needs to be professionalized by promoting 'Contractual Blasting Services', rendered by competent agencies duly approved and granted licenses to hold explosives in portable magazines mounted on motorized vehicles under specified conditions. An appropriate model should be developed.

iv) Modernization of the procedure for 'Indenting and Deliveries':

To develop and induct a computerized network for online procedure, duly linked with all the offices of the Department of Explosives, so that 'Delivery and Consumption' of explosives are constantly monitored in real-time.

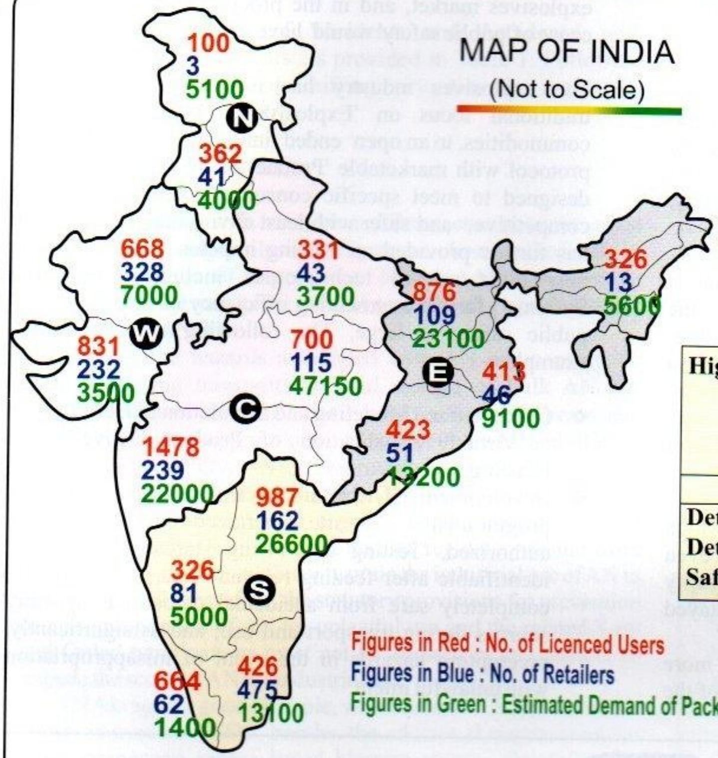
v) 'Certification of Competency' of Persons Dealing in Explosives:

Vi) To establish 'Central Explosives Storage Reserves' (CESRs):

Drawing upon the Australian Model, CESRs are strategically located, where all manufacturers would be required to set up their storage reserves, to facilitate supplies directly to the actual consumers to the maximum extent, by eliminating or minimizing intermediate transactions. These Reserves would be maintained / supervised by Government Agencies with adequate security and keeping up-to-date record of movement of explosives in close co-operation from the manufacturers.

(The "Cover Feature" is an 'In-House' contribution, as part of the serial on "Challenges and Issues" of the Explosives Industry - Editor)

Box - 1



Explosives Market - 2006

High Explosives (HE) (t)		Packaged	Bulk	Total
	Mining	141850	273490	415340
	Non-Mining	49600	-	49600
	Total	191450	238490	429940
Detonators	(mil. nos)			432
Detonating fuses	(mil. mtr.)			209
Safety fuses	(mil. mtr.)			109

Licensing and Delivery Regime for Packaged High Explosives (HE)

Item	ZONE					
	North Ⓝ (Punjab, Haryana, J &K, HP)	South Ⓢ (AP, TN, Karnataka, Kerala)	Central Ⓒ (UP, MP, Chg, Mah., Uttaranchal)	Eastern Ⓔ (Bihar, Bengal, Assam, Orrisa, Jharkhand)	Western Ⓦ (Goa, Rajsthan, Gujrat)	Total (All India)
1. Demand (t)						
- Mining	2100	33100	61250	41000	4400	141850
- Non-Mining	10700	13000	7900	10000	8000	49600
Total	**12800**	**46100**	**69150**	**51000**	**12400**	**191450**
2. No. of Licensed Users	462	2403	2507	2038	2547	9957
3. No. of Lincensed Outlets						
3.1 Manufacturer / Agents	23	60	78	81	12	254
3.2 Resale Outlets						
< 1 t holding capacity	9	256	29	29	53	376
> 1 t to 5 t ,,	41	354	118	62	261	836
7.5 t to 10 t ,,	12	105	86	52	132	387
> 10 t ,,	18	71	121	76	121	407
Total	**103**	**846**	**432**	**300**	**579**	**2260**

2.0 DISCUSSION :

2.1 Global Perspective :

The growth of explosives market in the USA, home to almost the entire array of new technologies since the 1950s, see Box - 2, provides important pointers/bench marks for India from the stand point explosives delivery regime and public safety, which are briefly highlighted below.

i) Close to 100% of the High Explosives (HE) market is serviced by Bulk Explosive Systems (BES) with the exception of a small requirement for 'permissible' explosives' for underground coal mining, thereby, ushering a paradigm shift in the HazOp profile of explosives delivery regime, free from all risks and hazards associated with handling, storage and transportation of an equivalent quantity of packaged HE.

ii) The market is predominantly 'ANFO' centric, which constituted 70% share of the market in the 1970s, and even after the advent of 'emulsion explosives' which are in reality emulsified avatars of ANFO, the share of ANFO has stayed its course, currently around 50%.

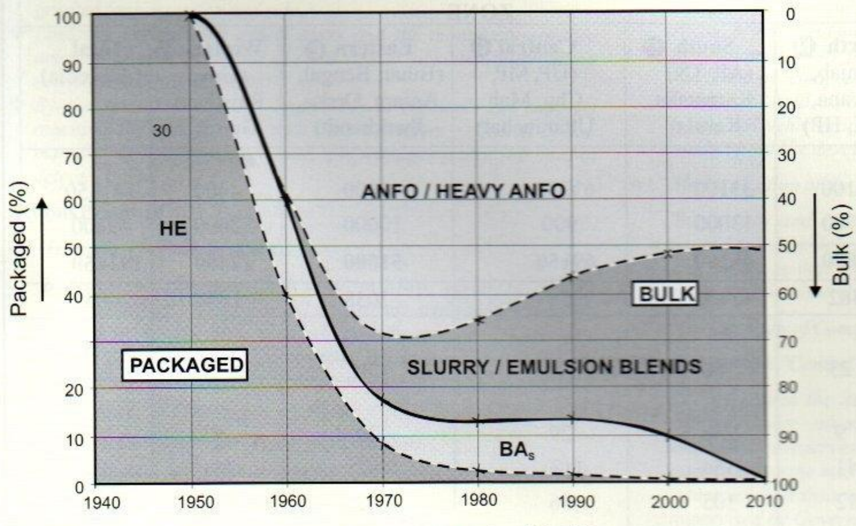
Whereas, a contrarian trend in India couldn't be more stark, with ANFO constituting only a minority share of the explosives market, and in the process without doubt, the cause of 'public safety' would have indeed suffered ?

iii) The explosives industry has moved away from the traditional focus on 'Explosive Products' as saleable commodities, to an open ended innovation driven business protocol with marketable 'Product Systems and Services', designed to meet specific consumer's needs, which are competitive, and safer with least environmental impact. It has further provided an abiding impetus for developing new blast related technologies including 'Initiating Systems`, further augmenting efficiency of operations and public safety at large. The following are outstanding examples:-

- ❖ Computerized Modeling and Simulation of Blast Design / 'Virtual' visualization of Product Delivery and Blasting.
- ❖ Development of Ultra Safe Electronic Delay Detonators, programmable at site, energized only through an authorized, 'Testing and Firing Hardware', uniquely identifiable after feeding relevant data, and therefore, completely safe from accidental detonation by stray sources during transport and use; and as significantly, preempting hazards in the event of misappropriation with unlawful intent

Box - 2

Profile of Explosives Market in the USA : 1940-2010



Legend : HE - Nitro compounds
BAs - AN based Blasting Agents

Source : Vol. No. 6, Visfotak Journal

Chronology of New Technologies

- 1955 - AN Prills : Dawn of Bulk Systems.
- 1960 - TNT/ Aluminised Slurries by Cook and Farnam.
- 1963 - Non-Aluminised, Fuel Sensitized Slurries, Ireco, Plant-Mixed and Site Pumped Slurry System, Ireco.
- 1969 - Emulsion Explosives, Methyle Amine Nitrate slurries, DuPont.
- 1971 - Emulsion - ANFO Blends.
- 1972 - On-Site Slurry Mixing and Delivery Unit, Ireco.
- 1974 - Shock Tube Non-Electric Detonators.
- 1977 - Computer Modeling of Blast Design.
- 1980s - Electronic Delay Detonators, Bulk Emulsion Matrix - AN prills. Blends, .
- 1990s - Laser profiling of benches; GPS hole spotting and automated Drilling and other blast related services.
- 2000 - Digital Age of "Virtual Product Delivery and Blasting".

2.2 Emerging HazOp Profile :

A sample survey of 'Incidents and Accidents' with explosives in recent years is provided in Table 1. Following inferences indicative of shifting priorities in regulatory paradigm, are self evident:-

2.2.1 High Explosives (HE) :

BESs / MBUs with near zero incidents, emerge as the safest mode for delivering explosives. However, closely allied with it, is the emergence of Ammonium Nitrate (AN) as a major constituent in the new genre of AN based blasting agents besides the traditional ANFO.

Historically, the hazards associated with AN as an energetic oxidizer, during transportation and storage of bulk AN has always been under a scanner, but more so in the recent years, due to the danger of misappropriation of AN for unlawful activities. A global regulatory 'Over - View' is provided in Box - 3.

However, some caution is in order. Whilst reasonable rules and regulations are warranted to regulate bulk transportation and storage of AN, it is as incumbent that the regulatory frame work does not in any manner inhibit or restrain the industrial use of AN to its full potential. Therefore, the statutory provisions for prevention of misappropriation of AN for unlawful use and the related 'Law and Order' ramifications must not be allowed in any manner to impede the scope of AN for industrial use.

USA is again a good example, where around 1.5 million tonnes of AN is used as ANFO, besides the additional requirement for other ammonium nitrate based blasting agents. The following extracts from "A Review of Recent Accidents involving Explosives Transport" by National Institute of Occupational Safety and Health (NIOSH), Pittsburg, USA, is illuminating.

"When most people think of explosives transport they think of a hazardous operation. We all know that we aren't allowed to transport explosives through tunnels and are discouraged from traveling through heavily populated areas. Popular opinion suggests that explosives transport is a very risky operation. The authors decided to look into this a little more thoroughly and found just the opposite to be true.

While there have been some disastrous world-wide accidents involving the transport of industrial explosives, this is not the case in the U.S. Over the past 10 years, accidents related to the transport of explosives used in mining and construction have resulted in 5 major injuries, 11 minor injuries, and no fatalities. Explosives and ammonium nitrate (AN) transport outside the U.S. has not had such a good record; there have been 4 major explosives or AN transport accidents resulting in a total of more than 300 deaths. Most of these fatalities could have been prevented if the accident site had been evacuated once the explosive or AN cargo began burning.

The safe history of explosives and AN transport in the U.S. is due to diligent efforts by government, labor, and industry. However, accidents will become more common and disastrous if we become complacent".

Table 1 - Sample Survey of No. of Incidents and Accidents with Explosives

Activity	India (2006-2011) Source : Annual Reports of the Department of Explosives	Global Sample (2009-2012) Source : Safex International
1. Manufacturing		
1.1 Fixed Plant		
NG	1	3
AN Emulsion (ANE)*	1	8
ANFO	-	1
Explosive Accessories (EA)	20	44
Sub-total	**22**	**56**
1.2 Mobile Bulk Units (MBUs)		-
ANE**	-	3
ANFO	-	-
1.3 Waste Disposal	?	8
2. Transportation/Handling		
Vans/Trailers	6	8
MBUs : ANE ***	-	4
AN/ANFO ***	-	12
Handling/Use	2	2
3. Storage		
HE ****	-	-
AN	-	1
EA	2	-
4. Un - authorized Premises	8	?
Total	**40**	**94**

Note :

* The incidents mostly relate to hazards during pumping / dispensing of emulsion explosives during manufacture in a plant.

** Only one incident relate to deflagration of ANE inside the hose reel during pumping; others relate to human errors / negligence, not involving ANE.

*** No incident of explosion or fire.

**** Incident of fire during storage .

THINK
THE SAFE WAY
IS THE
BEST WAY

Box - 3

MITIGATING HAZARDS ASSOCIATED WITH AMMONIUM NITRATE

Ammonium Nitrate (AN) is an energetic oxydizing agent that can cause combustible materials (such as wood, paper, and oil) to ignite. Only under extreme conditions of heat and pressure in a confined space will ammonium nitrate explode.

Following is an 'Over-View' of the regulatory paradigm to mitigate hazards associated with Ammonium Nitratre:-

1. UN MODEL REGULATIONS ON TRANSPORT OF DANGEROUS GOODS, AND THE MANUAL OF TESTS AND CRITERIA :

- Originally developed in 1984 by the Economic and Social Council's Committee of Experts on the Transport of Dangerous Goods which included Ammonium Nitrate within its ambit, and since been regularly updated and amended. The latest updating in 2009, has been done on the "Globally Harmonized System of Classification and Labelling of Chemicals". The Model Regulations are supplemented by a Manual of Tests and Criteria, prescribing test methods and procedures to be used for the classification of dangerous goods.

  Ammonium Nitrate is classified as Explosive Substance in Class 1, division1.1; that is, a substance which is capable by chemical reaction in itself of producing gas at such a temperature, pressure and such a speed as could cause damage to surroundings or which is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as a result of non-detonative self-sustaining exothermic chemical reactions.

- The UN Model Regulations / Manual of Tests and Criteria for dangerous goods, are not obligatory or legally binding on member countries, but have gained a wide degree of international acceptance, forming the basis of many countries laws/regulations.

2. USA :

- The Department of Transport, which regulates transportation of AN under its Hazardous Materials Regulations. Under these regulations, AN with less than 0.2% combustible substances, and AN fertilizers are classified as Oxidizer; whilst AN with more than 0.2% combustible is classified as an explosive.
- Environment Protection Agency's (EPA)Risk Management Program is intended to prevent and mitigate hazards from AN;
- The Occupational Safety and Health Administration (OSHA) regulates the manufacture, keeping, having, storage, sale, transportation, and use of explosives and blasting agents under its Occupational Safety and Health Standards for explosives and blasting agents involving AN.
- The Bureau of Alcohol, Tobacco, and Firearms of the Department of the Treasury regulates the importation, manufacture, distribution, and storage of explosive materials including AN
- Ammonium Nitrate Security Statutes and Regulations under the Homeland Security Act, to regulate the sale and transfer of AN by an AN facility to prevent misappropriation or use of AN in act of terrorism.

3. CANADA :

- Ammonium Nitrate Storage Facilities Regulation , Canada Transport Act, 2008.

  These regulations don't apply to Storage Facilities not containing more than 3000lbs of Ammonium Nitrate, and also to Nitro Carbo Nitrates or other AN Blasting Agents, the preparation, storage, or use of such blasting agents or similar mixtures.

4. UK :

- AN is classified as an explosive and assigned Class 1 of the UN Classification System, subject to control under the Explosives Act 1875.

5. INDIA :

- AN declared as a 'Special Category Explosive Substance' under the Explosives Substance Act 2008, by a gazette notification dt. 15.12.2008, on behalf of the Ministry of Home, to prevent mis-use of AN or possessing AN with unlawful intent.
- 'Ammonium Nitrate Rules 2012', under the Explosives Act1884 , vide gazette notification dt. 11th July, 2012, for regulating the manufacturing, conversion, import, export, stevedoring, bagging, transport, and possession for sale or use of AN, except as authorized or licensed.

2.2.2 Explosives Accessories (EA) :

The HazOp Profile, (Table 2), predictably places EA into a 'Stand Alone' sharper relief as the most hazardous amongst all the product systems at this juncture, perhaps warranting a separate Statute / By-Laws exclusively dedicated to the regulation of storage and transportation of EA, including provisions for measures to closely monitor delivery, which is germane to preempting hazards from misappropriation for unlawful use.

2.3 Developments in India : 2006 - 2012 :

2.3.1 Market (Bulk vs. Packaged) :

A sectorial growth profile of the market is given in Table 2. There is a welcome accelerated trend for BESs / BDUs, presently constituting a healthy share of the market @ around 70%, though confined to only large open mine projects, mostly in the coal sector. On the other hand, whereas, the share of packaged products has shrunk, but, quantitatively, the demand has surged by 60%, and as a result, the network density of explosives delivery has only worsened. Further, if the simultaneously rising requirement for explosives accessories is factored into this equation, the over all delivery regime would appear to have regressed since 2006, and worst compounded by the fact that a major proportion of the demand for EA arise in the construction sector, largely serviced through an extensive net work of small retail outlets.

2.3.2 Slowly Evolving Regulatory Response :

Not withstanding certain significant developments during this period, listed below, there are still serious anomalies in the delivery regime which have persisted since 2006 and need to be addressed without further delay.

❖ ***Revised Explosives Rules 2008 :***

The new rules have introduced some significant structural changes in safety management, lending greater specificity, clarity and focus with regards to security and safety during manufacture, compared to the Explosives Rules,1983. However, overall, the new rules fail to provide a comprehensive frame work of 'Standards and Specifications' with regard to every explosive related activity in a manner that would adequately provide a directional thrust for growth in technology and safety of the industry in conformity with the best global practices / trends.

Table 2 - Sectoral Growth of Market : 2006 - 2012

Sector / Explosive type	2006					2012				
	HE				EA	HE				EA
	Bulk	Packaged			Total	Bulk	Packaged			Total
		SD	LD	Total			SD	LD	Total	
Mining										
HE ('000t)										
ANFO	25				25	60				60
ANE	240	30	112	142	382	503	36	175	211	714
Total	265	30	112	142	407	563	36	175	211	774
EA										
Dets (mil.nos.)					70					102
Det. Fuses (mil.m)					100					160
Civil Constructions / Trade										
HE ('000t)										
ANFO	10				10	30				30
ANE	-	50	5	55	55	-	56	10	66	66
Total	10	50	5	55	65	30	56	10	66	96
EA										
Dets (mil.nos.)					360					370
Det. Fuses (mil.m)					110					120
Grand Total										
HE	**275**	**80**	**117**	**197**	**472**	**593**	**92**	**185**	**277**	**870**
EA										
Detonators (mil.nos.)					**430**					**472**
Det. Fuses (mil.m)					**210**					**280**

❖ ***New Statutes to regulate production, and delivery of Ammonium Nitrate (AN) :***

As a first step in this direction, AN was declared a 'Special Category Explosives Substance' under the Explosives Substance Act,2008, to prevent misuse of AN or possessing AN with unlawful intent.

Later, a separate Ammonium Nitrate Rules 2012, under the Explosives Act1884, has also been introduced for regulating the manufacturing, conversion, import, export, stevedoring, bagging, transport and possession for sale or AN, except as authorized or licensed.

It's too early to assess the full ramifications, but at the face of it, taking note of the initial aberrations created in the market for AN, it would appear that the 'Law and Order' conundrum has taken precedence over the economic 'raison d'etre' of pro-actively promoting wider and all round use of AN in conformity with global trends.

❖ ***Online 'Explosives Return System' (ERS) : e-Governance Initiative by Petroleum and Explosives Safety Organisation (PESO) under the Chief Controller of Explosives, Govt. of India :***

The latest advisory issued by PESO, dated 24.2.2013, in pursuance of the e-Governance initiative under the 11th Five Year Plan, is annexed (Annexure - 1) . The following milestones have been achieved:-

- All the PESO offices have been brought under 'Explonet Network'.
- All explosives manufacturers are submitting their daily manufacturing details on day to day basis online.
  100% achievement registered in respect of submission of RE-7 (Return of Explosives) online.
- Over 95% of licensees of LE-3 (To Possess for Sale) have registered for submission of RE-7 online.
- Online monitoring of the transactions of explosives with generation of online RE-12 (Pass issued by the Consignor for transport of a consignment of explosives).

3.0 EPILOGUE :

3.1 Need For a Nodal Agency for the Stewardship of 'Explosives - Environment' Paradigm :

Though India is ranked amongst the major producers of industrial explosives, the growth of the industry, unfortunately, has largely remained asymmetrical with the global trends, which is duly reflected by the delivery regime as illustrated in Table 3. In this context, therefore, without further ado, the following aspects need immediate attention:-

a) The regulatory process including legislation making has to have a robust underpinnings of 'Research and Development', responsive to new technologies as they emerge, to remain pro-actively and collaboratively engaged with the industry, in order to quickly promote technologies that offer maximum dividends in work quality, productivity, health and safety of workforce and not the least, the 'public safety' at large.

b) Such a process, enjoins an institutionalized framework, for "Technology Information, Forecasting and Assessment" of emerging technologies, duly affirmed with appropriate administrative incentives for the industry to adopt best technologies / practices within an assigned time frame.

c) The Industrial Development Act 1951, provides for an institutional framework for the explosives industry, in the form of Explosives Development Council (EDC), which unfortunately, has been moribund for quite a while. It is recommended that EDC should be revived and accorded a permanent tenure, fully representative of all relevant entities concerned with the explosives industry including research and development, and that EDC is duly mandated to act as a 'Nodal Agency' for a holistic stewardship of 'Explosives- Environment' paradigm in all its aspects.

3.2 Follow up on the Actions Proposed in 2006 :

3.2.1 Modality for rapid transition to MBUs for high explosives :

❖ ***Packaged Large Dia. Explosives Market :***

Aside from the large mining projects where MBUs are already deployed, the remainder of the large dia. packaged market, still very large at around 180,000t and easily amenable for conversion to BESs, should be targeted with appropriate administrative measures without further delay.

❖ ***Packaged Small Dia. Explosives Market :***

The small dia. explosives requirement is predominantly in 25mm dia. cartridge size, for civil constructions and quarrying, mostly comprising small operators.

Though small scale portable ANFO loading devices for small diameter blast holes, have been well established over decades and extensively deployed in other major explosives producing countries, India is probably the lone exception where ANFO hasn't had similar scope. Clearly, this asymmetry needs to be corrected.

Further, in consonance with the subsequent development of other AN based blasting agents, competitive versatile portable devices for emulsion explosives have also been developed for small dia blast holes. The world's first modular emulsion charging system for small diameter blasting, developed by AEL Mining Services , South Africa, is illustrated below:-

World First - Modular Pump for Narrow Reef Emulsion Charging

AEL Mining Services, an international leader and innovator in commercial explosives and blasting solutions, has launched the PCU010 portable charging unit for use in conjunction with underground emulsion in the Narrow Reef mining environment.

The mixer at the end of the hose converts chemicals into explosives "at the face" creating a safe, user friendly system for hard rock mining.

The simplicity of use and ease of maintenance makes this pump the LEADER OF THE PACK in this emerging technology.

The pump is used in conjunction with bagged emulsion in the confined spaces found in Narrow Reef stopes and tunnels. The system effectively replaces packaged explosives.

Courtesy AEL Mining Services, South Africa

3.2.2 Rationalization of the existing LE-3 licensees, and recasting Delivery Regime by establishing Central Explosives Storage Reserves (CESRs):

❖ ***Review of all existing LE-3 licensees :***

The demand for packaged products from the mining sector is largely delivered directly by the manufacturers or their accredited dealers / consignment agents through around 200-300 outlets. Whereas, quite the opposite, the demand arising from the construction sector including quarrying, etc, comprising 66000t SD, 370 million detonators, 120 million meters of Det. Fuses, is largely serviced by more than 2000 small retail outlets, which number is grossly disproportionate with the size of the market - the average volume of transaction annually per outlet is as low as 30t SD, and 1.5 lac detonators - proof enough of an entrenched commodity syndrome afflicting this sector; inimical to public safety at large.

Therefore, a process of rationalization of the licensing regime by reviewing all LE-3 licenses as per the criteria suggested in 2006, in tandem with the initiatives for e-Governance is over due.

❖ ***Establishing Central Explosives Storage Reserves (CESRs) :***

Simultaneously, the delivery regime needs to be recast by establishing CESRs, as recommended in 2006, so located as to facilitate and ensure supplies are effected from these Reserves either directly to actual users and/or through the accredited dealers / consignment agents of the manufacturers.

In this context, 'Small Users' are particularly vulnerable, and as proposed, they should be brought within the ambit of 'Contractual Services' provided by competent professional agencies, duly approved for this purpose, and granted licenses to hold explosives in motorized vehicles under specified conditions. The following model for explosives delivery should ultimately emerge.

Table 3 - Estimated Zonal Configuration of Demand for Packaged Producys and Licensing Regime : 2012

	North	South	Central	Eastern	Western	Total
A. Demand for Packaged Products.						
HE (t)						
LD	3000	43000	80000	53000	6000	185000
SD	15000	25000 (8000)	15000 (8000)	26000 (14000)	1000	92000
Total	18000	68000	95000	79000	17000	277000
EA						
Detonators (mil.nos)	80	130	80	130	60	480
Det. Fuses (mil.ms)	5	65	120	80	10	280

Note : Within brackets is the estimated demand for permissible explosives for under ground coal mining.

B. Sale Oulets / Users	J&K 2/78 HP 10/137 HAR 15/19 PUB -/1	AP 196/709 TN 833/1024 KAR 62/193 KL 76/1234	MH 344/1208 MP 111/435 CHG 49/262 UP 24/44 U.KHAND 15/36	WB 69/208 OR 54/200 JHA 73/364 B.R 5/5 N.East 19/30	GUJ 150/681 RAJ 159/372 GOA -/67	
Total	**27/235**	**1167/3247**	**543/1985**	**220/1089**	**309/1120**	**2266/7676**

The number of CESR would be guided by the current geographical configuration of the market vis-a-vis retail outlets and the users, as illustrated in Table 3 above. A schematic outline is provided on a map of India, Figure 1. Prima facie, two CESRs strategically located in every large explosives consuming State would adequately meet the objective.

3.2.3 Explosives Accessories (EA) :

The emerging HazoP profile of the explosive delivery regime as illustrated in Table 2, would arguably suggest the need for a separate regulatory framework, exclusively dedicated to EA, to closely regulated and monitor transport and delivery.

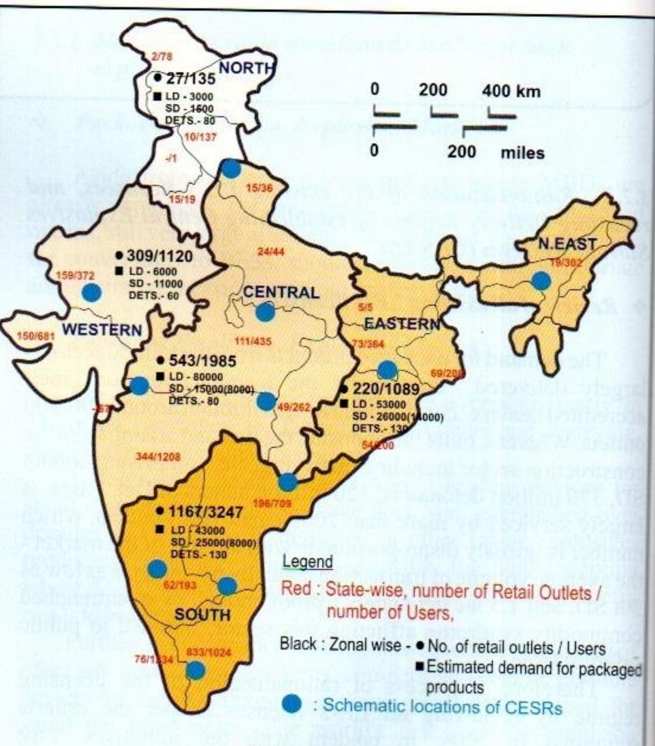


Figure - 1

REFERENCES :

(1) Vol. 1, Vol. 3 and Vol. 6 of Visfotak Journal.
(2) 'Safety Management System' - Provision for auditing and review : A Guide Line for Implementation, DGMS (Tech.) (S&T) Circular No. 02 of 21011.
(3) A review of recent accidents involving explosives transport, NIOSH, Pittsburgh Research Laboratory, Pittsburgh, USA, 2006.
(4) UN Recommendations on the Transport of Dangerous Goods, UNECE, 2009.
(5)) Science of High Explosives, Cook, 1974.

(The "Cover Feature" is an 'In-House' contribution, as part of the serial on "Challenges and Issues" of the Explosives Industry - Editor)

Annexure - 1

तार-॥ "विस्फोटक", नागपूर
Telegram: 'EXPLOSIVES', Nagpur
Website : http://peso.gov.in
Email: explosives@explosives.gov.in

दूरभाष/ Telephone : 0712-2510248

फैक्स/ FAX : 2510577

कार्यालयीन उद्देश्य के सभी पत्रादि "मुख्य विस्फोटक नियंत्रक" के पदनाम से भेजे जाए उनके व्यक्तिगत नाम से नहीं.

All communications intended for this Office should be addressed to the 'Chief Controller of Explosives' and NOT to him by name.

भारत सरकार
GOVERNMENT OF INDIA
पेट्रोलियम तथा विस्फोटक सुरक्षा संगठन
Petroleum and Explosives Safety Organisation
(पूर्व नाम – विस्फोटक विभाग)
(Formerly- Department of Explosives)
"ए-ब्लाक॥, पाँचवा तल, केन्द्रीय कार्यालय परिसर॥,
"A" Block, 5th Floor, CGO Complex,
सेमिनरी हिल्स, नागपूर - 440 006 (महा)
Seminary Hills, Nagpur- 440006

संख्या /No. D-18019/Comp./Implementation
दिनांक /Nagpur, dated 24/02/2013

To

All licensees for Manufacture/Sale/Use of Explosives

Subject : Awareness about PESO's Online 'Explosives Return System' (ERS)

Dear Sir,

You may be aware that the Petroleum & Explosives Safety Organisation has developed web based module for external stakeholders to do online transactions of explosives through PESO's Online 'Explosives Returns System' (ERS) available in PESO web site i.e. http:/peso.gov.in. The online facility has been so developed that relevant provisions of Explosives Rules are implemented through checks & balances built in the software system. The software will prevent the user from deviating from Rules. New facilities such as issue of online pass for use of explosives, to receive explosives online, alerts for non-receipt of consignment of explosives, notice for renewal of licence, real time stock position of the magazine etc. have been added to the existing Online 'Explosives Returns System' (ERS). Following are features of the module.

1. Record of Manufacture (RE 2)

The record of explosives manufactured (as per Rule 24) to be submitted online everyday in **'Explosives Returns System'** ERS.

2. Indents (RE 11) for purchase of Explosives:

Indents in form RE11 are raised by consignees as per Rule 50 & 77. The Consignee shall login ERS to generate indents. He can view present stock (real time) of explosives in his magazine before making indents. The approximate date on which you are ready to receive consignment of explosives shall be carefully entered. The RE 11 shall be generated only when following checks are fulfilled:

- ✓ Consignee's lincence is valid & endorsed **[Rule 7, 107(3)]**.
- ✓ Quarterly Returns as per **Rule 24** is uploaded online.
- ✓ Licence is valid for particular Class (division) of Explosives to be indented as per **Rule 10(4).**
- ✓ Quantity of Explosives to be indented shall not exceed lincensed capacity of the consignee (Rule 10(4).

OR

Class 2/3: 15T OR ED: 5.5 Lakh Nos. OR OD: 20 Lakh Nos. OR DF: 20 Lakh Mtr whichever is less

Other Features:

Separate Indents for detonators and other Explosives to be made. Indents if not utilized within 45 days shall automatically expire. Indents shall be made on current date only. Consignee has been given facility to cancel the Indents if necessary after giving reasons. Indent Management System with Record of Indents and summary of Passes issued against each indent is also made unavailable. Indents are generated with unique nos. e.g. RE-11/2012/0001

Master for Persons authorised to receive Explosives:

The user is required to upload the details (including photograph & specimen signature) of all Person authorised to take delivery of Explosives at consignee's magazine. This will enable the user to select the authorized person from the dropdown at the time of generating

Indents. Names of maximum four such authorized persons may be selected at the time of making indent (RE11). One of such authorized person is required to be present at the time of taking delivery of explosives. New authorized persons may be added to the master any time.

3. Passes (RE12) for sale of Explosives:

Passes in form RE12 are issued by consignors as per Rule 47 & 50. Pass shall be generated only against indents received online. However, Passes may also be generated against manual indents if received from DM licensees and for export purpose. The indent received online shall be displayed in all the licensees of the Supplier/Consignor. The supplier has the prerogative to supply explosives or to deny. He may process the indent to sale explosives and if does not want to supply may reject the indent after giving reasons. The consignor may also supply various explosives of an indent from his different magazines. This means multiple Passes may be made against the same Indent. The RE 12 shall be generated only when followings checks are fulfilled:

- ✓ Licence of Supplier/consignee to be valid & endorsed **[Rule 7, 107(3)].**
- ✓ Quarterly Returns as **Rule 24** are uploaded online.
- ✓ Explosives Van Licence is valid & endorsed **[Rule 7, 107(3)].**
- ✓ Brands of explosives and its quantity to be sold are available in consignor's stock.
- ✓ Quantity of explosives being sold shall not exceed indented quantity.
- ✓ Quantity of explosives being sold shall not exceed capacity of Explosives Van.
- ✓ Detonators are not transported with other explosives as per **condition 10** of Expl. Van Licence.
- ✓ Quantity to be supplied shall not result in exceeding the monthly purchase limit of the consignee **(Rule 77).**

Other Features :

In this system brands & quantity of explosives available in stock of the consignor can only be sold. Before making the pass, the consignor can view capacity status of the consignee's magazine to know whether the consignee is eligible to receive kind & quantities of indented explosives. Separate pass for detonator and other Explosives to be made. Pass3es shall be made on current date only. Once RE12 is issued online, entries of sale of explosives will be automatically effected in the quarterly Return of consignor.

Pass Management System with Record of passes and Summary of Passes issued against each indent can be seen. Passes are generated with unique nos. e.g. RE-12/2012/0001. route for transportation has to be made carefully.

Master for Routes:

The user is required to make master of the 'transportation routes' in the system by selecting names of all districts coming in between place of origin and destination. He may take help of map for deciding the route.

4. Accept (Receive) Explosives Online

On actual receipt of explosives, the consignee shall verify kind & quantities of explosives with RE-12 and shall **'accept'** it online in the System. If quantities are short/excess, the same shall be correctly entered in the system. Once consignment is received online, entries in this respect will be automatically effected in the quarterly Return of consignee. The consignee should accept the consignment on or before the date mentioned in Pass RE-12 of the approximate reach date.

5. Pass for end use of Explosive:

The licensee has to issue explosives online for end use and also to return un-used explosives online. After logging in **ERS** the user is required to select/make necessary entries regarding site particulars, blaster, purpose for use of explosives like mining, well sinking etc, no of holes to be fired, mode of transport, kind & quantities of explosives to be used. The no. of cartridges shall be automatically calculated and shown by the system after entering quantity of a particular brand/dimension of explosives. The quantity of explosives which is likely to be consumed in a day should only be issued. Excess issue of explosives should be avoided. The pass for end Use shall be generated only when followings checks are fulfilled.

- ✓ Licence to passes explosives for use is valid & endorsed **[Rule 7, 107(3)].**
- ✓ Quarterly Returns as per **Rule 24** uploaded online
- ✓ Quantity to be issued should not exceed licensed capacity.
- ✓ Shot Firer's permit issued by PESO/DGMS is valid
- ✓ Explosives Van lincence shall be valid & endorsed if transported by Van.
- ✓ Quantity of explosives transported should not exceed capacity of Explosives Van.
- ✓ Detonators issued are proportionate to the no. of cartridges of high explosives.

Provision has also been made in the system to make entries regarding return of the un-used explosives as required in **Rule 90(4),** on completion of the blasting work the un-used explosives has to be returned to the same magazine before Sunset and necessary entries to this effect are to be made online on the same day. The user will not be able to make these entries next day.

Pass for issue of Oil Well-logging imported Explosives, accessories for ANFO Mixing Explosives, SME/ANFO Bulk explosives and Gun Powder & Safety Fuse: Companies possessing lincence to manufacture and use ANFO (licence in For LE1) shall be able to issue pass for accessories like boosters [explosives of Class 3(ii), Class 6div.(ii)] & detonators after adding dock nos. in their existing profile. While companies possessing licence of SME/ANFO bulk explosives (licence in For LE1) shall be able to issue pass for accessories like boosters [explosives of Class 3(ii), Class 6div.(ii)] & detonators after selecting option of SME/ANFO bulk explosives. While licensees possessing licence for storage of well logging explosives and other imported explosives will be able to issue such explosives after selecting option for Oil Well-logging explosives.

Other Features:

In this system brands & quantity of explosives available in stock can only be issued for use. Separate pass for detonator and other Explosives to be made. Passes shall be made on current date only. Pass Management System with Record of Passes and Summary of Passes issued can be seen. Passes are generated with unique nos. e.g. RE-13/2012/0001.

Masters for Site of Use and DGMS Blasters

The user is required to upload the details of all new sites of use of explosives along with the names of Agent/Owner of the site for making master. This will enable the user to select the blasting site from the dropdown at the time of generating Pass for end use. Similarly the user will make master of DGMS blasters if he proposes to do blasting work in areas covered under Mines Act 1952. The blaster's photograph and permit issued by DGMS shall be scanned and uploaded in the master.

For area not covered under the Mines Act the blasting shall be one by Shot Firers whose permit have been issued by PESO. All such shot firers are attached to certain magazine and are already linked online to corresponding LE 3 licence for use of explosives. In case Shot firer's permit is not attached to LE3 licence, he should be advised to get his Shot firer Permit amended in this respect from the concerned PESO office immediately. Details of Shot Firer Permit need not be uploaded in the master, their names will automatically appear in the dropdown at the time of generating Pass for end use.

6. Quarterly Returns (RE7)

The statement of explosives purchased, sold used, destroyed, stolen, short received shall be submitted online in the **ERS** regularly and shall be uploaded in the system before 10th day of the next quarter as per **Rule 24(3)**. As the data of all transactions are in the PESO online **'Explosives Returns System' (ERS), you are not required to submit print out of the complete Quarterly Return to the concerned PESO Office. Instead, you are advised to submit the system generated Acknowledgement to the concerned PESO office. You are also advised to maintain printed and signed copies of such Quarterly Returns (RE7) in your office which may be required by any government agency for investigation in future.**

This is to apprise you that when you accept consignments explosives online and issue explosives online through PESO's Online 'Explosives Return System' (ERS), all entries regarding purchase, sale, use shall be automatically done in the Quarterly Returns of Consignor as well as consignee. You will be required to make entries of explosives destroyed, stolen short received if any and shall be uploaded in time. Please note that if Quarterly Return is not uploaded in time the system will not allow to make any transaction of explosives.

After uploading the Quarterly Return in the system, officers of PESO shall check transactions and discrepancy report shall also be generated by the system automatically. When all the transactions are made online, no discrepancy or minimum discrepancies will be generated.

7. Real time stock position :

Facility have been provided to users to view stock position of his magazine on 'real time' basis.

8. Alerts :

Alerts shall pop up on the home page of PESO Online 'Explosives Returns System' of the user if:

a) Explosives not delivered to the consignee as per schedule. On clicking the alert, suitable instruction with the list of such undelivered consignments can be seen.
b) Explosive not received by consignee as per schedule. On clicking the alert, suitable instruction with the list of such undelivered consignments can be seen
c) ***Due for renewal notice*** with list off all licences of the profile which are going to expire on 31 March will be displayed. This notice will be flashed wef 1st January till 31st March.

9. Reports:

Reports of manufacture, sale, use, transport of explosives may be generated by the user.

10. Circulars issued by PESO can be seen and downloaded.

11. **Mailbox** containing last 5 letters issued by PESO to licensees can be viewed and downloaded.

12. To monitor/track explosives at any time in near Future.

Facility to monitor and track explosives have been developed is being fine tuned. This will be made available in near future. This will help investigating agencies to track the seized/unclaimed explosives to its last legal source.

(T.R. Thomas]
Chief Controller of Explosives

Copy for information to :
All Circle Offices, Sub-Circle Offices, DTS & FRDS.

COVER FEATURE AND SUPPLEMENT

SUPPLEMENT

BULK EXPLOSIVES DEVELOPMENT FOR SMALLER DIAMETER APPLICATIONS : INDIAN PERSPECTIVE

H.N. Srihari
Member, Editorial Advisory Board

In the Indian explosives "Scenario" bulk explosives developments started in the early 80's largely encouraged by the exponentially growing market, especially in the opencast coal mining sector. Bulk explosives developments began in India with simpler pumper truck technology, essesntailly adopted through indigenous development in the early 1980's. This was quickly followed by the introduction of mix pump truck technology imported from USA. Subsequently, Indian market growing at such rapid pace embraced newer adaptations of global developments like mixer bowl concepts that enabled introduction of bulk emulsion explosives. This lead to product differentiations like Doped Emulsions and other hybrid innovations to meet various field requirements that included pumpable as well as augarable combinations.

In the smaller diameter applications in the underground coal & metal mining sector as well as civil construction projects, however such enthusiasm was not forthcoming for bulk explosives adoption. This could be attributed to two main reasons; first being the conservative response to modifications of rules & regulations governing use of explosives in underground mines by both inspectorate of explosives as well as mines safety directorate. Secondly, both users as well as manufacturers were in a way obsessively focused on so called high performing packaged N G based gelatines, which discouraged even promising innovations

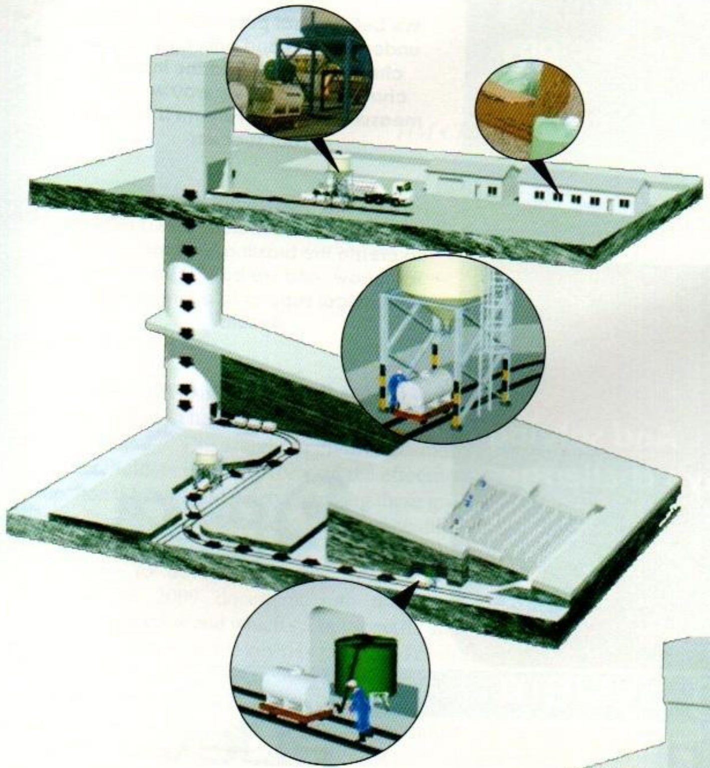
Despite this position, pioneering developments were taking place as early as in the late 1970's much before even large diameter bulk explosives got established. Manufacturers like ICI Explosives in India carried out pilot studies with simpler back-pack pumping concepts using safer slurry formulations. However limited progress was made due to low market response owing to reasons already stated.

In predominantly smaller diameter underground metal mining scene in South Africa, major developments have taken place over the years to establish bulk explosives delivery systems economically, safely and efficiently.

The accompanying illustrations accessed from AEL mining services, South Africa, provides us an exposure to both hardware and formulation developments to deliver bulk explosives to underground mining operations some of which are eminently adoptable for small dia applications in India.

AEL Mining Services

AEL MINING SERVICES, MOVING AWAY FROM CONVENTIONAL WAYS OF BLASTING



BULK SYSTEM

Application

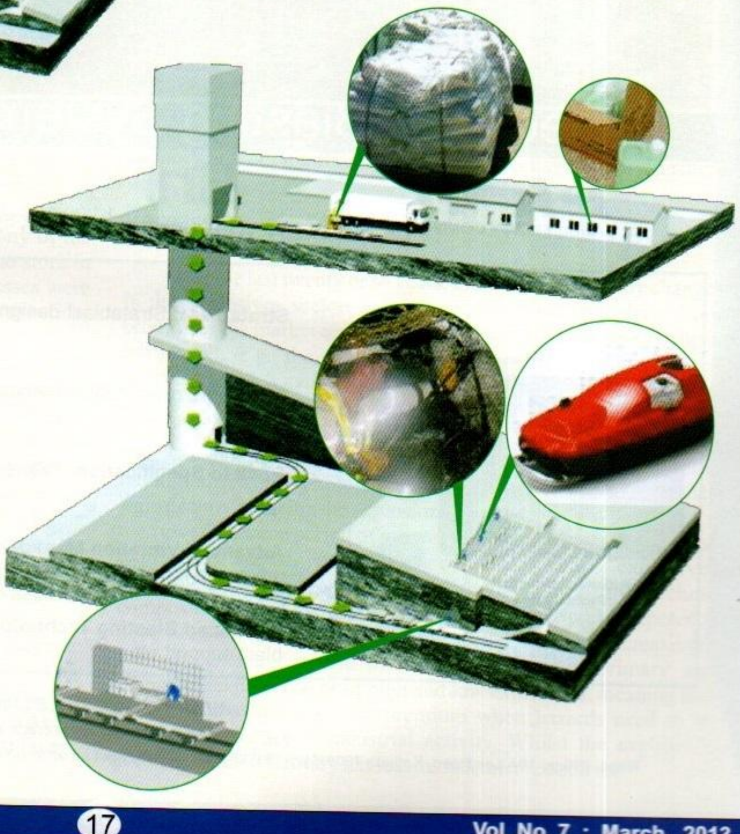
Conventional Narrow reef mining of any Depth.

Description

In a conventional mine with surface silos and emulsion cassettes the Bulk System is utilised in conjunction with PCU's.

Process:

- The bulk emulsion is delivered by tanker to a surface silo.
- Cassettes then take the emulsion from the silo on surface into the workings, or to temporary silos on the levels.
- The emulsion can be removed from the cassette and placed either in a portable tank adjacent to the workings for later pumping into portable containers or pumped directly from the cassette into portable containers.
- Emulsion containers and bottled sensitiser are sent into the workings as required and loaded into the tanks of the PCU at the face.



BAGGED SYSTEM

Application

Conventional Narrow reef mining of any Depth.

Description

In workings with no emulsion delivery infrastructure, the Bagged System is utilised in conjunction with portable charging units (PCU's)

Process

The bagged emulsion and bottled sensitiser are sent into the workings as required and loaded into the tanks of the portable charging units (PCU's) at the face.

THE EXPLOSIVES SECTOR IN THE 21ST CENTURY

Neil Morton

HM Chief Inspector of Explosives, Great Britain

ABSTRACT

This article is based on the Keynote Address' given to the Institute of Explosives Engineer's Annual Conference, Hayling Island, on 17 April 2012. It is published here with the kind permission of Diane Hall, Editor of "Explosives Engineering" Journal of IExpE, duly received through SAFEX International, which is gratefully acknowledge. The IExpE. and Visfotak are both Associate Members of SAFEX International.

INTRODUCTION :

In 2009 the Health and Safety Executive (HSE) published a document called "The Health and Safety of Great Britain – Be Part of the Solution" [1]. This sought to involve businesses, workers and other stakeholders in taking forward the effective management of occupational health and safety – getting these groups to recognize that they had key responsibility es for good health and safety.

As part of its roll-out of this approach, HSE worked with stakeholders to develop a series of sector strategies, which translated the 2009 document into the context of targeted employment sectors and which set out specific aims and objectives to tackle the issues (i.e. the key risk factors) of each sector.

During 2010 HSE's Explosives Inspectorate (Exl) produced an "Issues paper" which, based on the information and intelligence available to Exl, described the challenges and risks facing the explosives sector. For this purpose the "sector" was described as those businesses which manufacture explosives, or which store explosives in large (more than 2 tonnes) quantities. Many of the issues described will, no doubt, be relevant to others who store in small quantities or who use explosives but those businesses were covered by other sector strategies, e.g. mining, construction, entertainment etc.

The "Issues Paper" was shared with, and agreed by, the Explosives Industry Forum – a stakeholder liaison group within Great Britain (GB), chaired by HSE and which includes representatives of the main British explosives industry associations and the Institute of Explosives Engineers. A copy of the paper[2] is available on the Explosives Industry Forum community web-site.

A strategy was then developed to address the issues, identifying those activities Which Exl would discharge or lead and those where the sector would need to take on a greater role. This strategy formed the basis of the Exl plans of work for 2011/12 and 2012/13 and will continue to set the agenda for several years to come.

This article expands on a presentation given as the Keynote address of the annual conference of the Institute of Explosives Engineers in April 2012 and subsequently published in the Institute's journal, "Explosives Engineering". It is reproduced here with the kind permission of the Institute of Explosives Engineers. This article presents a summary of progress made so far in delivering the Sector Strategy, as well as highlighting some of the remaining challenges.

THE WAY WE WERE :

Not so many years ago, and certainly within the professional experience of many of us, the British explosives sector looked quite different to the industry we have today. Many manufacturing processes involved significant manual intervention by operators, under close supervision. The workforce was relatively large: sites employing 2,000 to 3,000 people were scattered around the Country. Between the workforce and management, there was significant experience of handling a wide range of explosives and although some of this experience had been bi/er, occasionally involving serious accidents, even this was retained in the corporate memory and often influenced subsequent behaviours in a positive way.

RECENT DEVELOPMENTS :

Over the last twenty or so years, there have been many changes in the explosives sector: new products and materials have been brought to the market and new manufacturing processes have been introduced, e.g. the manufacture of ammonium nitrate-based emulsions which can then be transported to the user site as non-explosive and sensitized as they are pumped into the shot-hole. Whilst these sorts of product have been often described as lower risk, we should recognize that this is achieved by reducing the likelihood of a mass explosion involving such products, rather than significantly reducing the explosion hazard itself.

Over the same period of me we have seen fireworks with mass explosion hazard, propellants containing high explosives constituents and propellants incorporated into pyrotechnic compositions. At a me when levels of experience and competence have been declining throughout the sector, we have increasingly seen the blurring of the traditional concepts of primary and secondary explosives, or of high and low explosives, meaning that technical knowledge is at a premium when hazards need to be assessed in an actual industrial activity. Whilst the explosives sector in the 21st Century has less human intervention in manufacture, and hence fewer people at immediate risk from process hazards, the losses of experienced, knowledgeable staff over the last twenty years may well be seen as contributing to the accidents occurring now. As a regulator, we are seeing hazardous situations and accident causations today where the solutions were well known many years ago. There is an emerging belief that the sector's loss of competent staff has led to the repetition of old mistakes. There seems to be a corporate or sector amnesia about accident causation, made worse in a shrinking industry, by the apparent reluctance of some businesses to share information about good practice in managing safety and about those accidents or near misses which do occur.

A similar concern arises from some of our experiences with explosives site licence applications. It sometimes appears that businesses simply regurgitate explosives quantities and separation distances from published tables without really understanding the "basis of safety" e.g. in the configuration to be used in the process, how the explosives will behave in the event of initiation and how (or indeed whether) the structure and orientation of the building will mitigate the consequences.

THE VISION :

As someone who has either worked in or regulated the explosives sector for most of my 35 year career, my personal vision for the future is to see an explosives sector which:

- is safe and sustainable;
- uses and shares good practice;
- continues to make a key contribution to our society;
- employs competent, knowledgeable, professionals; and
- is influential in relevant European & World-wide developments.

THE REGULATORY FRAMEWORK :

The UK Government's position on the regulation of major hazards industries, which includes the explosives sector described in this paper, was set out clearly in a Ministerial Statement, "Good health & safety, good for everyone" [3], published in 2011. This confirmed that, "Hazardous industries are essential to our everyday life but have the potential to cause large numbers of deaths or injuries from a single event as well as potentially catastrophic long term impacts on society, the environment or the economy. The Government believes the regulation of these industries to be soundly based and in accordance with international best practice and does not plan to reduce the current level of oversight. However there will be a continuing programme of modernization of regulatory approaches. HSE will build on and expand its joint working initiatives with industry to promote better health and safety and pass on good practice".

Within this context, the challenges to all of us are:

- to ensure the sector operates safely with its smaller workforce (and hence smaller group of competent people);
- to share good practice and lessons learned in managing safety;
- to ensure legislation is relevant, future-proof and easy to understand;
- to ensure that regulatory activities are transparent, consistent and targeted and that regulatory burdens are proportionate to risk; and
- to maintain a successful key economic sector

HSE has begun to tackle these challenges through the development of the Explosives Sector Strategy, in 2010/11, and its delivery from April 2011 onwards. Progress so far, and next steps, will be described below. At the same me, IExpE has been developing a strategy for its own future activities, and it's clear to both HSE and the Institute's officers that there is real scope to link these strategies and make them complimentary.

The Explosives Sector Strategy has six aims, which can be summarised as follows:

1. A robust regulatory framework implemented through statutory "permissions", inspections, investigation and enforcement
2. Organisations demonstrating strong and effective leadership to set the right culture and ensure their major hazards are properly controlled
3. Major hazard duty-holders managing asset integrity risks, from both ageing facilities and new build assets
4. Duty holders able to provide assurance to themselves and others that major hazard risks are under control
5. Duty holders who are competent to manage their major hazards and a regulator able to meet its responsibilities
6. Industry and other stakeholders playing a greater role in driving forward improvements in major hazards control

The first Strategic Aim is one of the most pressing challenges for all of us: to rationalize and simplify the legislative package which applies to explosives in GB. HSE has established an Explosives Legislative Review (ELR) which is looking at the complete suite of explosives legislation for which HSE is responsible. There are currently twenty separate pieces of legislation, from Acts to Regulations to Orders. We aim to produce a single comprehensive set of regulations for true explosives and to split off the controls which currently regulate acetylene.

The target date for delivery is 2014 and the intention is also for an update of the current guidance and Approved Code of Practice to be in place by that deadline. Industry and IExpE have already provided much expertise, knowledge and experience to the ELR regulation working groups previously established; we will certainly be looking for a continuation of such input as we review the guidance on good practice

In spite of the very challenging programme of work and tight deadlines, ELR has already achieved some early successes through the support of businesses, Institute members and other stakeholders: in October 2011 the Classification and Labelling of Explosives Regulations (CLER) were revoked and largely replaced by an industry code of practice[4], which means that GB now relies solely upon ADR to regulate the transport of explosives by road. This has produced immediate savings for those who import explosives into GB from other ADR signatory states, but without reducing standards of safety. A further early success for ELR was the urgently needed amendment to the Identification and Traceability of Explosives Regulations (implementing the EU Track and Trace Directive) to give industry more me to comply.

In addition to updating the regulations and guidance, HSE is also working to improve the quality and efficiency of its "permissioning processes" (e.g. Licensing, classification etc.) and to enhance the transparency of its inspection activity. On the la/er, we are steadily introducing internal instructions, "Delivery

Guides", which summarise for inspectors what they should regard as good practice and what is unacceptable. These documents also link to HSE's enforcement decision-making guidance[5] and should drive even greater consistency between inspectors. Whilst these guides are internal documents, the intention is to make all of them publicly available on the HSE web-site's "Freedom of Information" (FoI) pages6 in due course.

The second Strategic Aim is targeted at ensuring that explosives businesses have strong and effective leadership, which sets the right culture and ensures that major hazards are properly controlled. The widely-accepted principles of good process safety leadership[7] have been published and Explosives Inspectors are now assessing the take-up of these principles during site inspections. There is a real opportunity for the industry associations and I.Exp.E to influence businesses in this aim, by fostering a culture of effective safety management amongst their members and by supporting those who work in the sector.

The third Strategic Aim recognises that many of the facilities still used within the sector date back to the 1930s and are being used well beyond their original design life. Given the often critical function of building structures in mitigating explosion effects, it is essential that businesses understand the basis of safety within their operations and can maintain the effectiveness of protection measures which rely on building integrity.

Equally, where new facilities are being built, these are often within very constrained sites: it is often not an option to push licence separation distances out beyond their current envelope and so structural engineering techniques are increasingly being used to justify the "unitisation" of hazards and enable the new facilities to be squeezed into Exlsting sites. In these cases, the new structures are even more critical to overall safety than when traditional, aggregated quantitiy/distance approaches are used and HSE has worked with industry to produce new guidance on making, and assessing, what are termed "structural justifications"[8].

Strategic Aim four seeks the development and use by businesses of meaningful safety performance indicators to provide the assurance that their risk control systems are appropriate, are in place and will work when required. HSE has previously published HSG 254 [9], a piece of guidance on the development of process safety performance indicators, whilst an example specific to the explosives sector was published[10] following research carried out on our behalf by the Health and Safety Laboratory. An industry-led group was also established during 2011 to share experience and good practice in the development of performance indicators relevant to explosives businesses.

It is our view that the development and use of performance indicators is a prerequisite for the effective management of major hazards, and particularly so for sites which are subject to the Control of Major Accident Hazards (COMAH) Regulations. Explosives Inspectors are now actively assessing the take-up of such measures as part of their routine COMAH site inspections.

The fifth Strategic Aim will certainly not be news to those who have been around the industry for any length of me. It follows the widespread concern in recent years at the loss of competent staff from across the sector. The aim is to ensure that organisaons and their workforces are competent to manage the major hazards they create – and that the regulator has staff who are competent to regulate. Within GB, a great deal is being done, prompted and supported by I.Exp.E, to improve the management of competence.

National Occupational Standards (NOS) are in place for many safety-crical roles with the explosives industry and training is being developed and delivered, to match the needs of businesses. Within HSE we have also recognised the value of the NOS and have incorporated the principles of the safety management NOS within our own competence framework for explosives inspectors. Whilst we don't see the role of Explosives Inspectors as routinely assessing the competence of specific individuals, we do expect every business to have a competence management system proportionate to their needs. Inspectors are currently assessing such systems against expected standards and a Delivery Guide[11] has been published to assist this work specifically in relation to COMAH sites. An equivalent Delivery Guide for non-COMAH sites is under consideration.

Strategic Aim six underpins most of what has gone before. It was one of the key aspects of the 2009 Strategy "Be Part of the Solution". Under this aim, the sector itself will take greater ownership of safety; it will not wait for HSE to determine priories or develop standards but will voluntarily share knowledge and good practice.

Discussions are already under way with senior managers within the sector, with a view to establishing a group to take forward this aspect of the Strategy. I also see the expert working groups, recently established under the Sector Skills Strategy Group, as being a significant force for the sharing of knowledge and good practice. This article has described some of the safety challenges facing the explosives sector in the 21st Century and set out the strategy, agreed between HSE's Explosives Inspectorate and industry representatives, to address those challenges. Good progress has been made in the initial delivery against that strategy but more remains to be done. I firmly believe that success can be achieved and that the explosives sector has a strong and safe future, but this will rely on more and better co-operaon and collaboration between all stakeholders in the sector, whether they be regulators or regulated, business leaders or workers, or bodies such as SAFEX or the Institute of Explosives Engineers, which set out to improve knowledge, competence and standards of professionalism throughout the industry.

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BLASTING PRODUCTIVITY IMPROVEMENT AT HEAD RACE TUNNEL IN HIMALAYAN ROCKS

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ABSTRACT

The rapid growth of transportation and power sectors in India is demanding accelerated progress in tunnelling work. This ever increasing need for rock excavation for tunneling motivated the author to develop new underground blasting techniques with simple modifications in the conventional explosive loading patterns. The new tunnel blasting techniques include in-hole delay cut blasting and bottom hole decking. The in-hole delay cut technique involves inserting multiple delay detonators in cut holes to improve the solid blasting efficiency. The bottom hole decking technique involves inserting air-deck at the bottom of the blastholes by means of a plastic spacer at the bottom of the hole and the remaining portion of the hole is conventionally charged. These techniques were successfully applied at Lohari-Nag Pala Hydroelectric Power Project (LNPHEPP) and the overall improvement achieved in pull per round was 90-95%. This new cutting technique also resulted in reduced ground vibrations by 30 to 45%, which resulted in reducing rock mass damage. These techniques resulted in substantial improvements of pull and productivity and reduction of specific charge and overbreak in both hard and medium hard rock formations of tunnels.

Key Words: Tunnel blasting; In-hole delay cut; Bottom-hole decking.

1.0 INTRODUCTION :

Unlike opencut excavations, blasting technology in underground excavations are constrained with many restrictions like physical confinement, charge limitations and strata control problems. It is high time to concentrate upon underground blasting technology as greater proportion of world's annual tunneling is still achieved by drilling and blasting. The tunneling by drilling and blasting method has an unmatched degree of flexibility and can overcome the limitations of machine excavations by Tunnel Boring Machine (TBM) or roadheader. High advance at the minimum cost remains a general objective of tunnel blasting. However, the priorities among the various elementary tunnel blast results, such as the specific explosive consumption, the specific drilling, the pull and the overbreak / underbreak, may vary from site to site depending on the geo-mining conditions. A trend has been set world wide not to consider the blast results in isolation but in totality with due consideration to the priorities. Decisions to modify the blast pattern or minor change in tunnel configuration may be undertaken with this view to finally optimise the blasting practice. Rosenstock et al. (1994) observed that the charge and drilling requirement with parallel cut, which produced 70 per cent pull on an average, were more than those with convergent cut. According to Pokrovsky (1980) the pull that can be achieved in most of the rock mass is 95% of the blast hole depth.

The progress per round cannot be achieved more than the width of the tunnel in conventional blasting methods as it induces excessive confinement. This problem was overcome by in-hole delay cut blasting technique, which **involves inserting multiple delay detonators in cut holes to improve the solid blasting efficiency.** The chances of explosive malfunctioning in solid blasting due to close proximity of charges. Katsabanis and Ghorbani (1995) found that the sympathetic detonation might occur if different charges are separated at less than 8 times the hole diameter. Ramulu et al (2005) applied the in-hole delay solid blasting technique successfully for blasting productivity improvement in coal mines.

There is a restriction for longer rounds of blasts in rock tunnels or drifts due to confinement proportional to area of cross section of the opening. However, plenty of new ideas and efforts are being experimented to improve the yield per blast round and implemented in coal and rock tunnels. It is known that in solid blasting, a cut is blasted initially towards which the rest of the shots are fired. The confinement, which is maximum in the cut holes in absence of any free face, is released to a great extent one the cut is developed and hence, the balance holes are blasted with minimized confinement. The efficiency of a blasting round vastly depends on the success of cut development. Wedge type cut prevails over others in India. Innovations in various explosive accessories like relays, shock tubes and others are applied in opencast blasting not yet introduced in underground metal mines due to field constraints. Considering these restrictions, blast rounds deeper than 3m, are not common in India. The pull to hole depth ratio also lies in a mediocre range of 0.6-0.7. The experience of the authors shows that maximum pull, in general, is 60-65% of the least dimension of the opening. Therefore, for 6m diameter tunnel the maximum possible pull in conventions means is 3.9m only. So attempts were made to increase pull by applying innovative and productive techniques.

2.0 IN-HOLE DELAY CUT BLASTING :

In view of the above conditions, an innovative in-hole delay pattern was implemented to improve the solid blasting efficiency. This essentially includes the use of multiple delay detonators in a single hole so that total permissible explosive quantity is distributed or segmented in different delays which are fired sequentially from the top, where the confinement is originally smaller, to provide less confinement to the charge being fired in the next delay situated in the bottom part of the hole and having originally a larger confinement. Further, multiple delays provide additional time for the burden to be displaced more efficiently. Though this type of delay arrangement may be tried in all the holes for better fragmentation and output, but is especially useful in the cut holes or toe holes, where the confinement is larger than other holes in a round, to reap the major benefits in case of limited availability of delay detonators. The technique is briefly explained in Figure 1, which resembles to the in-hole delay initiation method used in opencast blasting.

This novel technique has been filed for patent and it was granted recently (IPMD, 2004). The uniqueness of the technique is that it abides by all the existing safety criteria and uses the conventional electric delay detonators, without demanding for extra resources. As the confinement in the cut holes are maximum and the blast performance in the underground openings depend mainly on the development of the cut portion, the in-hole delay were used only in the cut holes. The salient features of the in-hole delay pattern are:

a) The collar portion of the hole was blasted prior to the bottom portion. Thus, the confinement at the hole bottom Was less during firing.

b) Mid-column decking between the two charges in a hole was kept at least 0.6 m to avoid sympathetic detonation. This decking provided confinement for the bottom charge.

c) The top charge column should be charged conservatively on higher side than that of hole bottom charge column

d) The top charge column should be fired before the bottom charge column.

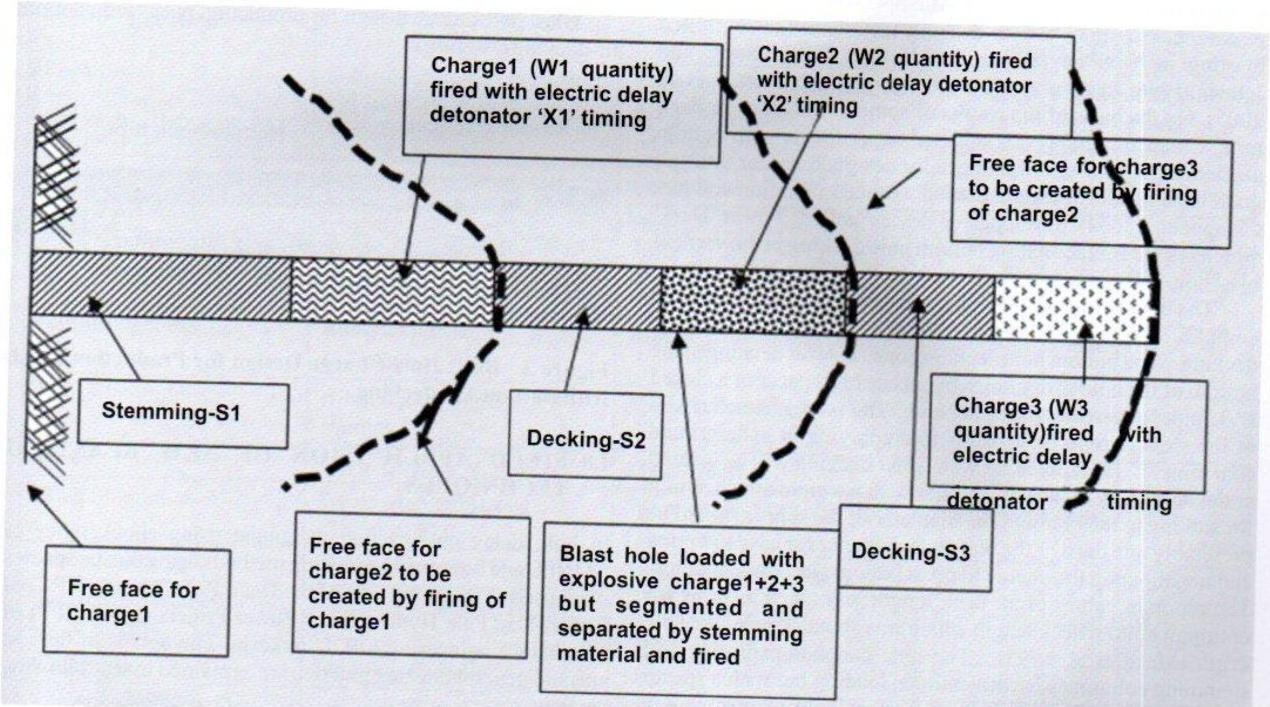

Figure 1- In-hole Delay Solid Blasting Technique a Schematic Diagram

3.0 BOTTOM HOLE DECKING TECHNIQUE :

The author experimented a blasting technique called 'bottom hole decking technique' to achieve the objective of blasting productivity improvement of the mining industry. The technique consists of air decking at the bottom of the blasthole in dry holes by means of a wooden spacer or a closed PVC pipe. Although, practice of air decking is not new thing, the concept of inserting bottom hole decking below the explosive column is relatively new. Explosives provide a very concentrated source of energy, which is often well in excess of that required to adequately fragment the surrounding rock material. Blast design, environmental requirements and production requirement limits the degree to which the explosive energy distribution within the blasthole can be significantly altered using variable loading techniques. Use of air-decks provides an increased flexibility in alteration and distribution of the explosive charge in blast holes. Mel'Nikov (1940) and Marchenko (1954)extensively conducted air deck blasts which demonstrated the transfer of explosive energy to the overall burden was due to the repeated action of the products of detonation on the walls of the charge chamber. The conventional middle air decking has got some limitations and cannot be universally applicable to all types of rock mass and materials (Mead et al, 1993). Instead of middle air decking, insertion of decking at the top of the blast hole resulted in improvement of blast performance in terms of better fracturing (Chiapetta, 1987; Sastry, 2001). Attempts were made by Indian researchers to apply the air-decking technique for controlled blasting as well as production blasting (Chakraborty and Jethwa, 1996; Jhanwar et al, 1999; Sastry, 2001; Ramulu et al, 2005). On the basis of the results of some of the early air deck tests, Chiapetta (2004) conducted experiments with bottom air-decking by means of a specially designed spacer and got good blast results of fragmentation, reduced vibration and toe. Chiappetta (2004) developed a device called 'Power Deck' which is used for facilitating bottom hole decking in the vertical blast holes of opencast mines.

The bottom hole air-decking was developed to simplify the complex charging procedure, associated with middle air decking. . The bottom hole decking consists of air decking at the bottom of the hole in dry holes by means of a spacer or a closed PVC pipe, covered at the upper end. The fume characteristics of the spacer are to be tested before applying in underground coal mine. If blast holes are wet, water decking will be created at the bottom by means of a spacer with a weight attached to it for sinking to the bottom. The diameter of the spacer should be preferably one third of the blasthole diameter for easy lowering and not allowing the charge to go to bottom side while loading. The reported values of air-deck length was taken as basis for optimum bottom deck length which was about 10% of the hole depth (Mead et al, 1993). The hole contains explosive and stemming column as in conventional loading but with a spacer at the bottom. The principle of bottom hole air decking in achieving optimum explosive energy interaction on rock mass is given below:

- Reduced shock energy around the blast hole due to cushioning effect of air decking, which otherwise would result in crushing.
- Explosive energy-rock interaction is more at the bottom due to relative relief zone existing at that zone.
- Effective toe breakage is due to striking and reflection of shock waves at the bottom face of hole

The procedure and sequence of blast hole loading and initiation for the bottom hole decking are given below:

- Inserting the spacer into the hole bottom by a stemming rod.
- Loading the primer explosive cartridge attached by delay detonator charging the column charge conventionally
- Stemming of the hole by proper stemming material, preferably by sand mixed clay cartridges or coarser sand cartridges.

The advantages of the bottom air decking technique in comparison to the conventional middle air decking are given below:

- The highly confined toe is free of explosive charge but exposed to high concentration shock energy, resulting in good toe breakage and low vibration intensity.
- The reduced overall peak shock reduces the back break and damage.

Blast hole charge design for production blasts with bottom air-decking is Figure 2.

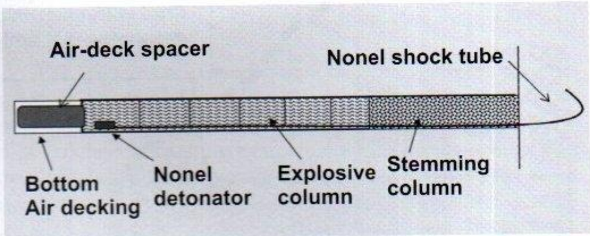

Figure 2 - Blast Hole Charge Design for Production Blasts with Bottom Air-decking.

4.0 FIELD APPLICATION OF NEW BLASTING TECHNIQUES :

In hole delay cut blasting technique using shock tubes of NONEL and bottom hole decking methods using plastic spacers were used at the down side of the Head Race Tunnel (HRT) of Lohari-Nag Pala Hydroelectric Power Project (LNPHEPP) of M/s Patel Engineering Ltd, Uttarkashi. The details of the test site and general blasting practice are explained in the following sections.

4.1 General :

LNPHPP is located in the Central Crystalline of Higher Himalayan Zone and situated in Uttarkashi District of Uttarakhand State about 230 km from Rishikesh on National Highway No.108 . The Project of 600MW capacity is located on the right bank of Bhagirathi River. The location of the site falls at a Longitude of 78.53°E and Latitude of 30.25°N. This infrastructural project comprises of construction of 73.40 m wide Barrage across river Bhagirathi. The major underground structures under excavation include Head Race Tunnel (HRT), Power House and Tail Race Tunnel (TRT). The HRT is of 14 km long and 6.0 m diameter with horse-shoe shape on the right bank of river meant for water transmission to the Underground Power House.

5.0 GEOLOGY OF THE EXPERIMENTAL SITE :

The slab of the Central Crystallines has been thrusted southward along the Main Central Thrust (MCT) over the quartzite and volcanic of Berinag Formation of the Lesser Himalayas or rock belonging to Garhwal Group. The Garhwal Group towards north is followed by the Central Crystallines which have been divided into three zones i.e. Upper Crystallines, Middle Crystallines and Lower Crystallines. Garhwal Group towards north is followed by the Central Crystallines which have been divided into three zones i.e. Upper Crystallines, Middle Crystallines and Lower Crystallines. The main rock type of powerhouse complex is schistose gneiss and augen gneiss with abundance of mica and geotechnically the rock mass is negotiating in "Fair Category" and it's having three prominent joint sets. The main two joint sets intersecting at right angle which makes wedge continuously. Some weak zone/clay filling, altered rock, sheared rock mass and excessive flow of water at places makes the rock poor. In maximum area it is found that the regional trend of foliation is perpendicular to the tunnel alignment, another joint which is intersecting the foliation at right angle and creates wedge on roof. The strike of the foliation is going through along the tunnel alignment which is geologically not favourable because of probabilities of plane failure and wedge failure in presence of heavy joint planes. The detailed geological information is given in Table 1. The density of schistose/augan gneiss was 2.7 t/m^3 and uniaxial compressive strength was 40-60 Mpa.

Table 1 - General Geological Information.

Location	Crown to Spring level (Both Sides)	Below Spring level (Left-side)	Below Spring level (Right-side)
Rock type	Schistose/Augen gneiss with alternative mica	Mica schist with alternative bands of quartz	Schistose/Augan gneiss with bands of mica and quartz
Critical joint angle	$50^0/52^0$, $210^0/50^0$	$095^0/55^0$, $175^0/45^0$	$095^0/55^0$, $175^0/45^0$
Seepage	Moderate	Continuous	Occa sional
Wedge portion	Crown	None	Walls
Spacing	6-20, 20-60cm	6-20, 20-60cm	<6, 6-20cm
Opening	0.25-2.5mm	0.25-2.5mm	0.25-2.5mm
Joint Roughness	Rough, Planar& Undulating	Rough, Undulating	Smooth, Undulating
Joint Alteration	Altered joint, highly staining	Moderately altered walls	Moderately altered walls
Type of Filling	Mica, Quartz	Mica, Quartz	Quartz
Rock Strength	Weak-Medium strong (25-50MPa)	Weak-Medium strong (25-50MPa)	Weak (5-25 MPa)
Nos. of Joint Sets	Three joint sets + Random	Three joint sets + Random	Three joint sets + Random
Degree of Weathering	Slightly Weathered Rock	Moderately-Highly Weathered	Moderately Weathered
Water Inflow	Dripping (Low)	Damp	Seepage at places
Rock mass quality Q	1.53-3.04 Poor rock	0.86-1.14, Poor rock	1.15-3.04, Poor rock
Rock mass Rating (RMR)	46-49, Class III, Fair	37-44, Class IV, Poor	52-57, Class III, Fair

6.0 DETAILS OF BLASTING :

The tunnel was excavated with heading and benching simultaneously by using drilling and blasting method. Rocket boomer was used for drilling of blast holes of 45 mm diameter. Wedge cut blasting pattern was adopted with a maximum hole depth of 3.5m for the tunnels of 42m^2 area of cross section. The specific charge was varied depending on the static and dynamic properties of rock. The explosive used was cartridged emulsion with 80% strength. Long delay detonators from 1 to 10 were used to fire various rows in different delays. The maximum charge per delay used in the blast round was 32 kg in the bottom holes and total charge per round was 224.8 kg. Total number of holes used was 96 which include 13 dummy holes at the crown periphery of the tunnel line. The specific charge used for Schistose/Augen gneiss was 1.88 kg/m^3. The progress per round with this blast pattern was observed as 2.75 to 3.0m out of 4m effective depth of blast round at both upside and down side of the HRT. Attempts were made to get more pull at the upside of the HRT by applying the in-hole delay cut technique and succeeded in getting maximum pull of 3.8m which is about 95% of the blast hole. The trial blasts were also conducted with longer holes of 5.85m length at the down side of the HRT aiming at longer pulls with in-hole delay cut blasting technique. The in-hole delay cut pattern is shown in Figure 3 and the blast pattern practiced for the full face tunnel blasting at HRT is shown in Figure 4. The charge details of cut pattern are given in Table 2. The blast design and output parameters before optimization are given in Table 3.

Test blasts were conducted to optimize the design parameters and improve the blasting productivity. The experiments were conducted under similar rock conditions and explosive parameters. Blast design parameters were modified to get maximum pull and minimum overbreak. Test blasts were conducted by applying the in-hole delay cut blasting in the first stage and the bottom hole decking in the second stage.

Table 2 - Burden, Spacing and Charge Configuration of the Blast Holes in the Cut

Short delay No. (25ms delay)	Square Number	Burden, m	Spacing, m	No. of holes	Charge /hole, kg	Total charge, kg
1	I	0.15	0.2	4	4	16
2/3	II	0.2	0.4	4	8.5	34
4/5	III	0.35	0.75	4	8.5	34
6/7	IV	0.45	1.2	4	8.5	34

Table 3 - Optimised Blast Design and Output Parameters at the Gneiss Rock Mass

Sl No.	Parameter	Value	Value
1	Diameter of blast hole	45mm	45mm
2	Depth of blast hole	4m	5.9m
3	Total no. of blast holes	96	96
4	No. of relief holes (Ø=89mm)	3	3
5	Charge per round	224.8kg	216.8kg
6	Maximum Charge per delay	40 kg	32 kg
7	Velocity of detonation	4000 m/s	4000 m/s
8	Specific charge	1.78 kg/m^3	1.4 kg/m^3
9	Specific drilling	3.0m/m^3	2.0m/m^3
10	Pull per round	2.7-3.0 m	5.5-5.6 m
11	Pull to hole depth ratio	0.6-0.7 (60-70%)	0.95 (95%)
12	Blast vibrations (at 30m)	7.6 mm/s $[V=1124(D/^{3}?Q)^{-2.3}]$	3.75 mm/s $[V=810(D/^{3}?Q)^{-2.1}]$
13	Overbreak	0.3-0.6m	0.15-0.25m

7.0 TEST BLAST RESULTS :

The test blasts on optimization by applying new controlled blasting techniques yielded encouraging results. The overall improvements in the blast performance are given in Table 3. The tunnel profile with visible half-casts resulted due to application of the above said innovative blasting techniques are shown in Figure 5 and 6. The following inferences are made from the outcome of test blasts:

i) In-hole delay cut blasting resulted in maximum pull of hole depth with pull to hole depth ratio of 0.95-0.98, i.e. 95-98% of the blast hole.

ii) Bottom hole decking with spacer of 0.30 m (PVC pipes) in periphery holes resulted in reduction of overbreak by 0.25-0.3m and substantial reduction in the intensity of ground vibrations.

iii) Application of the productive and controlled blasting techniques resulted in improvements in pull by 2.5-3.0m, decrease in specific charge and specific drilling by 0.4 kg/m^3 and 1 m/m^3. There was substantial reduction in ground vibrations from 7.5mm/s to 3.85mm/s at 30m distance.

iv) The application of innovative and productive techniques yielded 47-48% more pull than the conventional methods.

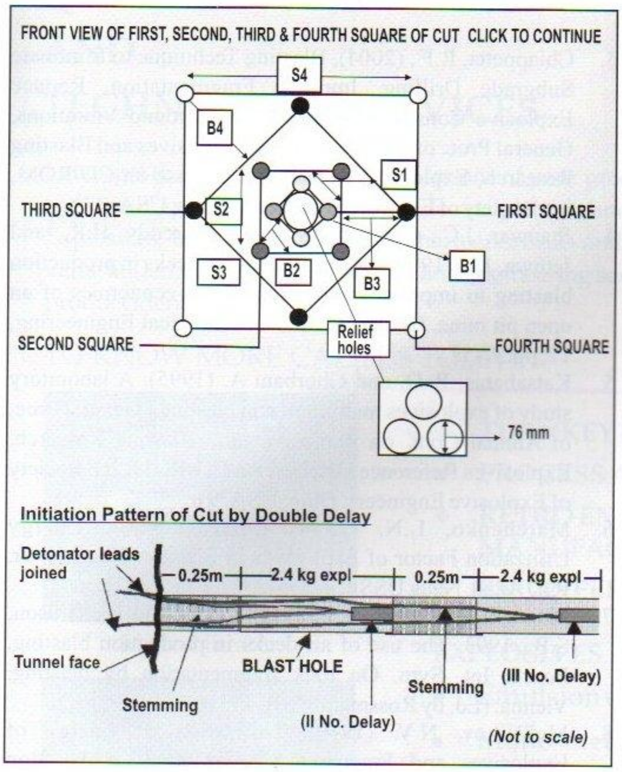

Figure 3 - In-hole Delay Cut Blasting Pattern

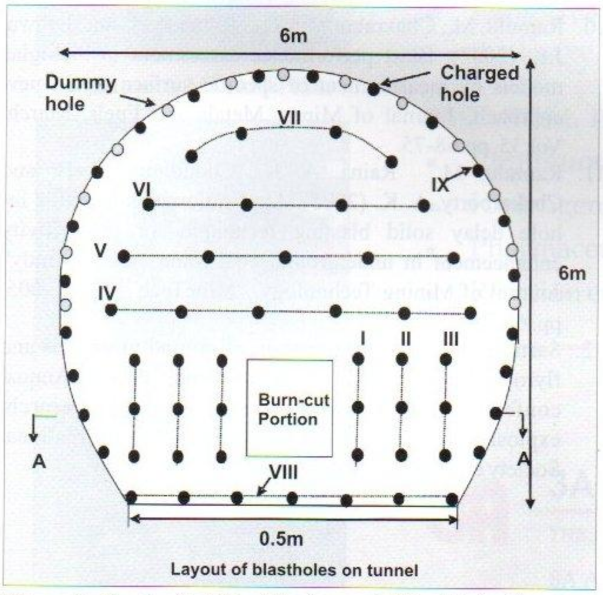

Figure 4 - Controlled Blast Design and Blast Hole Geometry for HRT, LNPHEPP.

Figure 5 - Tunnel Profile with Minimum Overbreak after Application of New Blasting Techniques at LNPHEPP

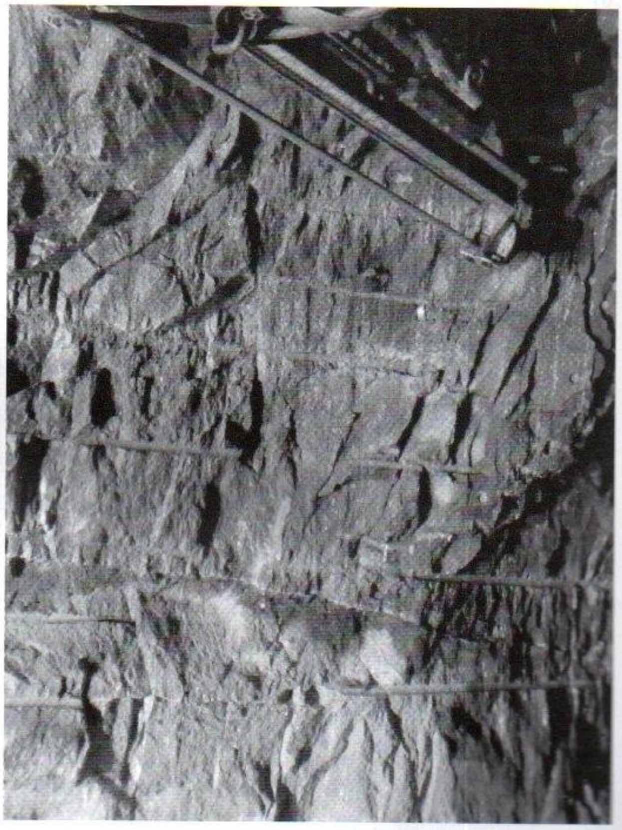

Figure 6 - Tunnel Profile with Maximum Half-cast Factor after Application of New Blasting Techniques at LNPHEPP

8.0 CONCLUSIONS :

The in-hole delay cut blasting and bottom hole decking techniques were applied successfully at LNPHEPP using shock tube detonators and PVC spacers to optimise blasting productivity. The technique deploys multiple NONEL delay detonators in a hole, which adds time for the burden displacement, to partition the total charge and firing sequentially from collar to bottom in order to provide less confinement for the bottom charge to pull a greater depth. With 6m deep rounds, the improvements observed in all the blast performance indicators like pull, specific charge and specific drilling. The pull/progress per round was improved by 93-95%, specific charge was improved by 23% and specific drilling was improved by 33%. There was an added advantage of reduction in ground vibration by 49-50%, which obviously results in improving ground control and roof support aspects of underground mine. The overbreak/sidebreak was also reduced by 50-58% due to the increase in relief and reduced vibration.

9.0 ACKNOWLEDGMENTS :

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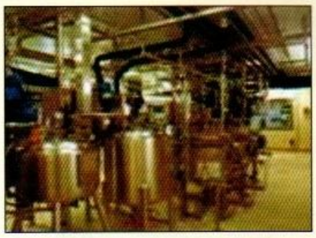

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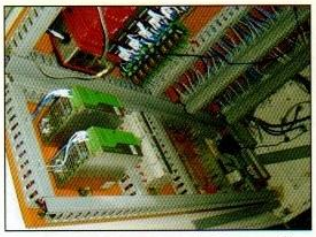

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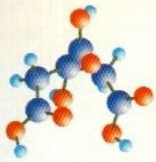

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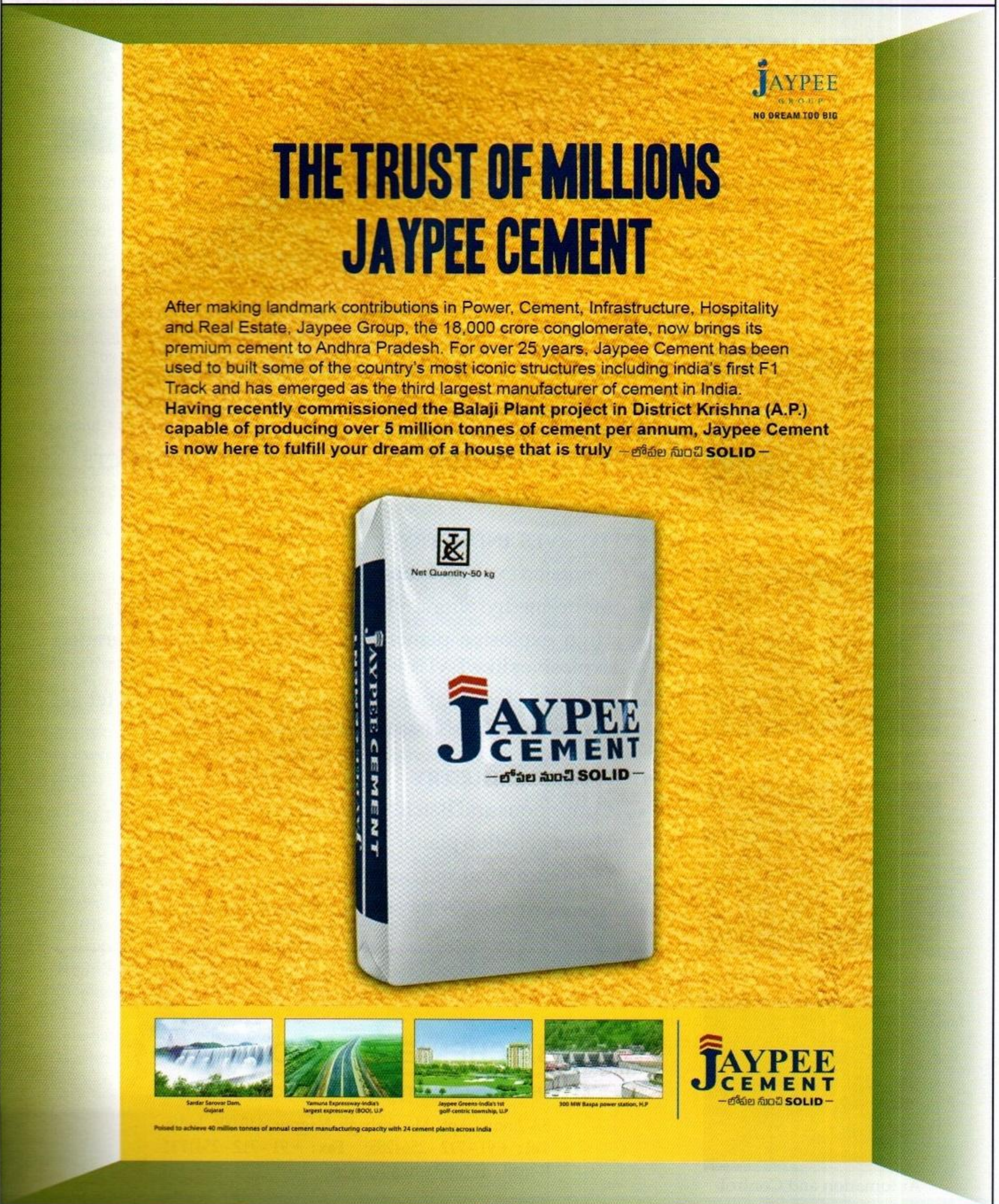
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SAFETY ASPECTS AROUND DELIVERING EMULSION TYPE EXPLOSIVES TO THE WORK FACE UNDERGROUND

Dr. Andre Pienaar
Chief Technologist
AEL Mining Services, South Africa

1.0 INTRODUCTION :

AEL Mining Services, a member of the JSE-listed AECI Group in South Africa, is a leading developer, producer and supplier of commercial explosives, initiating systems and blasting services for mining, quarrying and construction markets in Africa and Indonesia. AEL is also the largest supplier of explosives technology and initiating systems in Africa.

Emulsion explosive technology is solidly embedded into the product offerings that AEL provides to its customers. During the last 30 years numerous variations on the standard product offering have been developed. These variations include long shelf life products, cap sensitive emulsions for underground applications, permitted products specifically intended for use where the risk of methane gas explosions are a problem, sticky formulations for up-hole development as well as formulations where a high percentage of used oil is utilized in the production of the emulsion explosive.

A lot of information is currently available with regards to safety issues around the manufacturing, handling and transport of emulsion explosives. Generally in the Western World Explosive manufacturers conform to the UN test requirements to ensure that they have an in depth understanding of the safety limitations within which they need to operate. The UN Test series no 8 is traditionally used to obtain information regarding the thermal stability of newly developed emulsion formulations. This together with the Koenen test provides suppliers with sufficient information to know how to transport their products safely. The Minimum Burning Pressure (MBP) is specific to each formulation and is dependent on raw materials used within the formulation. Knowing the MBP of an emulsion explosive is crucial for the safe handling of that specific product. Specifically when the pumping of emulsions is involved, the MBP offers a guide to the high pressure trip settings as well the rating of the bursting disks that need to be used. No flow and temperature trips add to the pumping safety of these products.

However, recently AEL has been challenged with a different problem. Underground bulk emulsion explosives are normally delivered in 30 ton tankers to the various mines within South Africa and other parts of the world. The base emulsion is stored in surface silos at the mine from where it is distributed for use in the underground operations. Various methods are used to transport the emulsion underground. Some shallow mines drive out their charging units to refill them on service. Other mines make use of transfer cassettes which are loaded onto a dedicated vehicle that transports the emulsion to a dedicated area underground,yet others use the shaft to transfer the explosives to the underground workings. All these methods are costly and time consuming and thus increases the load on the logistical management of the product. In deep level underground mining the shaft is often the only means of transporting people, material, equipment and explosives to the underground workings. The shaft is also used for the removal of waste and ore to surface for further processing. It is desirable to minimise the amount of shaft time required for the transportation of the bulk explosives to the workings.

It was therefore decided to investigate a more elegant and cost effective alternative for the transport of the base emulsion. A vertical pipeline, which connects the surface silo to the underground operation, was invisaged as shown in Figure 1. An innovative development by AEL to deliver emulsion explosives in a pipe down a borehole to the underground workings was considered. At first glance this seemed relatively simple but the R&D team soon learned that various additional factors had to be overcome. This work led to the development of intellectual property and know-how in order to do this safely.

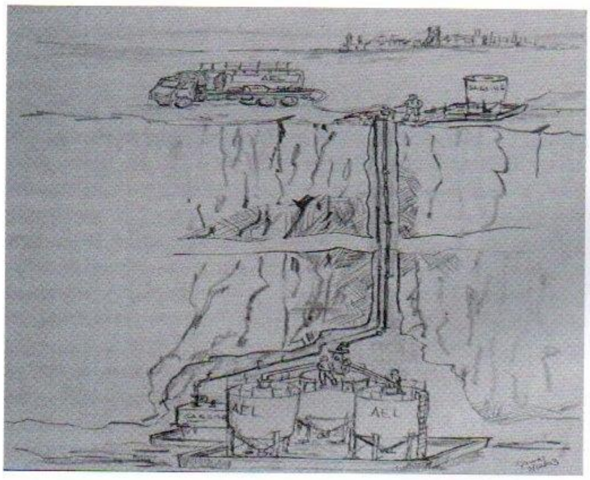

Figure 1 - Schematic Representation of a Vertical Transfer

2.0 UNDERSTANDING AND PREDICTING THE FLOW OF EMULSIONS :

Emulsion explosives by their very nature exibit non-Newtonian flow behaviour when they are subjected to shear. In more simple terms this means that emulsions do not flow like water, which is considered to be a Newtonian fluid. A better understanding is required in a special scientific field known as Rheology, which focuses on developing an understanding the flow behaviour of various materials. To this end AEL approached the Cape Peninsula University of Technology (CPUT) for some help in this regard.

After some extensive research work a theoretical model was developed which could predict the flow of emulsion via a pipeline over a pre-determined distance. This simplistic model took the following variables into account:

- rheology of the product,
- pipe diameter,
- input pressure,
- pressure drop along the pipe, and
- flow rate and the angle of the pipe.

The next challenge was to find a venue where the validity of the theoretical model could be tested.

An opportunity arose at Doornbosch mine (Figure 2) in Steelpoort to investigate the vertical drop of an underground base emulsion. The surface silo was located 42 meters above the underground loading station. A steel pipe had already been installed.

Initial calculations, from the rheological data of emulsion performed by CPUT, indicated that a transfer rate of 5.00 tonnes/hour could reasonably be expected with a free flowing system. The surface silo was filled and on the 7th of March 2008 R&D representatives witnessed the first vertical tranfer of emulsion explosives. It was found that the model provided a fair representation of the flow of the emulsion through this specific installation.

Initial rheological measurements and droplet size determinations indicated very little modification of the product during the transfer operations. It was demonstrated that a vertical transfer was equivalent to one pumping stage during normal operations.

The layout of the system used at Doornbosch was not designed by AEL from the onset. The start-stop flow of emulsion was controlled with a valve at the bottom of the transfer. Subsequent risk assessments has highlighted the risk of having emulsion explosives in a steel pipe under constant pressure as a high risk situation that needs to be avoided if at all possible. However, at Doornbosch mine at a maximum depth of 42 meters a pressure head of 4.6 Bar could be expected which is much lower than the MBP of the emulsion explosive. It was however decided to try and avoid a similar situation with subsequent installations.

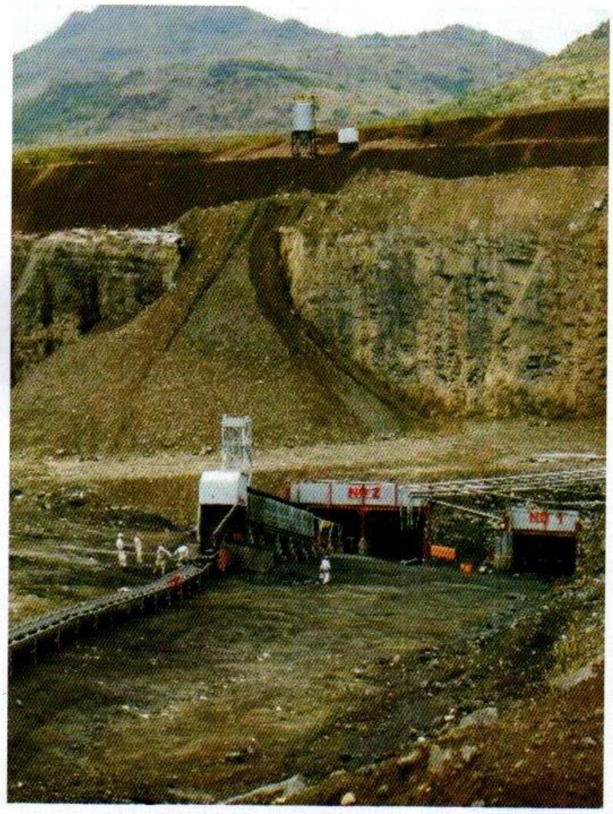

Figure 2 - Doornbosch Mine Layout

3.0 UNDERSTANDING THE RISK ASSOCIATED WITH AN INSTALLATION :

The similarity between a vertical drop and pumping of emulsion explosives during handling, manufacturing and transport has prompted us to engage in various risk assessments and perform a number of Hazop studies. From this extensive work we have identified a number of key factors that need to be addressed in order to deem any installation safe.

Firstly, the vertical drop of the emulsion is product specific. The rheology of the product needs to remain fairly constant. If the formulation is changed and the rheology affected the pipe diameter used in the installation might pose a safety problem (Figure 3). If the pipe diameter is too large the product goes into a "free-fall" situation. This results in the formation of a vacuum in the pipe. The structural characteristics of the pipe will then determine if the pipe will implode or not. If the pipe diameter is too small, the product will stop flowing or will flow at a reduced rate. This could have a significant impact on the operations. The inclusion of various sensitizers into the product, the fuel phase and or oxidizer make-up has a direct influence on the MBP of the product. This will determine how far the product can be transferred vertically. With a permanent installation care should be taken to ensure that the MBP of the product being transferred is not exceeded at any stage during the transfer operations.

Figure 3 - Emulsion Spillage

The material of construction of the pipe used for the transfer also needs to be considered (Figure 4). Steel offers a strong, durable and robust alternative at a price. The installation of bursting discs needs to be considered if a steel pipe is to be used to ensure that the pressure within the pipe remains below the MBP of the product at all times. Plastic on the other hand ensures that confinement, especially with underground fires, becomes unlikely and the whole pipe acts as an effective bursting disk.

Figure 4 - Transfer in Progress

The location of the transfer line also offers various challenges. Initially AEL has opted to only consider borehole installations. The risk associated with an installation in a shaft was deemed too high to allow us to consider this option.

The next transfer challenge came when the management of Bathopele Mine approached AEL at a time when they were considering an installation of a vertical transfer between 100 and 500 meters. The calculations and predictions were performed on the emulsion explosive that this mine was using at that time. After careful consideration and a mine specific risk assessment a borehole of 207 meters was drilled which allowed for a plastic pipe to be suspended within this hole. Three underground silos (Figure 5 & 6) were installed with this system. Product delivery was done via a tanker offloading directly into the pipeline and no valves were allowed on the transfer line.

This system was brought into commission in April 2011 and has been used since then to transfer the emulsion for the mine to the underground workings. Subsequent visits to this mine to monitor the installation has indicated a small amount of build-up of product inside the walls of the transfer pipe but until today no serious maintenance work has been performed on the installation.

This success has gone a long way to prove that the vertical transfer of emulsion explosives can be performed on an industrial scale. It is AEL's belief that they have gained the know-how and ability to design similar installations to a maximum depth of 500 meters.

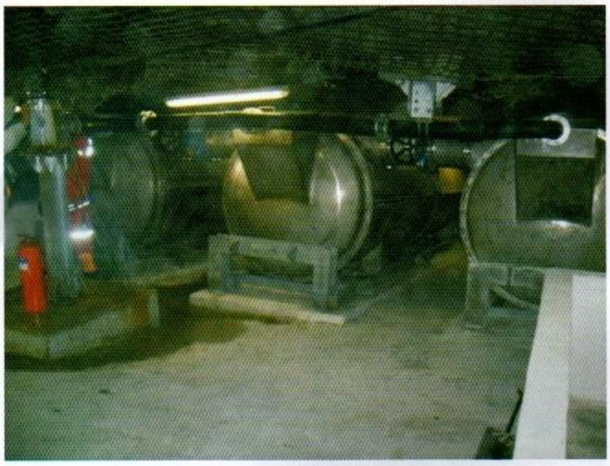

Figure 5 - Underground Silo Arrangement

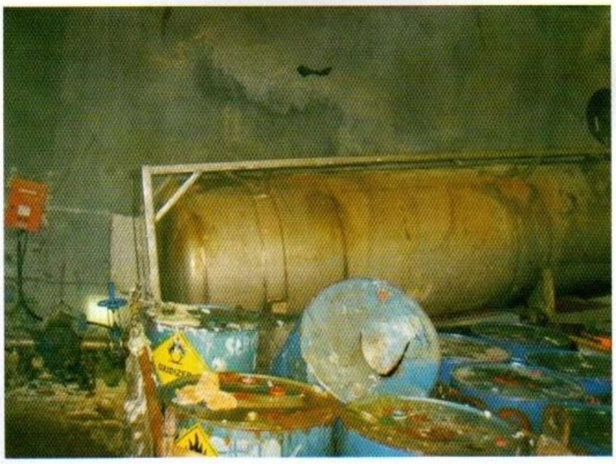

Figure 6 - Underground Silo for Emulsion

In the beginning of this article it was mentioned that at first glance the transfer of product via a pipeline to the underground workings seems relatively simple. Some mines in South Africa have forged ahead and taken things into their own hands. The following couple of pictures are examples of situations where this has happened and where things have gone wrong. Fortunately no serious injuries were incurred but the situation led to the mine being closed down for a period of time until the situation was rectified.

Understanding the risks together with the physical properties of the product being transferred results in the design of a system that offers seamless inventory control of your explosive product. AEL's R&D department believes that through time and effort they have developed an in depth understanding of the risks that need to be addressed. We would furthermore be happy to assist customers who wish to explore the delivery system as part of their solution to deliver their explosives to the underground workings.

4.0 CONCLUSIONS AND RECOMMENDATIONS :

AEL believes that they have come a long way towards understanding the risks associated with these installations. AEL is currently liaising with various Universities and consultants in order to develop the predictive model even further.

Challenges in the mining environment never cease to exist. AEL has been approached to investigate the possibility of transferring our explosive products to an underground level 3000 meter below the surface. We have accepted this challenge and we are considering various possible options that can be followed to make this operation possible.

APPROACH TO URBAN EXCAVATION WITH SPECIAL REFERENCE TO METRO RAIL



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ABSTRACT

Growth in infrastructure projects in India has created huge scope for excavation activities throughout the country. One of the major activities in any city is the development of public transport and metro rail is the most preferred one. The underground component of metro rail predominantly constitutes the tunnels and the stations in soil and hard rock. This paper deals with the methods for excavation in urban area and the means to control the adverse impact of blasting. A case study on the excavation at Bangalore metro is presented.

1.0 INTRODUCTION :

Economic growth and migration of people to urban destinations for employment is providing a huge scope for increase in infrastructure projects. This in turn is having a cumulative effect on the transport system in the cities. Traditional public transport in any of the cities has been the local bus or a sub-urban train which have already reached the saturation point. Considering this, it is essential that alternate means of public transport needs to be developed that does not over load the existing roads or the rail links. In general, Metro rail and mono rail systems compete / supplement each other in case of urban mass transport. Various departments of National Institute of Rock Mechanics (NIRM) have been associated with the Metro projects in India and the Rock Blasting and Excavation Engineering department has been associated with the works related to Bangalore Metro Rail Corporation Limited (BMRCL) and Chennai Metro Rail Limited (CMRL). This paper deals with the approach for the excavation of components related to metro rail.

2.0 COMPONENTS OF A METRO RAIL :

A metro rail requires the tracks to be laid for the movement of the trains, access points like the stations, service areas etc. These components can be above ground or below ground or in transition. The main components of a metro rail are:

- Track area Elevated or Underground
- Station area Elevated or Underground
- Transition areas Interface between the elevated section and the underground section
- Depot Ground level

The elevated sections are predominantly civil construction for laying the tracks and these are RCC structures over piles and pillars. The surface stations are also elevated and very rarely at the ground level. Due to space constraints and aesthetics in some locations the stations are constructed below ground (in front of Vidhana Soudha in Bangalore, opposite Chennai central railway station etc). Similarly, sometimes in busy areas too stations are constructed below ground (city railway station in Bangalore etc). Though the cost variation is almost five times as compared to surface construction, underground stations have the advantage of retaining the surface for the use of the public. For the trains to ply, tunnels have to be excavated below ground. The transition between the elevated section and the underground section shall be partly on the ground and partly below the ground and this section could be cut and cover. Most of the metro tunnels are excavated by Tunnel Boring Machines (TBMs) and certain secondary excavations by drill-blast method (D&B). However the access shafts and the stations if in rock are excavated by D&B.

3.0 TUNNELLING IN URBAN LOCATION :

Tunnelling can be carried out by the conventional D&B method or by mechanical methods like TBMs, road headers etc. The choice of method depends on site geology and project-specific conditions, such as the length and cross-section of the tunnel. In case ground vibrations are not a concern then D&B method of tunnelling is preferred over mechanical excavation. Despite having certain drawbacks like rigidity in the shape of the tunnel (only circular) and fixed tunnel size for a machine, TBMs have proved effective in excavating tunnels in urban environment. Changing rockmass conditions hamper the progress of the tunnel with TBM as in adverse geological conditions they were found to get struck up at the face. The advantage with TBM is the concurrent lining which shall arrest deformation and depletion of water table. The Downtown Line (DTL) Stage 2 tunnel Project for Mass Rapid Transit line (MRT) in Singapore is an example of tunnel excavation with TBMs. It totals 16.6km in length and includes 12 underground stations, running under some of the busiest urban corridors within the city and densely populated residential areas. D&B method was employed in some areas for the auxiliary excavations. This is similar to what was done at the Delhi Metro excavations. The underground section of the Bangalore Metro project comprises two corridors the east west and north-south. The tunnels in these corridors are of 4.45km and 4.37km in length and are being excavated using TBMs. Similarly at the Chennai metro project, tunnels are being excavated with TBMs. The Stockholm Northern Link project being excavated for the underground expressway consists of twin, parallel 3-lane main tunnels and a complex of junctions, inlets and exits, it includes a total of 11km of tunnels, 9km of which are in rock. These tunnels are being excavated by D&B method. Over one million m^3 of rock has been blasted in this project. Scheduled to open to traffic in 2015, the Northern Link's tunnels run beneath a variety of urban environments, including public institutions, residential and commercial properties, and an important city-state park (Jonson, 2012).

4.0 STATION BOX EXCAVATION :

To create any underground facility like the metro station, the site involves the removal of soil/rock to the desired depth (may be <30m). The station width could be about 30m and its length could be about 400m. Conventionally the excavations of this size are undertaken by one of the two prevalent methods, namely top down method and bottom up method (Figure 1). The major considerations for the choice of them is the width of the excavation, depth of the excavation, hydrogeology, strata condition (rock/soil), highwall support design, availability of space for movement of HEMM, requirement of the surface space for immediate use (urban logistics), population and traffic density, speed of construction etc. conventional methods of excavation for station box excavations

Bottom up method is the most simple excavation approach in urban conditions for both soil and rock. This method shall enforce traffic restrictions and lead to congestion etc. In case the excavations are to be done in rock, say the top soil is about 3m below which there lies a rock strata and that the depth of required excavation is beyond the soil then it becomes difficult to remove the rock by conventional soil excavation machines like hydraulic excavators, grab (in case of embedded boulders in soft soil) etc. Under these conditions it becomes essential that the rock strata is to be removed by other means by deploying breakers, pyro-techs, splitters, manual rock breaking by feather & wedge, diamond saw cutters, rippers, chemical expansion compounds, plasma blasting, hydro-fracturing, jet cutting etc (these methods are termed as alternate to blasting). These techniques have limitations and are effective in concrete, limited quantities of rock removal and in reasonably weathered rock conditions etc. When the rockmass is extremely hard and the production requirements are high then under such conditions many alternate means to blasting have proved to be ineffective and rock blasting becomes the most preferred method. Blasting is, however, associated with certain adverse impacts like ground vibrations, air overpressure and flyrock.

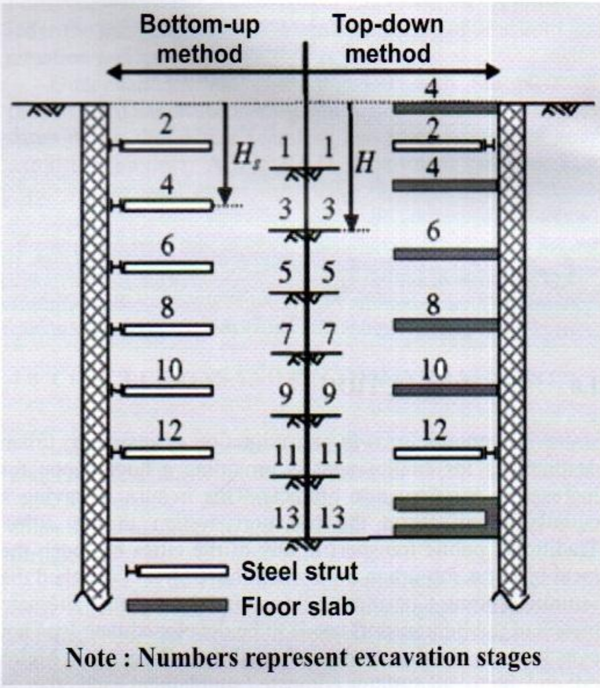

Figure 1 - Construction Sequences for Two

Top down method is the most preferred and suited method in soil as it helps in simultaneous construction above and below ground for minimising the construction time. Generally in top down method the excavations do not go beyond the rock strata and the column foundations are erected over the competent rock strata. While adopting top down method in soil, due to limited investigations of the site, it is assumed that the rock strata shall not be encountered till the depth of the excavation. But in reality, rock strata is encountered at a much higher level than predicted and this poses serious excavation problems. Adoption of Top down method in hard rock with blasting is an extremely difficult task and it gets compounded if the quantity of hard rock to be removed is high. Excavation in hard rock with top down method leads to a situation where in blasting is to be carried out under more or less a closed confined conditions below an immediate RCC roof. Though the construction design provides openings at specified locations for the entry of men and machinery, it is to be established whether these openings suffice to bring down the rapid gas pressure exerted on the concrete slabs while blasting the rockmass and whether these slabs are safe from the exerted pressure. This condition can be viewed similar to blasting in a partially closed vessel. Due to this situation there shall be limitations on the quantity of explosive that can be used at a time and that in turn affects the planned production target. Moreover the ventilation of the noxious gases/fumes from the explosives too becomes difficult in top down method with blasting. However, under compulsion, an integrated approach with very light blasting and secondary breakage with alternate means could be adopted. This approach shall be slow, expensive and needs caution. Under these conditions it is better to choose bottom up method.

5.0 GROUND VIBRATION LIMITS :

Different countries adopt different standards of safe limits of vibration. In India, the permissible ground vibration for different types of structures for mining is specified by Directorate General of Mines Safety (DGMS), which considers PPV and the frequency of ground vibration for deciding the permissible levels (Table 1). These standards (Anon 1997) are adopted by NIRM while considering blasting applications in civil engineering projects for arriving at permissible limits for various structures as the response of structures due to blasting does not change with reference of the purpose for which blasting is carried out. However, Gupta et al (2013) report that the frequencies in the mining blasts are different from that of the construction blasts. They state that though, both the blasts are characterized by same peak particle velocity, a structure with fundamental frequency of about 10Hz would respond to the mining blasts with relative displacement of about three times that of typical construction blasts as mining blasts, in general produce much higher structural response in the low frequency range (about 4 25Hz) compared to construction blasts.

Table 1 - Permissible Peak Particle Velocity (mm/s) as per DGMS, India (Anon 1997)

Type of structure	Dominant excitation frequency, Hz		
	<8	8-25	>25
Buildings/structures not belonging to the owner			
Domestic house (Kuchha brick & cement)	5	10	15
Industrial Buildings (RCC & framed structures)	10	20	25
Objects of historical importance & sensitive structures	2	5	10
Buildings belonging to owner with limited span of life			
Domestic house (Kuchha brick & cement)	10	15	25
Industrial buildings (RCC & framed)	15	25	50

The frequencies due to construction blasts are generally beyond the frequency range of most civil engineering structures which can be gainfully used in defining the safety criteria for construction blasts (Gupta et al. 2013). During the monitoring of ground vibrations at Sir M. Visveswaraiah station (Sir. M. V. station) box area (bottom up method) at BMRCL site Balachander et al. (2011) observed that the frequency of the vibrations was above 25Hz (Figure 2) and in conformity with the observations of Gupta et al (2013).

Considering the recorded frequency at the BMRCL site the permissible particle velocity as per the DGMS circular happens to be 15mm/s. In order to ensure the vibration levels to be within the suggested limit the maximum charge per delay was computed for a vibration level of 10mm/s at 50% confidence level so that this will take care of the scatter and still ensure the vibrations are within 15mm/s.

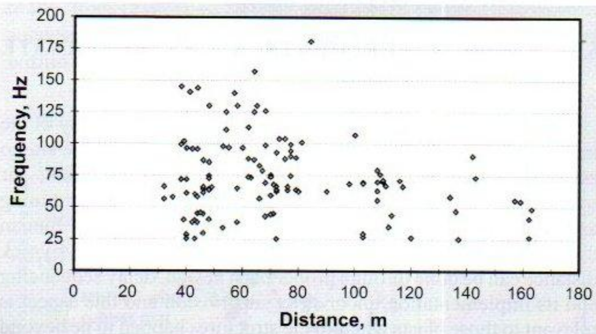

Figure 2 - Recorded frequency of ground vibration at BMRCL sites

During the excavation of the TBM launching shaft for Tan Tah Kee Station, Singapore, rock was encountered at a depth of 13m below the ground level and another 10m had to be excavated in order to reach the final depth. The blasting area was located in close proximity to a junior College and Bukit Timah road with Duchess Road, sub-station and canal situation just outside the boundary of the construction site. The total excavation volume was in the range of 7000m^3 and the rock excavation depth being 1214m. The total blasting area was divided into smaller blasting areas which had a maximum of 30 blast holes each depending on the location of each blast. The main aim was to keep the blast at each excavation level to a minimum so that the maximum charge per delay was within acceptable limits to avoid high vibrations to surrounding structures and buildings. Furthermore, to ensure that the structures are not subjected to heavy impact from the blasting, the blast direction was designed away from these structures of concern. The permissible vibration limits followed in case of this Singapore project was 300mm/s for the Earth Retaining Stabilising Structures (ERSS) and 15mm/s for residential buildings and buried utilities (Manolas and Arusu, 2012).

Rock excavations for Stockholm City Station, Sweden was carried out under and over T-Centralen, the central underground metro station. The approach tunnels had to cross under existing metro tunnels in an area of high horizontal rock stress with as little as 3m of rock cover, extremely close to sensitive installations. In order to control vibrations within a permissible limit of 100mm/s when blasting as close as 10m from an existing heating-supply tunnel electronic initiators had to be used. While blasting close to a multi-modal interchange the vibrations were limited to 50 to 60mm/s. In some zones, even controlled blasting was abandoned and while the excavation reached almost at about 3m to an existing metro platform, it was decided to crack and break up the face mechanically. For the tunnels directly passing under Gustav Vasa Church a permissible limit of 18mm/s were set with an "alarm" level of 13mm/s. In practice, the PPV values in the service and rescue tunnels were limited to 1317mm/s (Jonson, 2012). It can be observed from the above review that the vibration limits for urban structures are lying close to about 15mm/s.

6.0 FIELD EXPERIMENTS AT AN ALTERNATE LOCATION:

Before starting the full scale blasting operations at any of the metro sites it is essential to conduct trials at an alternative site to establish initial baseline data with regard to vibration, air overpressure and flyrock distances. Blasting in general for mining and hydel projects are carried out beyond 500m from human dwelling, public roads, utilities, offices, etc. Control of flyrock distance can be done through proper blast design, delay sequencing and its implementation under strict supervision and this aspect is relevant to those blasts wherein the structures happen to be beyond 100 to 150m. However, in case of urban blasting considering the proximity to offices, houses, structures, public roads, utilities etc, flyrock needs to be controlled well within short distances. In order to do so additional measures to physically arrest flyrock by muffling/covering the blasting area by heavy rubber mats/wire rope mats needs to be done. Human beings are more sensitive to ground vibration and noise than structures. People inside buildings will respond differently than people outside. People tend to complain about ground vibrations even below the accepted damage level because of many reasons. One of the most important factor is the presence of secondary sounds, such as rattling windows and doors. The threshold of perception for ground motion (without sound effects) is roughly 0.51mm/s (Anon, 1998).

For excavation of the proposed underground stations for BMRCL, blasting of hard rock was carried out at different locations in the heart of Bangalore city (Figure 3). As the critical distances from the blasting sites varied from 20 to 125m it was planned to conduct mock blasting experiments at an alternate site in an aggregate quarry near Bangalore with similar rockmass conditions. In total three blasts were monitored using ten seismographs placed at different distances ranging from 5m to 60m.

Considering the frequency of ground vibration monitored at the alternate site (>8Hz and <25Hz) and the structures around the metro sites, the corresponding permissible vibration levels of 10mm/s was arrived (Table 1) as per DGMS norms, India (Anon 1997). The derived predictor equation shall be used to compute the maximum charge per delay till such time the site specific predictor equations are established for each station area. For this permissible limit of 10mm/s vibration it was found that the vibrations attenuated below this level beyond a distance of 20m at the alternate site (Figure 4). The maximum charges per delay used during these trials were 0.5 and 1.0kg. Considering this 20m as a safe distance it was decided not to carry out blasting closer than 20m from any structures till site specific observations were made at the actual metro blasting sites (Venkatesh et al. 2008). The measured air overpressure levels are shown in Figure 5. It can be observed that the air overpressure level was invariably above the permissible level of 133dB.

Figure 3 - Blasting Close to Residential Structures at City Railway Station

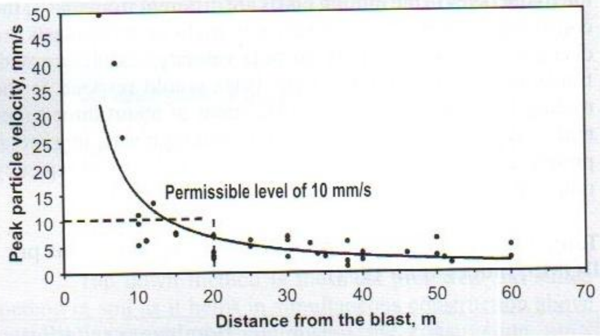

Figure 4 - Attenuation of Peak Particle Velocity with Distance an Alternate Site

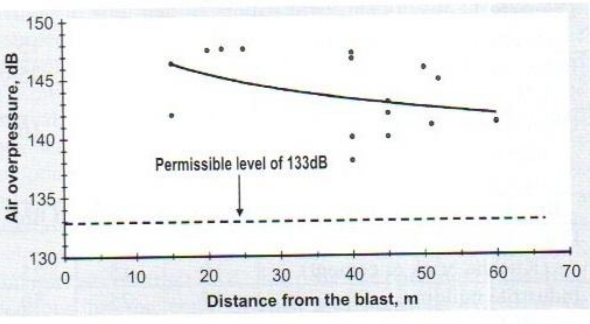

Figure 5-Measured Air Overpressure at an Alternate Site

Experiments conducted in a surface coal mine showed that the intensity of air overpressure levels from the detonating cord (covered or uncovered) are significantly greater. Therefore, while blasting close to built-up areas, trunklines of detonating cord should not be used. If the detonating cord is the only available device, the air overpressure level can be reduced by 15 to 16dB by covering it with soil (Adhikari et al. 2002). Keeping this in view, it was concluded that the air overpressure levels could be controlled within the permissible limit by various site-specific muffling techniques and choice of an appropriate initiation system. However it was decided that one more set of experiments at an alternate site shall be conducted to ascertain the methods proposed to control air overpressure and flyrock could actually control them to the desired levels.

Two trial blasts (one box cut and another bench blasting) were conducted at an alternate site to assess the efficacy of suggested muffling on mitigation of flyrock distance and air overpressure levels. Ground vibrations were recorded for both the blasts at distances ranging between 5m and 40m and at this site too it was found that the vibrations attenuated below the limit of 10mm/s within a distance of 20m. Both blasts were muffled with rubber blasting mats. Orange flags were placed at 10m and green flags at a distance of 20m from the blast on four sides to observe the flyrock travel distance (Figure 6). The blasts were recorded and analysed in slow motion. The analysis of these blasts showed that the flyrock was within 10m. The air overpressure levels during mock blasting and actual blasting were plotted (Figure 7) and it can be observed that they are within the permissible limit of 133dB.

Figure 6 - Observation of Flyrock using Flags at Predetermined Distances

7.0 CASE STUDY :

As part of the excavation works to be carried out in connection with proposed under ground stations for Bangalore Metro Rail Corporation Limited BMRCL, blasting of hard rock was to be carried out at different locations in the heart of Bangalore city. Controlled blasting operations had to be carried out keeping the Adverse impacts like flyrock, ground vibration and air overpressure within the stipulated limits. Excavation was carried out for the East West corridor at Cricket stadium, Vidhana Soudha, Sir. M. V. station and City Railway Station. The tunnels are being made by tunnel boring machines while some of the underground stations are excavated by D&B method (bottom up method). In general, each station box is about 20m wide, 272m long and 20m high. Based on the site specific ground vibration studies, condition of the structures and the prevailing norms, a permissible limit of 10 mm/s was decided. The suggested muffling in conjunction with heavy rubber blasting mats restricted the flyrock distance within 10m. The blasthole diameter was restricted to 45mm while the maximum charge per delay was kept below 2.5kg. The specific charge was between 0.5 and 0.6kg/m^3. Bench heights were gradually increased from 1.5 to 3.0m and a production higher than the targeted production of 300m^3 per day was achieved many times (Figure 8). In total about 500 controlled blasts were successfully conducted to excavate about 35,000m^3 of hard rock within the city of Bangalore during the study period.

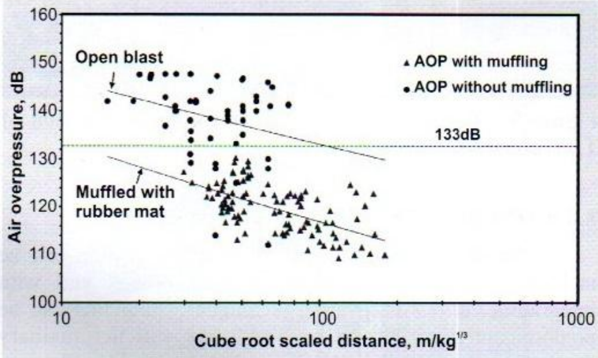

Figure 7 - Recorded Air Overpressure Levels without and with Use of Rubber Mats as Muffling Material

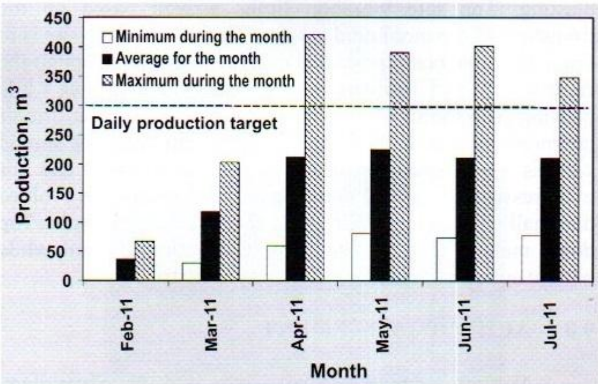

Figure 8 - Consolidated Production Details during the Investigation Period at Sir. M. V. Station

Controlled blast designs and the guidance on sequencing of benching operations facilitated BMRCL to that extent that the excavation of a launching shaft for the TBM at Sir M V Station area was not necessary. This had brought down the need for hard rock excavation and also saved time as the TBM launching could be done from the station area itself (Figure 9).

Figure 9 - Face made in the Station area for Launch of TBMs for Twin Tunnels

8.0 CONCLUSIONS AND DISCUSSIONS :

Various components of an urban excavation can be tackled by choice of appropriate methodology and with integrating various excavation techniques. Tunneling can be predominantly carried out by TBMs but still the auxiliary excavations need to be done by other means like blasting, splitting etc. The vibration standard applicable to structures as recommended by the Directorate General of Mines Safety was adopted to ensure safe excavations in urban environment by blasting. The safe vibration limits arrived based on the frequency of the monitored blasts at Bangalore metro site is in line with those being practiced in other countries. Though the control of flyrock happens to be the most challengeable while blasting in proximity to structures, equally of concern are the air overpressure levels. Muffling in urban environment should address two aspects namely control of flyrock and air overpressure. Integrated muffling methods need to be evolved that shall reduce the muffling time and give desired results. Top down method is more suited for excavations in soil while bottom up method is suited for excavation in rock.

9.0 ACKNOWLEDGEMENT

We are extremely thankful to Mr. N. Sivasailam, Managing Director, Mr. B.S. Sudhir Chandra, Director of Projects and Planning, and Mr. N.P.Sharma, Chief Engineer, UG, BMRCL without their active involvement and support the project at BMRCL not have been successfully completed. We thank Mr. Y. Raghavendra, Project Director, SOMA, for his keen interest in awarding the project and for his ever extended co-operation and support. Our thanks are due to Mr.Ken Wong, Project Leader, CEC-SOMA-CICI Jv for his co-operation. We are thankful to Mr. Nigel Butterfield, Project Manager, UG, Mr.Y.Tezuka, CSE, UG, Mr.K.V.V.Ramana Murthy, CRE - GC to BMRCL for their kind cooperation and technical discussions. We are thankful to Director, NIRM for permitting to publish this paper.

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ABSTRACT FROM SAFEX NEWS LETTER NO. 43, 4TH QTR. 2012 : "GREENER" DETONATORS USING NICKEL HYDRAZINE NITRATE (NHN), PREMIER EXPLOSIVES LTD, INDIA

INTRODUCTION

Historically detonators used mercury fulminates as the primary explosives. Being ultra sensitive to friction and impact, it was replaced with a combination of lead azide (LA) and lead styphnate (LS) along with a small quantity of aluminium powder. This is commonly known as ASA.

ASA had been a common primary explosive since its advent some 70 years ago. Though safer than mercury fulminate, ASA is quite sensitive to friction, impact, static electricity, etc. Our observation is that most of the untoward incidents in the detonator production process occur during handling, drying and manipulation of lead azide, lead styphnate or ASA. There have been efforts all over the world to develop a safer molecule or a mix to replace LA, LS or their combination.

A primary explosive needs to be sensitive enough to initiate a detonator but at the same me it should also be safe enough during manufacture. These are conflicting requirements making it difficult to find an alternative. The primary explosive charge in a detonator is initiated by the flash from the squib or fuse head, then starts deflagrating before evolving in a reliable detonation that sets off the base charge of the detonator. Nickel hydrazine nitrate (NHN) has been identified as a suitable replacement for LA and LS as well as ASA in detonators.

PROPERTIES OF NHN

NHN is a bright purple coloured and free flowing powder having the following Properties:

Molecular Formula	$N_i H_{12} N_8 O_6$
Formula weight	278.69
Colour	Purple violet
Crystal density (g/cm^3)	2.1
Nickel content (%)	21.16
Hydrazine content (%)	34.46
Nitrate content (%)	44.47
Nitrogen content in co-ordination sphere (%)	30.25
FTIR peaks, (cm^{-1})	3238, 1630 (NH_2); 1356, 1321 ($-NO_3$)
Moisture content (at 333K for 10 min) (%)	0.34
Average mol wt of combustion products	27.35
Percent condensable Ni (l)	18
Oxygen - fuel ratio	0.8571

With a decomposition temperature of over 2000 °C, it is a stable compound. The NHN synthesised at Premier Explosives has a polycrystalline structure and is almost spherical in shape (see Figure 1). It is free flowing and amenable to the dosing and consolidation required during the manufacture of detonators. In in-house testing at the laboratory of Premier Explosives, NHN was found to be less sensitive than ASA in friction sensitivity with 50g torpedo released at 80° angle as shown below:

- NHN: 50% Ignition height = 40 - 45 cm
- ASA: 50% Ignition height = 15 cm

DETONATOR PERFORMANCE—NHN v ASA

Being relatively insensitive to impact and friction, NHN has lower capacity to move from deflagration to detonation. A longer column is, therefore, required to achieve full detonation. However, under optimum conditions it has a higher VOD compared to other primary explosives. VOD of various primary explosives are compared in Table 1. The NHN detonators give a very reliable initiation of base charge and give equivalent or be/er dent in 3mm aluminium witness plate than that of ASA as Figure 2 illustrates.

Various products manufactured by Premier with NHN have been successfully qualified by Departmental Testing Lab of Petroleum and Explosive Safety Organization (PESO). Their effectiveness has been further upheld in actual use on the mines. After various tests, Premier's NHN - based detonators have been included in the list of Authorised Explosives by PESO.

Premier is now regularly manufacturing all types of NHN based detonators on a commercial scale. They are not only free of lead chemicals but safer too .

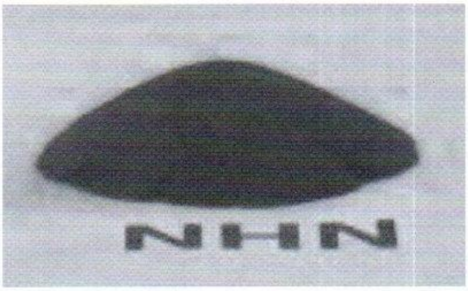

Figure 1 - Appearance of HNH Synthesised at Premier Explosives

Table - Comparison of VOD's of Primary Explosives

Compound	VOD m/sec	Density g/ml
LA	4630	3.0
LS	4900	2.6
DDNP	6600	1.5
NHN	7000	1.7
DDNP = Diazodinitrophenol		

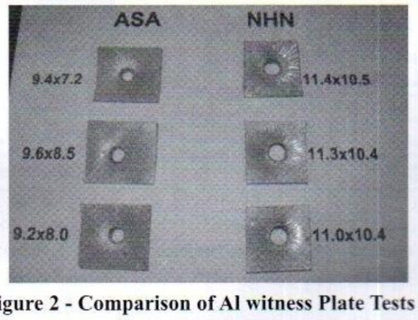

Figure 2 - Comparison of Al witness Plate Tests

TECHNOLOGY ABSTRACTS

SELECTED ABSTRACTS FROM THE PROCEEDING OF THE 10TH SYMPOSIUM OF ROCK FRAGMENTATION BY BLASTING (FRAGBLAST 10), HELD IN NOV. 2012 AT NEW DELHI, INDIA)

Publication of the abstracts duly authorized by the Editors Dr. Pradeep K. Singh and Dr. Amulendu Sinha, Central Institute of Mining and Fuel Research, Dhanbad, India.

SECTION 1 : KEYNOTE ADDRESS

INNOVATIONS IN BLAST MEASUREMENT: REINVENTING THE PAST

by
A.T. Spathis
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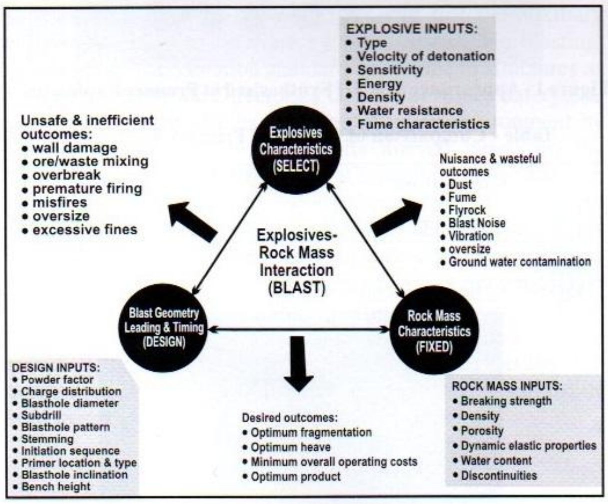
ABSTRACT

A blast is a dynamic violent event generated over a few seconds and involves detonation waves, shock waves, and gas expansion that interact to produce the rock fragmentation, rock movement, environmental effects, and rock damage to the remaining rock. The blast outputs influence the overall productivity of mining, quarrying and construction projects. This paper reviews measurement systems and transducers that help us understand the blasting process. The geology, geometry, and the explosive and initiation systems are the inputs used to target desired blast outcomes. Careful measurement of these inputs and the resultant outputs provide a rich data set whose careful analysis and interpretation enables better and smarter blasts. Measurement systems range from informed visual observation combined with sophisticated instrumentation of high dynamic range and fast data sample rates. Some of the measurement systems described are relatively new—most are evolutions of prior approaches.



Explosives-rock mass interaction (after Little and van Rooyen 1988)

Pre-blast	In-blast	Post-blast
Geology: Relevant dynamic rock characteristics Water Rock Structure	Detonation velocity Borehole pressure history	Condition of remaining rock Fragmentation Sizing: • Fines • Oversize • Intermediate
Explosives: Composition Density Uniformity Stability Sensitivity	Relationship between pressure behind and ahead of blastholes	Rockpile shape, looseness and movement
Blast Geometry: Hole profile Proximity of holes to surface, each other and rock structure	Pressure-time history with distance from hole	Depth of break
Initiation: Position Strength and orientation or primers etc. Robustness and accuracy of system	Effect of stress from multiple holes on development of fracture and movement	Fumes
	Effect of energy partitioning on different rock types	**Viability**
	Dynamic interaction of blastholes: • Sympathetic • Desensitizing • Timing	Loading rates Power/fuel consumption Wear and tear Production rates Drilling costs

Blast Monitoring Zones (after Cunningham 1990)

SECTION - 2
ROCK MASS CHARACTERISATION AND FRAGMENTATION

INFLUENCE OF INITIATION POINT POSITION ON FRAGMENTATION BY BLASTING IN IRON ORE

by

Y. Long, M.S. Zhong, Q.M. Xie, X.H. Li, K.J. Song & K. Liao
PLA University of Science and Engineering, Nanjing, China

ABSTRACT

Reasonable control of blasting fragmentation has direct influence on improving the efficiency and benefit of mining operation. Influence of the initiation point position on blasting fragmentation in iron ore is investigated in detail at the Dading iron mine, the largest open pit iron mine in Guangdong province of China. Pressure at the bottom of the blasthole is analyzed theoretically and compared for the different initiation point positions. Then, the blasting effects of the different initiation point positions in deep hole are studied by numerical calculation. Blasting experiments using top, bottom and central initiation were carried out in rocks formations with different iron content, testing theoretical calculations in a practical setting. The influence of the initiation position on blasting fragmentation in deep hole blasting is assessed from the comparative study of the results of theoretical analysis, experimental tests and numerical calculation. The results can be used to guide the blasting of iron ore in future projects.

(a) Results with top initiation (b) Results with bottom initiation (c) Results with central initiation

Blasting effect of different initiation.

CONCLUSIONS

1. The explosion load generated initially is higher when the top initiation technique is used, but decays quickly. When bottom initiation is used, explosion load is small, but the duration is longer. When central initiation is used, the instantaneous explosion load is higher than with bottom initiation, but the decay time is shorter, although there is a middle pressure plateau of short duration. Its effects are thus between those of top and bottom initiation modes.
2. The influence of the initiation position on the blasting effect is different with iron content. When the iron content is between 25% and 30%, the bottom and central position initiations have nearly the same effect, but the effect of bottom initiation is somewhat better, while top initiation gives the least satisfactory results. When the iron content is greater than 40%, blasting boulder yield is higher.
3. Bottom initiation technique in deep hole blasting in iron ore mining projects can reduce the blasting boulder yield and operation costs effectively, which can also avoid wasting resources in boulder crushing. This has important practical significance for reasonable mining and decreasing operation cost.

SECTION - 7
HEALTH, SAFETY & ENVIRONMENT

QUANTIFICATION OF THE LEVELS OF RISK OF FLYROCK

by
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ABSTRACT

Because in Europe and in many other countries as well every new project (quarry, mine, public work) needs a risk estimation to prove its feasibility, a model to estimate flyrock risks became necessary. This paper presents the basic hypothesis which should underlay such a model to estimate statistical flyrocks range for not only some single blasts but a whole project and in particular the way to take into account rockmass or blast pattern parameters variability. It describes a first usable quantitative flyrock model based on the characteristics of the blasting plan and of the generic laws utilised in casting and selective blasting operations and on a statistical approach of rockmass. In a second step, this paper discuss an approach of risks estimation compared to the classical one used in pyrotechnics studies for explosive magazine risks assessment.

ESTIMATION OF FLYROCK RANGE

The variability of rock mass confinement ability, of the thickness of rock confining explosive charges and of blasting situations prompted us to find a model that was both stable and simple to determine flyrock parameters. The formula put forward by Frank Chiapetta (1983) allows us to obtain a good estimation of the flyrock speed of the blocks coming from the face. It can easily be adapted for flyrock produced from the blasting surface. This formula is noted as follows:

$$V = K\left[\frac{B}{\sqrt[3]{E_i}}\right]^{-1.17}$$

here V is the flyrock speed expressed in m/s, B is the depth of the rock perpendicular to the explosive expressed in m, El is the linear energy of the explosive charge expressed in MJ/m and K is a coefficient expressing the probability of attaining the estimated speed.

This relation is dependant on the explosive energy being implemented, the rock depth and on coefficient K which represents the blasting situation, and particularly the rock mass characteristics, as in the coefficient in the laws of propagation of vibrations and airblast. Our own experiments lead us to slightly modify K factor from original one.

This approach of the rock can therefore be expressed through a statistic variation of the coefficient K. The first estimation of this variation was established assuming that there was a normal distribution of deviations around a mean value based on studies carried out in the United States since the 1980s: the evaluation of the speed of moving fragments from the working face through high speed imaging.

The variation of coefficient K varies depending on the level of probability according to a normal distribution. This variation is expressed in Table .

Any air drag is negligible. The movement illustrated in each block is therefore regarded as ballistic.

Table - Evolution of K with Probability

Probability of speed attainment	50%	5%	1%	0.1%	0.01%
K	14	25	32	40.7	50.4

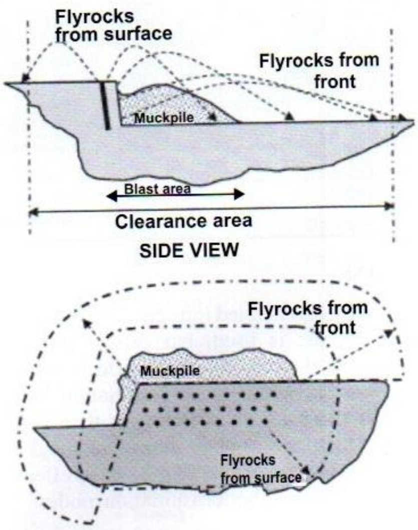

Figure - Areas affected by Flyrock Generated from Blast Faces.

ANALYSIS OF BLASTING RELATED ACCIDENTS WITH EMPHASIS ON FLYROCK AND ITS MITIGATION IN SURFACE MINES

by
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ABSTRACT

In India, around 90% of coalproduction comes from surface mines. In any surface mine, blasting plays a crucial role for production and explosives in large quantities are used for fragmentationof rock. Blasting practices provide quick, efficient and cheap over-burden removal compared to other processes. But only a part of the explosive energy is used in doing the useful work, the rest is consumed towards unwanted work such as ground vibration, flyrocks, noise and air blast. In surface mines there are many sources causing injuries and blasting is being one of them. Usually blasting related injuries are due to flyrocks, lack of blast area security, premature blast and misfire. Out of these, flyrocks and lack of security account for majority of total injuries incurred by blasting practices. Serious injuries and fatalities result from flyrock are usually caused due to improper blast planning, judgment, practices during rock blasting. This paper mainly discusses the accidents trend with emphasis on blast related fatalities, serious injuries in coal and non-coal mining sectors in India for last two decades, and also analyses the causative factors, and emphasizes preventive measures to be taken to avert such menace.

Table - Details of Accidents due to Explosive during 1996–2011.

Causes	No. of Fatal accidents		Fatalities	
	Coal mine	Non-coal mine	Coal mine	Non-coal mine
SBP	9	2	9	4
DHBP	7	9	7	10
SeBP	–	2		2
OP	5	21	7	21
M/S (WD)	2	8	2	8
M/S (OD)	1	4	1	8
DI	1	–	1	–
BTS	6	–	8	–
OEA	4	17	4	30
Total	**35**	**63**	**39**	**85**

Table - Year-wise Trend of Accidents due to Explosives in Coal Mines.

Year	Fatal accidents	Fatalities
1996	1	1
1997	4	4
1998	4	4
1999	5	7
2000	1	2
2001	2	2
2002	4	4
2003	3	3
2004	5	6
2005	2	2
2006	0	0
2007	1	1
2008	1	1
2009	0	0
2010	1	1
2011	1	1

Table - Year-wise Trend of Accidents due to explosives in Non-coal Mines.

Year	Fatal accidents	Fatalities
1996	2	5
1997	6	6
1998	3	4
1999	7	7
2000	5	5
2001	6	6
2002	8	11
2003	5	6
2004	3	4
2005	4	5
2006	3	3
2007	2	2
2008	2	10
2009	1	3
2010	3	3
2011	3	5

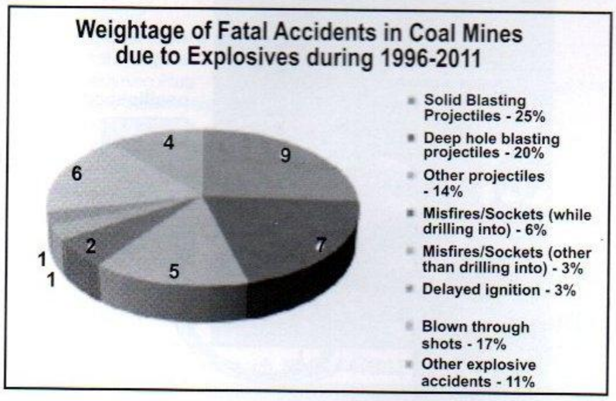

Figure - Pie Chart showing the Fatal Accidents in Coal Mines due to Explosives

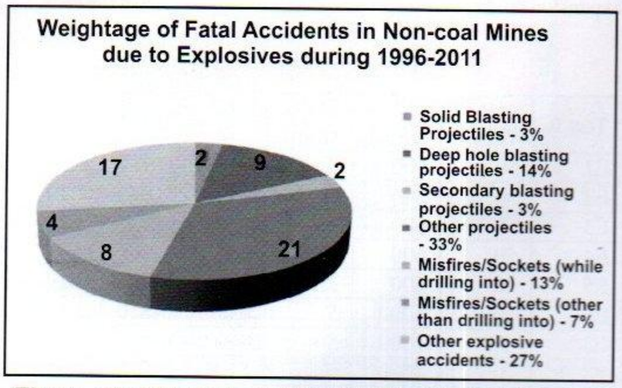

Figure - Pie Chart showing the Fatal Accidents in Non-coal Mines due to Explosives

SECTION - 8
INNOVATIVE BLASTING TECHNOLOGIES

EVALUATION OF ANFO PERFORMANCE WITH CYLINDER TEST

by
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ABSTRACT

Cylinder test allows knowing the expansion of a copper cylinder by the detonation of an explosive charge inside. This test, originally designed for high explosives, has been adapted for industrial explosives with non-ideal behavior. The cylindrical geometry of the charge, the expansion ratio, the Velocity of Detonation (VOD) and the behavior of the explosive are in line with typical conditions in rock blasting. Pins are located at different radial distances to record time-displacement curve, from which tube velocity is obtained. A total of 10 cylinder test were carried out: 5 with 50 mm diameter (C-50) and 5 with 100 mm diameter (C-100). ANFO with a charge density of 0.83 g/cm3, was located inside the copper cylinder with the VOD cable, so the tube wall expansion and VOD were measured simultaneously. The repetitively of the test can be considered satisfactory since the relative uncertainties obtained for Gurney energy, are 2.5% for C-50 and 3% for C-100. The influence of the diameter on cylinder test results has been investigated, concluding that diameter affects to the VOD and initial acceleration. Although both Gurney energy and Gurney velocity increases as the cylinder diameter does, no statistical differences between the means can be assessed.

TEST DESCRIPTION

A total of 10 cylinder test were carried out: 5 with 50 mm diameter (C-50) and 5 with 100 mm diameter (C-100). The explosive was ANFO with a charge density of 0.83 g/cm3. Cylinder dimensions, copper an explosive mass data are collected in Table 1. Soft free oxygen annealed copper EN 12449 was used for the tests.

The explosive charge is located inside a copper cylinder with the VOD cable, so the tube wall expansion and VOD were measured simultaneously. The charge was initiated with an instantaneous detonator and a 250 g pentolite booster in order to obtain a detonation as plane as possible. Two wooden discs were used to maintain the cylinder upright until detonation. Figure shows the test setup.

A set of 10 pins were radialy mounted on a pin support specially designed for the test. The contact pins, manufactured by Dynasen Inc. were connected to a pin-mixer which sends a signal to an oscilloscope each time the pin is ionizated. The distances from every pin to the original wall tube surface, Δr_y and the corresponding expansion ratios, v/v_0, are presented in Table *2* for each of the tests.

Table 1 - Test Parameters

Test #	*Di* (mm)	*L* (mm)	*s* (mm)	*C* (g)	*M* (g)	*M/C*
E1	50	600	2.5	952	2191	2.30
E2	50	600	2.5	955	2194	2.30
E3	50	600	2.5	955	2191	2.29
E4	50	600	2.5	952	2196	2.31
E5	50	600	2.5	952	2176	2.29
E6	100	1000	5	6390	14810	2.32
E7	100	1000	5	6412	14816	2.31
E8	100	1000	5	6405	14805	2.31
E9	100	1000	5	6394	14815	2.32
E10	100	1000	5	6409	14811	2.31

Table 2 - Pin Position and Expansion Ratio

Pin #	E1–E5		E6		E7–E10	
	Δr_y (mm)	v/v_0	Δr_y (mm)	v/v_0	Δr_y (mm)	*v/v0*
P1	0.5	1.04	0.5	1.02	0.5	1.02
P2	5	1.43	5	1.23	10	1.48
P3	10	1.93	10	1.48	20	2.04
P4	15	2.49	15	1.75	30	2.68
P5	20	3.12	20	2.04	40	3.40
P6	25	3.81	25	2.35	50	4.20
P7	30	4.57	30	2.68	60	5.08
P8	35	5.40	40	3.40	70	6.04
P9	40	6.29	50	4.20	80	7.08
P10	45	7.25	60	5.08	90	8.20

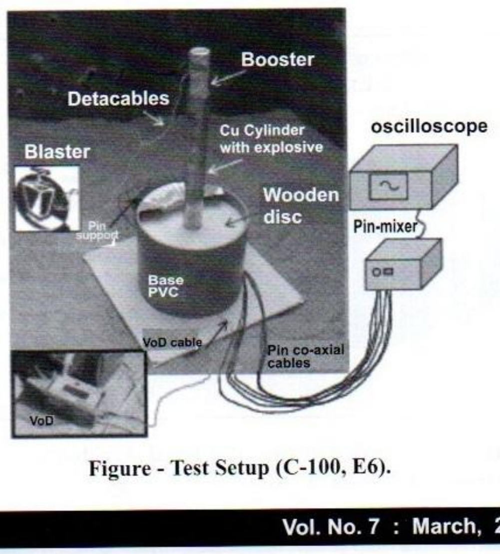


Figure - Test Setup (C-100, E6).

MEASUREMENT OF BOREHOLE PRESSURE DURING BLASTING

by

G. Teowee & B. Papillon
Austin Powder Co., Cleveland, Ohio, USA

ABSTRACT

This paper describes the use of a modified piezoelectric sensor and the supporting electronics which were used to measure instantaneous borehole pressures from adjacent boreholes during blasting. The key features of this measurement approach are the relatively low cost and ease of set-up in the field rather than bulky electronics on-site or complicated pre-calibration procedures. SPICE (Simulation Program Integrated Circuits Emphasis) was used to simulate the time-dependent outputs from the circuitries. The system was compared with respect to a commercial pressure sensor inside a water tank where an underwater testing of standard output electronic detonators were utilized; excellent agreements between the measurements of both systems were obtained at 34–128 MPa range. The actual outputs also compared well with the SPICE simulation results. Results are presented on several blasts where non-electric and electronic detonators were used. Single primed and decked shots were monitored; in dry holes, sympathetic pressures from neighboring boreholes or underlying decks of 34–48 MPa were measured while wet holes can exhibit almost 69 MPa of peak pressure. This system can measure a maximum pressure of 138 Mpa in the boreholes.

BOOK REVIEW

AMMONIUM NITRATE EXPLOSIVES FOR CIVIL APPLICATIONS

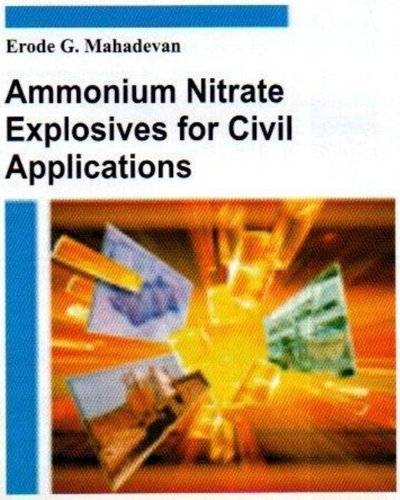
Slurries, Emulsions and Ammonium Nitrate Fuel Oils

By

Dr. Erode G. Mahadevan,

Reviewed by

Auflage Januar 201399,- Euro 2013. XVI, 214 Seiten, Hardcover 27 Abb., 39 Tab.
Monographie - ISBN 978-3-527-33028-7 - Wiley-VCH, Weinheim

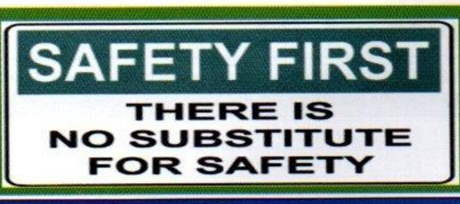


This work describes the science and technology of formulation and manufacturing of non-nitroglycerine explosives with ammonium nitrate as the main ingredient. Based on the author's industry experience of more than thirty years, it provides an unparalleled treatment of one of the commercially most important classes of explosives and therefore stimulates further research and development efforts in the field of explosives for civil applications

Explosives based on ammonium nitrate can be handled more easily than other explosives because they are more stable and less sensitive to external stimuli such as pressure, shaking or inadvertent ignition. Consequently, they provide more safety for both the manufacturer andthe end user, making them the explosives of choice for civil applications such as mining, construction and pyrotechnics.

This book is an invaluable addition to the library of any Explosives and Mining Specialist, Pyrotechnician, Materials Scientist, Military Authority, and Safety Officer.

Contents :



SPECIAL REPORT

Safex International

'Safex Incidents Notices' : January, 2011 to March, 2013

Summary

Activity				No. of Incidents
*	Manufacturing :	Fixed Plant		
		HE	3	
		Explosive Accessories	14	
			17	17
	Mobile Manufacturing Unit (MMU)		-	-
*	Handling :	Within Plant Area	3	
		Outside Plant Area	-	
			3	3
*	Storage :		2	2
*	Transportation	Vans	3	
		MMU	1	
			4	4
*	Waste / unused explosives disposal, etc.		3	3
			TOTAL	29

Almost all the incidents were due to human errors either arising from lack of due diligence during supervision or plain negligence / lack of awareness.

- Editor

1

1) **INCIDENT TITLE :** 18 Jan 2011: France -Ignition in bulk emulsion production line
2) **INCIDENT OUTLINE**
   a) **What material was involved :** Unknown quantity of bulk emulsion
   b) **What happened :** Soon after start-up, the operator observed a yellow flame for about 30 seconds. As the flame stopped, he did an emergency shutdown of the bulk production line. The flame originated from the insulation material around the joint of the rigid and flexible pipes of the aqueous phase
   c) **Why did it happen theory :** Combustion of small quantities of materials must have occurred due to factors such as:
      - Presence of ingredients such as crystallized ammonium nitrate, oil or vegetation matter in gaps of the insulation material.
      - High temperature of 158°C from the steam during operation.
   d) **What was the impact :** There were no injuries and material damage was minor. No environmental impact occurred.
3) **COMMENT**
   a) **Value of incident :** Fuel and oxidizer contamination of the insulation around heated pipes must be avoided. Good housekeeping and maintenance practices must be adopted.
   b) **Observations :** None.

2

1) **INCIDENT TITLE :** 12 Aug 2011: India: ASA powder explosion
2) **INCIDENT OUTLINE**
   a) **What material was involved :** Approximately 2.7 kg of an ASA mixture consisting of lead azide/lead styphnate/aluminium powder.
   b) **What happened :** The ASA mixture is dried, sieved and filled into bottles by way of remote and automatic operations. Each antistatic bottle is normally filled with approximately 900 g of ASA mixture. The operator enters the premises only to collect the three bottles, transfer them manually into a wooden carrying box and carry them to the designated magazine for storage. An inadvertent explosion took place when the operator went inside the room to fetch the ASA filled bottles.
   c) **Why did it happen theory :** One of the bottles with ASA initiated during collection / handling leading to sympathetic detonation of the other two bottles. No process abnormalities were noted. Probable reasons for occurrence of the explosion are:
      - Mechanical – impact / friction.
      - Static electricity - inadequate dissipation thereof
   d) **What was the impact :** The operator was fatally injured. The roof and soft walls of the building were severely damaged as was the equipment in the drying chamber.
3) **COMMENT**
   a) **Value of incident :** In addition to its statistical value, this incident highlights the extreme sensitivity of such primary explosives mixtures. More learning points will undoubtedly surface in the IR
   b) **Observations:** None

3

1) **INCIDENT TITLE :** 25 Aug 2011: South Africa - Shock tube extruder head explosion
2) **INCIDENT OUTLINE**
   a) **What material was involved :** HMX/Aluminium powder calculated as approx. 50 mg
   b) **What happened :** A loud and violent explosion occurred at the cross-head of extruders two and three on Line 3 during normal operation of the shock tube manufacturing line.
   c) **Why did it happen theory:** It is suggested that a reasonably large amount of powder (>50 mg) must have accumulated rapidly in the cross-head and initiated before it had time to degrade.
   d) **What was the impact :** No-one was injured in the event and there was minimal damage to equipment
3) **COMMENT**
   a) **Value of incident :** Besides its statistical value, this incident points to the importance of avoiding the accumulation of explosives, especially in dead space, through equipment design and appropriate cleaning regimes.
   b) **Observations :** None

4

1) **INCIDENT TITLE :** 4 Oct 2011: Saudi Arabia - Ammonium nitrate truck fire
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 21 t ammonium nitrate
   b) **What happened** : Fire started at the right, rear wheels and after failure to extinguish the fire, it spread to the rest of the truck and eventually the load. The Emergency Services and Civil Defence were notified.
   c) **Why did it happen theory** :Inadequate truck maintenance standards and use of defective equipment
   d) **What was the impact** : There were no injuries. Besides the truck, the ammonium nitrate was completely destroyed with consequent delay in the delivery of product, disturbance to general public.
3) **COMMENT**
   a) **Value of incident** : In addition to its statistical value, this incident illustrates the importance of explosives truck maintenance standards. The IR will undoubtedly highlight some valuable lessons.
   b) **Observations :** MCS is a new member and we appreciate their honesty in reporting this incident

5

1) **INCIDENT TITLE :** 11 Nov 2011: France – Decomposition of emulsion in cartridging building
2) **INCIDENT OUTLINE**
   a) **What material was involved :** Small quantity of cartridging emulsion
   b) **What happened** : The plant was shut down for a bank holiday when smoke started coming from a pipe between the emulsion blend hopper and the sensitisation reactor on top of a Chub machine. The generation of smoke without any flame was picked up on a video camera and lasted for about 40 minutes. Operating personnel only became aware of the problem on the Monday.
   c) **Why did it happen theory** : The temperature gauge was accidently moved from its designated position which resulted in the electric heat tracing within the pipe running continuously. As a consequence the residual emulsion layer inside the metallic pipe decomposed due to the heat.
   d) **What was the impact** : There were no injuries and no significant environmental impact. Material damage was limited to the electrical tracing system, pipe and sensitisation reactor stator.
3) **COMMENT**
   a) **Value of incident** : In anticipation of the IR, change management (e.g. moving the temperature gauge) and plant shut down procedures (e.g. Residual emulsion in the pipes) are some of the learning points.
   b) **Observations** : Presumably, the heat tracing has to be switched on all the time. The record provided by the camera videoing the operation continuously contributed to pinpointing the cause in this case.

6

1) **INCIDENT TITLE :** 11 Dec 2011: India - Fire in detonating cord spinning plant
2) **INCIDENT OUTLINE**
   a) **What material was involved :** Approximately 8 kg PETN and 1800 m semi-fuse
   b) **What happened** : A fire started near the semi-fuse take-up reel of a detonating cord spinning machine. There was no explosion.
   c) **Why did it happen theory** : It is believed that friction, possibly caused by the drive belt of the spooling reel, resulted in an ignition of yarn dust near the drive pulley guard.
   d) **What was the impact** : There were no injuries. The fire destroyed two spinning machines in separate compartments. Significant smoke and soot damage occurred throughout the building.
3) **COMMENT**
   a) **Value of incident** : Besides the statistical value of this incident, it shows the importance of identifying and eliminating areas where heat is likely to build up, especially through friction events. Good housekeeping to prevent the accumulation of material such as yarn dust is also illustrated. The emergency plan and evacuation procedures prevented any escalation of the incident.
   b) **Observations :** None

7

1) **INCIDENT TITLE :** 28 Dec 2011: Finland –Emulsion detonation on burning ground.
2) **INCIDENT OUTLINE**
   a) **What material was involved :** About 100 kg emulsion explosive cartridges gassed with sodium nitrite.
   b) **What happened**: Some 5 min after igniting the wood-fired burning ground to destroy waste emulsion cartridges, a detonation occurred.
   c) **Why did it happen theory** : An internal investigation has commenced to determine the probable cause
   d) **What was the impact** : As the nearest people to the burning site were 250m away, there were no injuries. Several windows were broken in the vicinity.
3) **COMMENT**
   a) **Value of incident** : Besides its statistical value, this incident illustrates the value of having personnel at a safe distance from the burning ground during operation. Additional learning points will be highlighted in the IR.
   b) **Observations :** None

8

1) **INCIDENT TITLE :** 9 Jan 2012: Spain: Intermediate product magazine fire
2) **INCIDENT OUTLINE**
   a) **What material was involved :** An estimated 12,000 kg of Class 1.3 material comprising an impregnated nitrocellulose semi-product
   b) **What happened**: A fire took place in the magazine which is licensed for 21,000 kg of Class 1.3 material. The local emergency plan was initiated and the external fire brigade extinguished the fire in 15 minutes.
   c) **Why did it happen theory** : Cause of fire is not known and is under investigation.
   d) **What was the impact** : There were no injuries. As result of the fire the light roof of the concrete walled magazine building collapsed.
3) **COMMENT**
   a) **Value of incident** : Besides its statistical value, further learning points will become evident once the Investigation Report is issued.
   b) **Observations :** The decision to fight the fire is of interest. MAXAM indicated that the reasons for calling the local fire department to fight the fire were: (a) to prevent the fire spreading to other facilities in the factory; and (b) the nature of the materials involved did not present a blast hazard. Furthermore, the building offered no confinement and fire fighters were able to spray water on the fire from a good vantage point a safe distance away.

9

1) **INCIDENT TITLE :** 9 Feb 2012: Sweden: Explosion during drying of lead styphnate
2) **INCIDENT OUTLINE**
   a) **What material was involved :** Less than 4,5 kg lead styphnate.
   b) **What happened** : An automatic drying process is used for the production of lead styphnate. An explosion occurred in the precipitation bunker involving about 0,5 kg of lead styphnate in the drying equipment and about 4 kg in the precipitation vessel. The lead styphnate in the precipitation vessel did not detonate fully. Some of the product remained undetonated in the vessel and the rest of it was dispersed on the walls and ceiling.
   c) **Why did it happen theory**: A probable cause of the accident is attributed to electrostatic discharge. It is thought that the electrostatic charge resulted from too high air flow during drying of the lead styphnate.
   d) **What was the impact** : No injuries but the equipment in the bunker room was totally destroyed and had to be rebuilt. There was no damage to the building itself.
3) **COMMENT**
   a) **Value of incident** : Besides the mitigating measures used in this incident to prevent injury and damage to the structure, there are lessons to be learnt in the electrostatic controls that were employed and recommendations for improving them. This will only be apparent when the IR is issued.
   b) **Observations :** None

10

1) **INCIDENT TITLE :** 29 Feb 2012: India - Electric detonators explosion after crimping
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 5 bundles of electric detonators with 25 detonators in each bundle.
   b) **What happened** : A cloth conveyor belt is used to move crimped electric detonators from the crimping section to packing section. While they were being transported on the conveyor belt, 5 bundles accidentally detonated.
   c) **Why did it happen theory** : Two possibilities are being investigated:
      - Improper location of fuse head causing rubbing against the primer charge – ASA in this case.
      - Impact of detonators against idlers of the conveyor.
   d) **What was the impact** : There were no injuries but the conveyor belt was damaged.
3) **COMMENT**
   a) **Value of incident** : In addition to this incident's statistical value, it also demonstrates the importance of locating fuseheads properly within the detonator. Lead wires should be twisted to prevent movement and direct contact with the primer charge.
   b) **Observations :** None

11

1) **INCIDENT TITLE :** 4 Mar 2012: India : Shock tube assemblies explosion at crimping
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 74 shock tube assemblies. Each assembly consists of a non-electric detonator (STL) and shock tube coil 5 m long.
   b) **What happened** : As the crimping operator removed the crimped assemblies from the container in which they are kept, an explosion took place. 73 detonators initiated and one uninitiated detonator was thrown about 2m away
   c) **Why did it happen theory** : While the operator was removing the assemblies, the shock tubes may have got entangled and the detonators hit the concrete wall of the cubicle. Relative humidity in the house was above 55% and equipment was properly earthed. Further investigation is in progress
      The operating instructions clearly state that no more than 25 crimped detonators should be kept in the crimping cubicle. In this case the operator had accumulated 74 crimped detonators.
   d) **What was the impact** : The operator sustained injuries to his face and right hand. There was no damage to the plant or equipment.
3) **COMMENT**
   a) **Value of incident** : In addition to its statistical value, this incident highlights the importance of handling explosives and components containing explosives with care. Compliance with operating instructions is also underlined.
   b) **Observations :**It will be interesting to see whether the investigation confirms the hypothesis for the unplanned initiation.

12

1) **INCIDENT TITLE :** 1 Jul 2012: Bolivia – Lead azide explosion
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 100 g of lead azide
   b) **What happened** : A small container of lead azide went off when the operator grabbed it from the surface on which it was placed. The container material and type of surface are both unknown.
   c) **Why did it happen theory**: The investigation ruled out the possibility of electrostatic discharge as all the groundings were in place. Tests carried out later showed no buildup of electrostatic charge on the surfaces or the container. The injured operator stated that the container exploded after he grabbed it but he cannot remember any detail. The most likely cause is impact and/or friction between the edge of the container and the surface as result of human error in handling the container. Spillage of lead azide prior to initiation cannot be ruled out.
   d) **What was the impact** : The operator lost his right hand and received shrapnel injuries to his chest.
3) **COMMENT**
   a) **Value of incident** : In addition to its statistical value, this incident demonstrates the sensitivity of primary explosives like lead azide. These explosives must be handled with utmost care and preferably remotely if at all possible.
   b) **Observations :** None

13

1) **INCIDENT TITLE :** 7 Jul 2012: South Africa – LMNR fusehead fire
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 4 kg lead mononitroresorcinol (LMNR)
   b) **What happened** : An operator was transferring dry LMNR to a storage container using a stainless steel scoop when an ignition occurred.
   c) **Why did it happen theory** : LMNR is normally kept well-wetted with amyl acetate. However, the incident batch had been allowed to dry out making it highly sensitive to friction, impact and electrostatic stimuli. It is suspected that impact was the most likely cause.
   d) **What was the impact** : The operator suffered facial burns and the compartment was slightly damaged by a secondary fire.
3) **COMMENT**
   a) **Value of incident** : It is important to adhere to measures designed to minimize the probability of ignition of sensitive pyrotechnic compositions. There are also questions around the suitability of the Personal Protective Equipment in this instance: was it used and, if so, is it appropriate?
   b) **Observations:** We are experiencing a spate of incidents that suggest operators have not internalized the Basis of Safety (BoS) of the substances and processes with which they work. To put it simply, BoS is knowing:
      - What is required to prevent unplanned initiations; and If they occur, how to manage the consequences

SPECIAL REPORT

14

1) **INCIDENT TITLE :** 9 Jul 2012: Australia - AN Semitrailer rollover
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 20 000kg of ammonium nitrate
   b) **What happened :** A semi-trailer rolled over on a mine site discharging ammonium nitrate
   c) **Why did it happen theory :** The alignment of the prime mover and trailer as well as the incorrect application of the prime mover and trailer brakes caused the hoist mounts to fail which resulted in the trailer rolling over
   d) **What was the impact :** There were no injuries but the prime mover and trailer sustained significant damage. 20 000kg of ammonium nitrate spilt.
3) **COMMENT**
   a) **Value of incident :** Primarily of statistical value pending the outcome of the investigation and the IR issued. Driving techniques may be an issue.
   b) **Observations:** None

15

1) **INCIDENT TITLE :** 16 Jul 2012: India – Lead azide explosion
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 4 kg of lead azide
   b) **What happened :** A container with 4 kg of lead azide was kept on one side of the weighing table. The operator was standing behind the safety shield and weighed out 800 g of lead azide when an explosion occurred.
   c) **Why did it happen theory :** It is suspected that the operator dropped the container during the weighing process.
   d) **What was the impact :** The operator who was weighing the lead azide was killed as well as another operator in the adjacent cubicle. The building was destroyed.
3) **COMMENT**
   a) **Value of incident :** Besides illustrating the sensitivity of lead azide once again, the true value of this incident will be evident once the IR is issued. The incident drives home the desirability to minimize the exposure of personnel to explosives as well as the quantity of explosives in an operation. The impact of the explosion on the adjoining cubicle is also of interest.
   b) **Observations :** The SAFEX community extends its sincerest condolences to the family and friends of the deceased as well as the management and staff of PEL.

16

1) **INCIDENT TITLE :** 24 Jul 2012: South Africa – Pyro powder sieving fire
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 20kg of G Composition, pyrotechnic delay powder.
   b) **What happened :** G Composition powder was being sieved remotely in an automatic sieving operation when an ignition occurred.
   c) **Why did it happen theory:** The exact cause of the ignition could not be determined. It is likely that either an impact or frictional situation had occurred causing the very sensitive G Composition to ignite.
   d) **What was the impact :** There were no injuries. However, the equipment and compartment were seriously damage.
3) **COMMENT**
   a) **Value of incident :** In the absence of a definitive cause, it is difficult to extract maximum value from this incident. However, it does illustrate the benefit of remote process in which the operator is no longer directly exposed to the operation.
   b) **Observations :** None

17

1) **INCIDENT TITLE :** 10 Aug 2012: USA - Explosives trailer fire
2) **INCIDENT OUTLINE**
   a) **What material was involved :** NEQ of 18,098 pounds Explosive Blasting Type B, Class 1.5D, UN 0332, PG II
   b) **What happened :** Trailer of a vehicle transporting explosives caught fire and burned out completely leaving behind about 50 pounds of residue and partially burned material.
   c) **Why did it happen theory :** The cause is unknown and under investigation
   d) **What was the impact :** There were no injuries but the trailer was destroyed. The road was closed for several hours and the road surface damaged from excessive heat.
3) **COMMENT**
   a) **Value of incident :** This incident is of statistical value only until the investigation has been conducted and the cause(s) determined.
   b) **Observations :** None

18

1) **INCIDENT TITLE :** 13 Aug 2012: Chile – Shock tube extrusion line feeder explosion
2) **INCIDENT OUTLINE**
   a) **What material was involved :** Approximately 5kg HMX/Aluminium composition.
   b) **What happened :** An explosion occurred in the powder feeder of the shock tube extrusion line. It communicated back to the expense magazine which detonated a few seconds later.
   c) **Why did it happen theory :** An investigation is being conducted to identify possible causes of the incident.
   d) **What was the impact :** One operator was fatally injured and some structural damage occurred.
3) **COMMENT**
   a) **Value of incident :** At this stage the incident is of statistical value only. When the Investigation Report is issued, it will undoubtedly highlight the relevant learning points.
   b) **Observations:** On behalf of its members, SAFEX extends its sincerest condolences to the family and friends of the deceased as well as the management and staff of Orica Chile SA

19

1) **INCIDENT TITLE :** 17 Aug. 2012: India - Explosion in detonator magazine
2) **INCIDENT OUTLINE**
   a) **What material was involved :** 212,270 detonators - copper and aluminium instantaneous electric detonators; aluminium short delay detonators; non-electric detonators; and electronic detonators.
   b) **What happened :** At 07:00am a detonator magazine with licence capacity of 1.5 million detonators was unlocked and two cases of aluminium short delay detonators were placed in it. The crew locked the magazine again and went about their other duties before going for lunch at 10:00am. At 10:20am a sound similar to series firing of delay detonators preceded the explosion. The main door of the magazine was thrown about 135m from the magazine but the lock and tower bolts were in the locked position. The windows also seemed to have been closed. A number of unexploded detonators were seen at the site.
   Conditions at the time of the incident: Overcast with no rain or lightning; Temperature 30 °C; RH 85%.
   c) **Why did it happen theory :** The reason(s) are unknown and under investigation.
   d) **What was the impact :** No one was injured but the magazine was totally destroyed. There was no damage to any other magazine or building in the vicinity.
3) **COMMENT**
   a) **Value of incident :** Besides the statistical value of this incident, actual learning points depend on the outcome of the investigation.
   b) **Observations :** We urge members to let us have their ideas about possible causes of this incident or information about similar incidents elsewhere.

20

1) **INCIDENT TITLE :** 22 Sep 2012: Mexico - MMA leak during unloading

2) **INCIDENT OUTLINE**

a) **What material was involved :** A trailer load of monomethylamine (MMA)

b) **What happened** : While unloading MMA from a tank trailer, a leak occurred at the coupling between the hose and the tank trailer's discharge valve. The plant manager ordered all MMA shut-off valves to be closed and for the equipment in that area to be de-energized (power off).
In parallel, the site evacuation plan was triggered and all personnel were evacuated

c) **Why did it happen theory** : Three contributory causes were identified in the investigation:
- Slag from a weld in the tank trailer migrated onto the gasket of the discharge valve and compromised its sealing function. This was as result of a failure to clean the tank properly after welding.
- The discharge hose remained connected after unloading was interrupted the previous day. Operating instructions require the hose to be disconnected and a male plug fitted to the tank.
- The hose coupling was not tightened properly. When the operator inspected the initial leak he unknowingly loosened the connection even more.

d) **What was the impact** : There were no injuries and no material damage. It was estimated that a total of 5 litres (content of the discharge hose) of liquid MMA was released to the atmosphere.

3) **COMMENT**

a) **Value of incident** : Toxic gases such as MMA liquid vapour can be hazardous and must be treated with the respect it deserves. In this instance lack of control on the maintenance of equipment from a 3rd party provider, non-adherence to operating instructions and poor execution of a task (tightening the hose coupling) could have resulted in more severe consequences.

b) **Observations :** Even though there are no explosives directly involved in this incident, the learning is relevant as MMA is a widely used precursor in explosives manufacturing.

21

1) **INCIDENT TITLE :** 22 Oct 2012: USA - MMU roll-over on highway

2) **INCIDENT OUTLINE**

a) **What material was involved :** 90 lbs of 1.1D (UN 0042); 90 units of 1.4B (UN 0255) Electronic Detonators; 22,000 lbs of Matrix Oxidizer (UN 3139)

b) **What happened** : A Mobile Manufacturing Unit (MMU) rolled and came to rest on the side of the highway. There was no release of emulsion from the tank and the explosives remained secured during this single vehicle incident. Emergency personnel evacuated the incident area according to PHMSA's Emergency Response Guidebook (ERG) standards.

c) **Why did it happen theory** : Under investigation. Initial findings reveal the IME-22 boxes remained intact and there was no loss of containment of oxidizer or explosives.

d) **What was the impact** : The driver sustained non-life threatening injuries but the road was closed for nine hours. On-scene management was effective and efficient.

3) **COMMENT**

a) **Value of incident** : Besides its statistical value, this incident emphasizes the effectiveness of the measures taken to minimize the consequences of an event such as this. It illustrates the value of good standards and adherence to the same

b) **Observations :** While at this stage the reasons for the roll-over are uncertain, people involved in the response to the incident must be complimented on containing its impact.

22

1) **INCIDENT TITLE :** 1 Nov 2012: Sweden - Pyrotechnical composition fire

2) **INCIDENT OUTLINE**

a) **What material was involved :** Approximately 2,5 kg of a pyrotechnical composition

b) **What happened**: Granulation of the composition is done remotely. The operator opened the door and vent to the bunker which houses the operation. While he was standing against the Frewitt granulator the pyrotechnical composition inside it ignited.
The flame and hot gasses spread horizontally at table-level and reflected upwards from the floor between the trousers and the jacket of the personal protective equipment (PPE) worn by the operator. As the operator turned to escape, the heat and flames continued to burn his stomach, side and back.
The fast sprinkler system was activated.

c) **Why did it happen theory** : At the moment the operator has no recall of what happened. Friction or electrostatic discharge appears to be the most likely causes of the initiation.

d) **What was the impact** : One operator received 10 % first-degree burns to his stomach, side and back. He also has first-degree burns to the outside of the right hand. A second operator was slightly shocked. There was some damage to equipment and the light wall of the bunker.

3) **COMMENT**

a) **Value of incident** : In addition to its statistical value, this incident illustrates the peculiar behaviour of the fireball and the necessity to protect exposed personnel accordingly. The Investigation Report will highlight additional lessons from this incident

b) **Observations :** SAFEX Advisory SSA06-12 refers. Please let me know if you did not receive a copy.

23

1) **INCIDENT TITLE :** 27 Nov 2012: Colombia - Explosive truck rollover

2) **INCIDENT OUTLINE**

a) **What material was involved :** 10,096 kg hydrogel explosive (Indugel Plus AP) and 424 kg cartridge emulsion (EMULTEX).

b) **What happened** : As the driver was trying to change gears the transmission jammed and the engine stalled causing the steering of the truck to lock. The driver instinctively applied the brakes and the vehicle overturned. The load spilled from the truck and some of the cartridges were damaged or contaminated with oil.

c) **Why did it happen theory** : Suggested explanations pending the investigation of the probable cause include:
- Driver did not adapt to the road conditions.
- Inadequate truck maintenance.
- Poor truck design. It has been suggested that the truck should be modified to alter the centre of gravity.
- Poor loading practice and pre-trip inspections.

d) **What was the impact** : There were no casualties but the truck was written-off and some of the explosives material had to be destroyed.

3) **COMMENT**

a) **Value of incident** : Besides its statistical value, the incident seems to point to the importance of proper truck maintenance and design. Pending the outcome of the investigation, there may also be issues around the way the truck was loaded and pre-trip inspections.

b) **Observations :** One wonders whether the time the incident occurred is relevant.

24

1) **INCIDENT TITLE :** 29 Nov 2012: India – NHN deflagration:
2) **INCIDENT OUTLINE**
a) **What material was involved :** A 4.5 kg batch nickel hydrazine nitrate (NHN)
b) **What happened** : A batch of NHN was manufactured and given a preliminary wash. After a while a relief operator noticed a smell and temperature rise of the material. He advised supervision who instructed him to move the material to an empty building licensed for NHN. 2 hours later the supervisor noticed that the material was still hot and called management. Two managers had gone in and came out of building to discuss what to do. While they stood outside the building, the deflagration occurred.
c) **Why did it happen theory**: Heat was the cause of the deflagration. Improper washing of the batch resulted in decomposition and eventually deflagration of NHN. The incident could have been avoided if the material was drowned in water when the rise in temperature was first noted.
d) **What was the impact** : Two people suffered minor injuries. Building damage amounted to a cracked wall and broken doors.
3) **COMMENT**
a) **Value of incident** : Pending the issue of the IR, the incident highlights a failure in the hand over from one operator to another resulting in inadequate washing of the material. For whatever reason, operators and the supervisor did not adopt the appropriate emergency procedure (to drown the material when it started decomposing). However, moving the material to an empty building minimized the impact.
b) **Observations :** None

25

1) **INCIDENT TITLE** : 8 Jan 2013: Spain – Laboratory initiation of lead styphnate sample
2) **INCIDENT OUTLINE**
a) **What material was involved :** 60 g of lead styphnate
b) **What happened** : The sample was in a small aluminium container when it detonated while the laboratory analyst was pouring water on top of it in order to desensitize it. Several quality tests had been performed on the sample. Three other containers, located on a shelf approximately 60 cm away, also initiated.
c) **Why did it happen theory** : The investigation is ongoing and all possibilities are being considered. More information will be obtained when the injured analyst returns to work.
d) **What was the impact** : The operator, with more than 15 years of experience in this test, was injured by shrapnel from the aluminium container. The safety glasses played a vital role saving her eyes. Other damage was minimal.
3) **COMMENT**
a) **Value of incident** : The incident highlights the risks associated with explosives testing as well as the sensitivity of primary explosives. It also demonstrates the value of using the prescribed personal protective equipment (PPE). The IR will undoubtedly illustrate further learning points.
b) **Observations :** None

26

1) **INCIDENT TITLE :** 19 Feb 13: Canada – Explosives truck collision
2) **INCIDENT OUTLINE**
a) **What material was involved :** 39,000lbs of a cartridged dynamite product
b) **What happened** : The explosives truck collided with another heavy vehicle
c) **Why did it happen theory**: Cause of collision is unknown and under investigation
d) **What was the impact** : One employee in the Dyno Nobel vehicle was killed and another seriously injured. The driver of the other vehicle was also killed.
3) **COMMENT**
a) **Value of incident** : In the absence of any additional information at this time, this incident is of statistical value only.
b) **Observations :** SAFEX extends its sincerest condolences to the family, friends and colleagues of the deceased as well as the management of Dyno Nobel.

27

1) **INCIDENT TITLE** : 28 Feb 2013: Germany – Blackpowder corning machine initiation
2) **INCIDENT OUTLINE**
a) **What material was involved :** 100 - 150 kg of blackpowder.
b) **What happened**: An initiation occurred in the corning machine of the black powder production line. The authorities have placed a moratorium on further information until they have completed their investigation.
c) **Why did it happen theory** : An investigation is being conducted by a team of experts who will consider all possible causes. More information will be provided when the investigation is finalized.
d) **What was the impact** : The employee suffered serious burns (70% of his body). Unfortunately, after two weeks in hospital, he passed away as a result of his injuries. The soft wall of the building was blown out and the corning machine was damaged.
3) **COMMENT**
a) **Value of incident** : IUntil we receive more information about the incident and its causes, it is of statistical value only at this stage.
b) **Observations :** SAFEX extends its heartfelt condolences to the family, friends and colleagues of the deceased as well as to the management of Wano Schwarzpulver.

28

1) **INCIDENT TITLE** : 13 Mar 2013: Poland – NG explosion in intermediate storage
2) **INCIDENT OUTLINE**
a) **What material was involved :** 600 kg of a 60/40 nitroglycerine/nitroglycol mixture
b) **What happened** : An explosion occurred in an intermediate nitroester storage facility which receives the nitroester mixture directly from the production line or from the main nitroester stock. Nitroesters from both sources are piped as a water/nitroester emulsion. The nitroester emulsion from the intermediate stock is then transferred to a weighing room which is in a building adjacent to a Tellex mixer. All processes in the intermediate storage facility operate automatically without any staff present.
c) **Why did it happen theory** : At this stage the cause of the explosion is unknown and is being investigated
d) **What was the impact** : There were no injuries but the storage building is completely destroyed. NG production is unaffected.
3) **COMMENT**
a) **Value of incident** : At this stage the incident is of statistical value pending the outcome of the investigation.
b) **Observations:** Nitroerg has appealed to any SAFEX member who has experience of similar events to please share their knowledge with us. You may let me have your comments.

29

1) **INCIDENT TITLE :** 17 Mar 2013: Finland - Emulsion waste fire
2) **INCIDENT OUTLINE**
a) **What material was involved :** About 300 kg factory waste comprising emulsion, luminized emulsion explosive, ammonium nitrate solution and cleaning waste.
b) **What happened** : A 1000 litre plastic IBC container with emulsion waste began to smoke inside the emulsion plant building. It was immediately moved to outside the building where it started to burn after some minutes.
c) **Why did it happen theory** : The cause of reaction has not been established but is under internal investigation.
d) **What was the impact** : There were no injuries, environmental impact or material damage.
3) **COMMENT**
a) **Value of incident** : The value of this incident will become apparent after the investigation. Besides the incident's statistical value, it emphasizes the care with which waste must be handled and mixed.
b) **Observations :** Forcit has invited comments and suggestions as to possible causes. Kindly direct those to me and I shall be happy to pass them on.

सी.एस.आई.आर - केन्द्रीय खनन एवं ईंधन अनुसंधान संस्थान

CSIR-CENTRAL INSTITUTE OF MINING & FUEL RESEARCH

(A CONSTITUENT LAB OF CSIR, UNDER MINISTRY OF SCIENCE & TECHNOLOY, GOVT. OF INDIA, NEW DELHI)

CSIR- Central Institute of Mining & Fuel Research (CIMFR) has been formed after integrating the core competencies of erstwhile Central Mining Research Institute (CMRI) and Central Fuel Research Institute (CFRI) both at Dhanbad.

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- Blasting Optimization & Productivity Improvement Investigations
- Subsidence Investigation
- Studies on Mine Gases
- Studies on Mine Ventilation
- Studies on Mine Fire
- Investigation on Explosive and Explosion
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- Performance Evaluation of FLP Equipment, Wire Ropes and other Mining items, Miners' Safety Equipment, etc.
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- Investigation on Coal Carbonization
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C - Environment

- Environmental Management including Environmental Impact Assessment and Preparation of Environmental Management Plan for Mines and other Industrial Areas.
- Fly Ash Utilization

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CSIR-CIMFR also extends testing and evaluation of explosives and accessories, mine ventilation and safety equipment, roof supports, personnel protection equipment, flameproof and intrinsically safe equipment, electrical cables, other mining and allied industrial components such as wire ropes, cage and suspension gear components, aerial ropeways, etc. to ensure safety of the mines and miners. Monitoring and analysis of air, water, noise and soil pollution are also carried out. It also provides calibration services of different instruments.

All facilities for analysis of coal, lignite, petroleum products, etc. are also available at this institute for the benefit of the coal producing and user industries as well as other organisations.

For Further Information Please Contact:

Dr. Amalendu Sinha
Director
CSIR-Central Institute of Mining & Fuel Research
Barwa Road, Dhanbad – 826 015 (Jharkhand)
Phone : 91-326-2296023/2296006/2381111
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Unit - II : 17/C, Telenkhedi Area, Civil Line,
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ABOUT THE SOCIETY

Visfotak

Explosives Safety & Technology Society

GOVERNING COUNCIL

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R.N. ZALPURI, Gen. Manager (L&R) Western Coalfields Ltd.

Secretariate

Address :
Maimoon Chambers
Gandhibagh, Nagpur - 440 032

E-mail : visfotak@yahoo.com

Website : www.visfotak.org

History

The idea of "Visfotak" as a Scientific Society took birth in 1998, on the eve of the National Seminar on Explosives Safety and Technology : *Visfotak - 98,* when for the first time the three major constituents of the industry, viz, the Government Regulatory Bodies, the Manufacturers, and the Users respectively, were formally brought together on one platform to deliberate on common Concerns and Issues. Arising from the deliberations, a proposal to establish a Scientific Society exclusively dealing with the Safety & Technological aspects of the Explosives industry was unanimously endorsed.

Consequently, the Explosives Safety & Technology Society (Visfotak) was registered vide Certificate No. 410 / 99 (Nagpur) dated June 17th, 1999.

Objectives

(a) To promote and develop modern concepts relating to safety and technology in manufacture, handling, and usage of explosives.

(b) To assist the Government of India through its appointed departments and officials in recommending, formulating policies pertaining to explosives manufacture, handling and usage.

(c) To hold seminars, workshops, conferences to promote interaction between the three constituents, viz. the Government regulatory bodies, the manufacturers of explosives and the users of Explosives, in the interest of the growth and health of the explosives industry.

(d) to collaborate with academic and research institutions in promoting the objectives mentioned above.

(e) To promote and strengthen affiliation with other world bodies / societies dealing with explosives safety and technology for exchange of information.

(f) To institute awards, fellowships and scholarships for the excellence in the field of explosives.

The Society has been accepted as an ***Institute Associate Member*** of SAFEX INTERNATIONAL at a General Meeting of SAFEX members on 30 May 2008 with the privileges and obligations that pertain to the membership.

SAFEX INTERNATIONAL is a non profit global organisation founded by the manufactures of explosives and pyrotechnics; currently having 110 members in as many as 46 countries. Visfotak is committed to discharge its obligations as a member by sharing information with SAFEX on all accidents with industrial explosive in India. Visfotak urges all the explosives manufactures and users to cooperate by reporting all accidents to the Society.

Membership

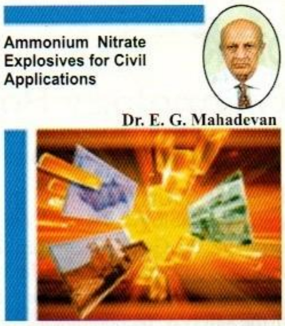
The membership application form which is enclosed, may be filled and sent to the Secretary General at the Secretariat along with the membership fee by a crossed account payee Cheque (add. Rs. 30/- for outstation cheques) or Demand Draft in favour of **Visfotak, payable at Nagpur.**

Student Chapter : This is a new initiative launched by the Society to promote the mission of the Society amongst the students/academics who are associated, directly or indirectly, with the science and technology of explosives.

The membership application form which is enclosed may be filled and sent to Dr. N.R. Thote, Assistant Professor (Hony. Secretary, Student Chapter, Explosives Safety & Technology Society (Visfotak) Department of Mining Engineering, Visveswaraya National Institute of Technology, Nagpur - 440 011 along with the membership fee by a crossed account payee Cheque (add. Rs. 30/- for outstation cheques) or Demand Draft in favour of **Visfotak, payable at Nagpur.**

Visfotak being a Scientific Society, shall totally refrain from partisan activities of any manner or kind and shall not entertain tasks which are biased with commercial interest to its individual members.

The society is proud to acknowledge the first ever exhaustive treatise from India, on modern industrial explosives, authored by Dr. E.G. Mahadevan, our esteemed Patron. Full details in the Book Review.



Dr. More Ramulu, on the left, receiving the award.

The society congratulates Dr. More Ramulu on receiving "Dr. H.R. Annireddy Memorial Award" in mining technology at a special function organised by the Indian Mining & Engineering Journal.

INVITATION TO MEMBERSHIP

In its quest for interaction towards improved Safety & Technology in Explosives, Visfotak cordially invites concerned people to enrol as members.

Membership Categories comprise :

CORPORATE OR INSTITUTIONAL

Entrance Fee	***Membership for 5 years***
Rs. 2000/-	*Rs. 3000/-*
US $ 200	*US $300 - For Foreign Nationals*

INDIVIDUAL

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Rs. 1000/-	*Rs. 1000/-*
US $ 100	*US $300 - For Foreign Nationals*

STUDENT

Entrance Fee	***Membership for 5 years***
Rs. 50/-	*Rs. 200/-*

Application forms are enclosed with this journal for necessary action.

- Secretary General, Visfotak

ORDER FORM
For Advertisement in Visfotak

To,
Secretary General
Explosives Safety and Technology Society (Visfotak)
Maimoon Chambers, Gandhi Bagh, Nagpur - 440 032

1. Name & Address of the Organisation.
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HOMAGE

Sri K.C. Vijh
1941-2012

An iconic and distinguished doyen of the Indian Mining Industry, Shri K.C. Vijh passed away in July 2012.

He was amongst the leading lights during the founding of Visfotak, fully supportive in every manner he could, initially in his official capacity as the Chairman-Managing Director of Western Coalfields Ltd., and later after retirement, as an esteemed Patron of the Society. The Governing Council deeply mourn the irreparable loss, and miss his wise counsel and association.

Tear along this line

Visfotak EXPLOSIVES SAFETY & TECHNOLOGY SOCIETY

REGISTERED UNDER SOCIETIES REGISTRATION ACT MAHARASHTRA NO. 410 / 99 NAGPUR (INDIA)

MEMBERSHIP APPLICATION FORM

(Registered members will be given a Certificate and they would be entitled to participate in all the events conducted by the Society, and receive the publications of the Society free of cost).

Category of Membership : (Please tick ✓) MEMBERSHIP FEE FOR FIVE YEARS ONLY

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Entrance Fee Rs. 2,000/- (US $ 200)	Entrance Fee Rs. 2,000/- (US $ 200)	Entrance Fee Rs. 1,000/- (US $ 100)
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* NAME IN FULL ____________________

(First Name) (Middle Name) (Surname)

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Mailing Address ____________________

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Telephone (Office) __________ (Home) __________ (Mobile) __________ (Fax) __________

Qualifications Educational __________ Professional __________

Year of passing __________ Institute / University __________

Nature of Industry (Explosives, Mining, Hydel Power, Cement, Highways, Irrigation, Academic / Research / Technical Services, Defence, Statutory Bodies, Other) (Please specify) __________

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Mode of Payment : Payments towards Membership fee may please be made by Cheque in favour of 'Visfotak' drawn on any Bank. Add Rs. 30/- for Outstation Cheques or send a Demand Draft payable on any bank in NAGPUR.

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Please forward the above application along with Cheque / Demand Draft to the following address :

The Secretary General, Visfotak - Explosives Safety & Technology Society
Maimoon Chambers, Gandhibagh, Nagpur - 440 032 (India)

Tel. : 2768631 / 32 ▪ Fax : 0712 - 2768034 ▪ E-mail : visfotak@yahoo.com

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Place : __________ Date : __________ Signature __________

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For Corporate and Institutional Members enclose Bio-data of the Head or Representative

Please send your detailed address, telephones / mobile numbers, fax and e-mail ID

admas

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Visfotak

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Membership Fee : (Please tick ✓) MEMBERSHIP FEE FOR FIVE YEARS ONLY

ENTRANCE FEE ☐ Rs. 50/-   MEMBERSHIP FEE FOR FIVE YEARS ☐ Rs. 200/-

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* NAME IN FULL ______________________
(First Name) (Middle Name) (Surname)

Date of Birth ______________________

Name of Institution ______________________

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Telephone (Office) ________ (Home) ________ (Mobile) ________ (Fax) ________

Educational Qualification ______________________

Academic Course being persued : ______________________

Membership of Professional Bodies, Awards, Recognitions ______________________

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Membership of Professional Bodies, Awards, Recognitions ______________________

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Areas of Interest ______________________

Mode of Payment : Payments towards Membership fee may please be made by Cheque in favour of 'Visfotak' drawn on any Bank. Add Rs. 30/- for Outstation Cheques or send a Demand Draft payable on any bank in NAGPUR.

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Please forward the above application along with Cheque / Demand Draft to the following address :

Dr. N.R. Thote, Assistant Professor
(Hony. Secretary, Student Chapter
Explosives Safety & Technology Society (Visfotak)
Department of Mining Engineering
Visveswaraya National Institute of Technology, Nagpur - 440 011

Place : ________ Date : ________ Signature ________

*** Please enclose a detailed BIO-DATA and a recent passport size PHOTOGRAPH.**

Please send your detailed address, telephones / mobile numbers, fax and e-mail ID

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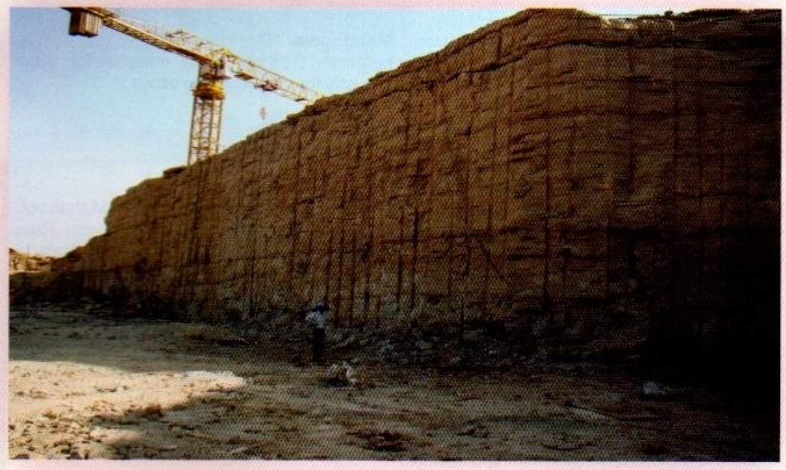

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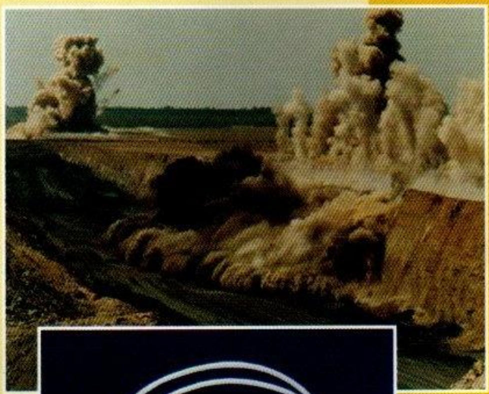

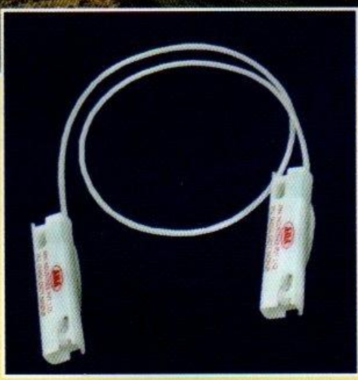

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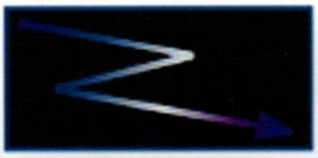

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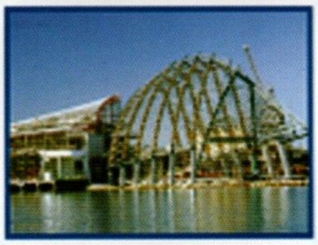

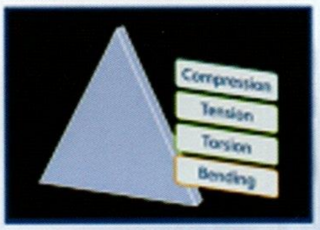

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