The safe use of shock-tube and detonating cord systems in shaft sinking—a global trend

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Synopsis

Traditionally, South African shaft sinking operations have used electric detonators for the initiation of blastholes.

Globally, the trend in shaft sinking is to use the shock tube and detonating cord (STDC) initiation system, with value adding benefits.

In pursuing this global trend, Cementation Mining of South Africa in partnership with SMX have ventured the STDC route. This paper explores the work carried out to date, and identifies a number of benefits to be gained by using the system.

Introduction

In March 1997, one of Cementation Mining of South Africa's shaft sinking crews were introduced to the shock tube and detonating cord (STDC) system of blast initiation.

This method was a new concept to the local shaft sinking industry, and was approached cautiously, but also with an eagerness to venture into alternative technology.

The STDC method of initiation provides a number of features, which were seen to prove beneficial to the mining industry.

Such features include:

- Few, to no, misfires in the shaft bottom—SAFETY
- Reliable quality product
- Product flexibility
- Cost effectiveness
- Ease of use.

What is the shock tube and detonating cord system (STDC) ?

The shock tube system (Refer to Figure 1)

The non-electric delay detonators are comprised of four major components.

- A shock tube to transmit a signal from the detonating cord trunkline, to the delay detonator in the hole.

  Shock tube is a small diameter plastic laminated tube coated with a thin layer of reactive material (16mg/m). When initiated, shock tube reliably transmits a low energy signal at ± 2000 m/s, from one point to another.

  This shock wave phenomenon, which is similar to a dust explosion, will propagate through most bends, knots and kinks in the tube.

  The detonation is sustained by a small quantity of reactive material, the outer surface of the tube remains intact during and after functioning.
- A high strength detonator with an integral delay element. A range of units of up to 19 different delays are available. The detonator contains a Heavy Duty (H.D.) charge of PETN, which is ideally suited for use with commercially cap-sensitive explosives.
- Each unit has a connector attached to the end to make connection onto the detonating cord trunkline easy and reliable, whilst ensuring the 90° angle required between shock tube and detonating cord.
- A color-coded delay tag is also attached to the end of each unit, highlighting the Delay Period Number and the nominal delay time of the unit

The detonating cord (Refer to Figure 2)

The lowest core load detonating cord is recommended for use with the non–electric delay detonators, in the shaft sinking applications.

The detonating cord has a core load of 3.5g/m of PETN, which is encased in a series of ribbons and yarns for maximum tensile strength and abrasion resistance.

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A wax finishing jacket optimizes moisture and oil resistance, while ensuring superior handling characteristics.

Procedure when using STDC systems in shaft sinking

- *Blowing over*
  Full advance per blast is achieved with finer fragmentation and an even bottom since moving to the STDC system, the blowing over process takes less time, as no big rocks have to be removed.
  Sockets are, therefore, more easily exposed and marked, leading to easier perimeter hole position establishment.
- *Even bottom*
  Positioning of the 'Jumbo' drill rig is made easy due to an even bottom, hence the round can be drilled as per plan.
  The more solid bottom provides a more stable hole, and hole closure due to poor blasting practices is vastly eliminated.
  This makes finding and desludging of the holes easier, as the holes stay intact after the drill steel is removed from the hole.
- *Making of primers and charging up*
  Detonators are inserted into the blasting cartridges, and a half hitch made with the tubing to secure the detonator in the blasting cartridge.
  The detonator will point to the toe of the hole, directly in contact with the explosives. If any misfires are encountered, the detonator can safely be extracted from the hole, as the detonator will point away from the direction of the operation of the blowpipe.
  The primers and the rest of the explosives are pressed home with a charging stick and tamped well. Refer to Figure 3.
- *Hook–up of round*
  This activity only commences once all holes have been charged, and the minimum number of workers remain in the bottom, to assist with the hook-up of the detonating cord.
  A small spool of detonating cord sufficient for only one blast is used for connecting the shock tube, thus eliminating excess detonating cord in the bottom.
  Work on the stage is now restricted to preparing the raising of the stage.
  The connector is simply attached to the detonating cord trunkline nearest the hole and any excess slack is drawn out by sliding the connector towards the hole, until taut.
  The detonating cord must be suspended ± 50cm above the shaft bottom, and away from the kibble path using wooden poles.
  This allows flexibility of the cord, hence reducing the risk of detonation, should anything fall on the cord from the stage.
  The detonating cord must form a closed loop, with no knots, and the two ends joined with a 'reef knot' to ensure twin path initiation. Figure 4 shows a typical hook up.

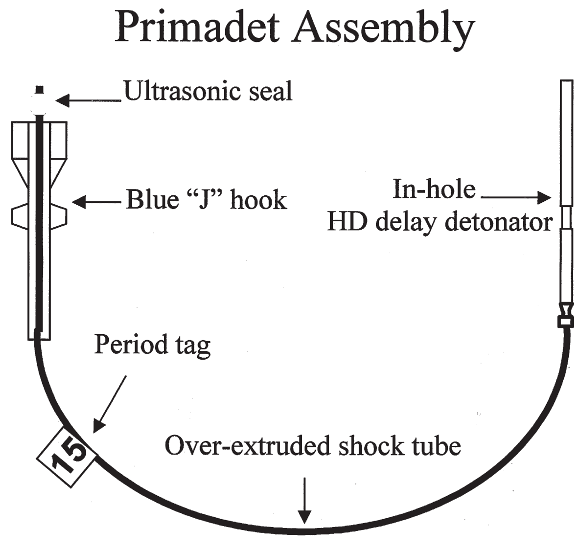

Figure 1—Shock tube assembly

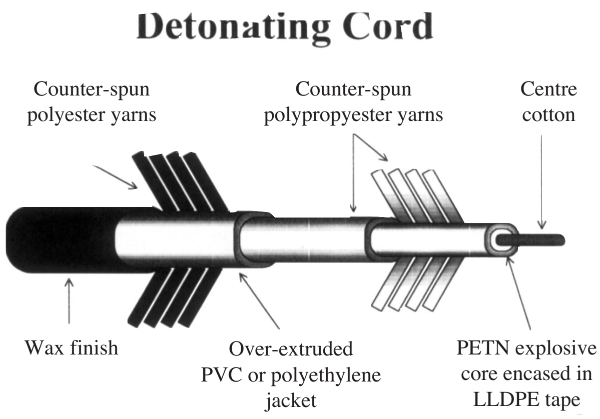

Figure 2—Detonating cord assembly

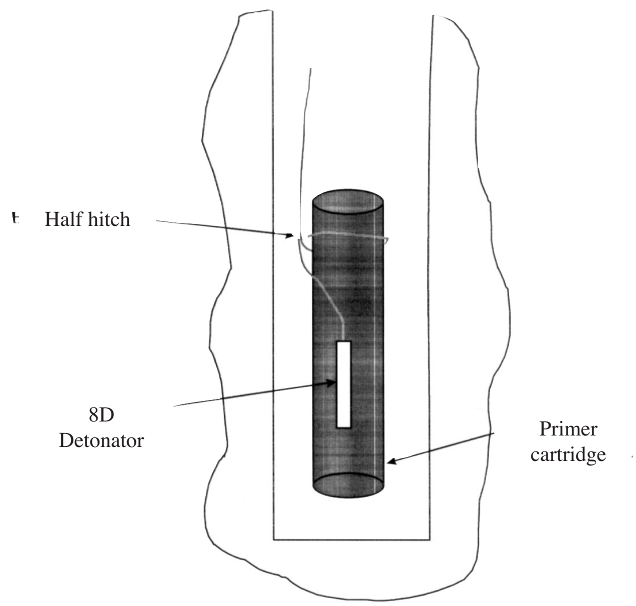

Figure 3—Priming procedure

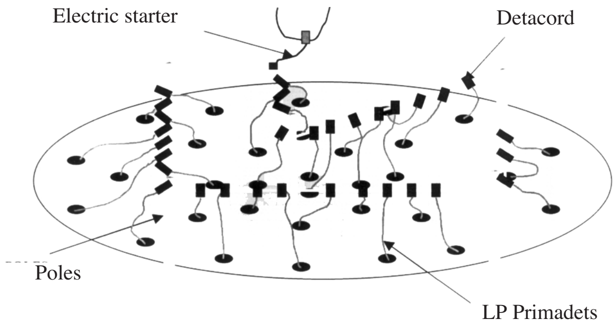

Figure 4—Hook up of round

Identified benefits through the use of STDC systems

Safety

Detonators

Inverted wax primers cannot be used with shock tube detonators owing to the hot wax melting the tube. Therefore, detonators are inserted into a primer cartridge before pushing it down the hole.

The detonator is firmly secured with a half hitch in the shock tube around the primer cartridge, and pointing downwards away from the charging rod. The danger of damaging the detonator required to blow out the hole is averted. This method of priming ensures proper initiation of explosives, and no inert obstruction can get between the detonator and the explosives column, ensuring that all holes detonate.

The long-period delay detonator used has a number of built-in patented safety features, shown in Figure 5, which makes it safe to handle under harsh conditions.

Detonating cord

A range of impact tests have been conducted on detonating cords. In these tests, up to four different core load detonating cords as well as 'shocktube' were subjected to the following: large-scale drop weight impact, 0.50 calibre projectile impact, sliding weight test and pendulum friction.

The international standard safety test for detonating cord is dropping a 15kg weight (with an impact area of 80mm) from 3 metres onto the cord placed on a steel plate, and no detonation must occur. (See Figure 6)

Tests on the all of EBSA's detonating cords, were conducted using a 15kg weight dropped over 3 metres, results of which can be seen in Table I. Note that the only cord to have failed this test is SB Cord, designed for secondary blasting, and is the only cord not to be countered and waxed. This has been demonstrated on a regular basis to the end user at the SMX facility at Kwandebele.

To further qualify these results, a further set of tests have been carried out on Detacord where the weight was increased to 30kg and the impact area reduced to 5mm. No detonations have been experienced.

➤ *Product quality*

Since the introduction of the shock tube and detonating cord system, in March 1997, the misfire rate has been seen to be less than that of other systems.

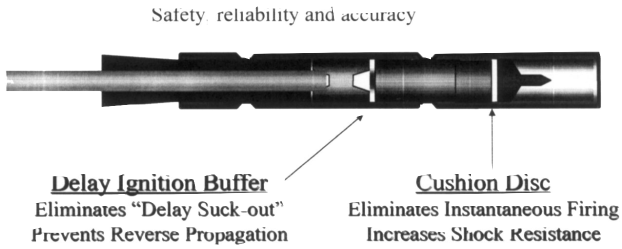

Figure 5—Safety features of EBSA detonator

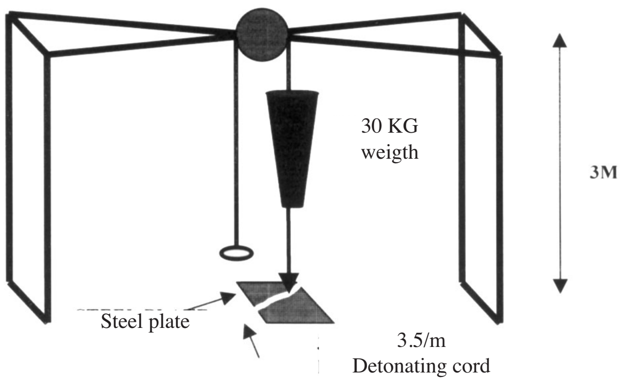

Figure 6—Standard drop test

Table I
Results of drop test with 30kg weights

Sample	No. of tests	Detonations
Detacord	50	0
E-Cord	50	0
SB Cord	8	8
Zap Cord	50	0

➤ *Product flexibility*

The inherent user-friendliness of the shock tube and detonating cord system, and the flexibility of the product lends itself to be used in both vertical and horizontal development applications.

However, experience has shown that proper training is essential in the motivational process to overcome any resistance to change, which is very common in this industry. Therefore, SMX has committed itself to provide in-depth training for the end-user at all levels.

➤ *Cost Effective System*

The direct cost of the initiation system is approximately 50% that of the conventional electric detonator system currently being used in shaft sinking.
Good advance per blast has so far been recorded, resulting in maintaining the planned daily sinking call.
It has been observed that the cleaning and blowing over cycles have been reduced by 7%, due to finer fragmentation of the rock, allowing quicker access for drilling and blasting operations.

Time is not wasted on positioning of the 'jumbo' drill rig, and holes are easily desludged due to a more even and solid bottom.

Advances of 130 m per month, averaging 2.7 m advance per blast (hole length, 2.7 m) utilizing a 'Jumbo' drill rig and an Eimco 630 Loader for the cleaning has been achieved at Beatrix Number 3 Ventilation Shaft.

Conclusions

The use of STDC initiation systems in South Africa has shown to provide a number of benefits to the shaft sinking cycle, resulting in improved efficiency for both Cementation Mining of South Africa and their customers.

The benefits provided by the use of STDC systems will result in it becoming the preferred system used by Cementation Mining in their sinking operations. ◆

Canadian company announces a new testing facility in South Africa to serve the African mining industry*

Lakefield Research Limited have announced the launch of Lakefield Research Africa (Pty) Limited, a new commercial testing facility located in Johannesburg, South Africa. This addition to the Lakefield group of companies has been made to better meet the needs of our clients, operating around the world in a truly global industry. The new testing facility will work in close co-operation with Lakefield Research's world-class testing facility located in Lakefield, Ontario, Canada, and will complement Lakefield's other international operations in Chile, Brazil and Peru.

Lakefield Research Africa (Pty) Limited resulted from the recent signing of an agreement with Gold Fields Mining and Development of Johannesburg, South Africa, to purchase Gold Fields Laboratories (Pty) Limited. Lakefield Research Africa (Pty) Limited will use its facilities in Johannesburg to provide high quality technical support to the mining industry in Africa.

The Johannesburg laboratory is fully staffed with experienced and capable professionals and can immediately offer a wide range of metallurgical, analytical, mineralogical and environmental testing and consulting services.

The metallurgical testing facility is well equipped, and can offer bench scale testing or pilot plant capabilities for a broad range of extraction metallurgical processes. It can conduct most standard mineral dressing tests, including crushing, milling, screening, flotation, gravity concentration and magnetic and electrostatic separation. Hydrometallurgical capabilities are available for atmospheric, pressure and bacteria-assisted leaching, solvent extraction and electrowinning. Pyrometallurgical equipment allows for small scale roasting, smelting and fuming tests.

The analytical laboratory facilities support the metallurgical testing, and also offer custom analytical services to clients in the exploration, mining and metallurgical fields. A broad range of classical wet and dry analytical techniques and instrumental methods are available, including precious metals by fire assay, XRF techniques, and AAS. A special section of the laboratory is devoted to the comprehensive analysis of environmental samples, such as soils and natural and treated water.

The mineralogical services group is a particular area of strength, with significant expertize in ore characterization, process mineralogy and QEM*SEM investigations.

Lakefield Research Limited is a management and employee owned firm with over 55 years experience. Lakefield provides a full range of metallurgical, analytical, mineralogical and environmental testing and consultant services. With over 400 employees in Canada, Brazil, Chile, Peru and South Africa, Lakefield Research is well positioned to provide diversified services to international mining firms. ◆

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De Beers appoints new director*

Mr Louis Nchindo has been elected to the Board of Directors of De Beers Consolidated Mines Limited.

Louis Goodwill Nchindo is managing director of Debswana Diamond Company (Proprietary) Limited. Born in Botswana on 30 November 1941, Nchindo attended Oxford University where he obtained a BA (Hon.) in Politics, Philosophy and Economics. He joined Anglo American Corporation in Botswana in 1974 and became chairman of that company in January 1980. He is also currently chairman of the Botswana Stock Exchange and of Morupule Colliery, and a director on the Boards of De Beers Prospecting Botswana, Diamond Corporation Botswana, and Botswana Diamond Valuing Company.

Nchindo is married with four children. He is a keen conservationist and is a founder member and chairman of the Kalahari Conservation Society. ◆

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