Chapter 22

Blasting consumable and accessories

22.1 INTRODUCTION

To engineer a blast in a mine, apart from the main explosive, many additional items are required. Collectively all these are referred to as accessories. These can be divided into three categories viz. consumables, instruments and tools.

Very careful selection of the accessories is essential so as to perform the blasting operation safely, smoothly and with minimum hazards.

In this chapter the various accessories needed in surface blasting operations have been described to the necessary depth.

It is to be clearly understood that the variety available in blasting accessories is so wide that it is almost impossible to give details of everything available. Manufacturer's representatives do give information about their own and occasionally their competitor's products. This information must be used intelligently in proper selection.

22.2 BLASTING CONSUMABLES

Consumables used in a blast are: a booster cartridge, a primer cartridge, initiation transmission line (ITL), a detonator, and stemming material. Placement of these items in a blasthole is as shown in Figure 22.1.

Of these, the primer and boosters are meant to amplify the energy generated by the detonation of the detonator.

The most commonly used explosive in primer or booster cartridges is Pentolite which is a mixture of PETN and TNT, usually in the proportion of 50%:50%. Primers and booster cartridges typically have a density of 1.55 to 1.7 g/cc. They have excellent water resistance and detonation velocity ranging between 6000 to 7600 m/s. Often other explosives such as dynamite, water gel/slurries or emulsions are also used in primer or booster cartridges.

Both primers and boosters are available in cartridge form as shown in Figure 22.2. Such cartridges are made from casting the explosives in the pre-formed cartridge shells of lined paper.

A primer cartridge typically has one through hole and one well within it. The well is meant to accommodate the detonator and the through hole is meant to carry the ITL from the bottom side of the detonator to the ground, where it is connected to the main ITL that leads to an initiating device.

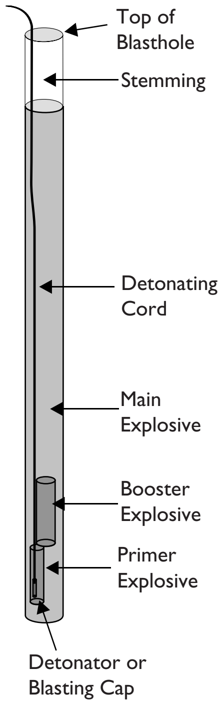


Figure 22.1 A charged blasthole.

Primer Cartridge | Booster Cartridge

Figure 22.2 Primer and booster cartridges.

Some manufacturers make a primer cartridge with embedded detonator. In such cases the cartridge may have only one through hole or no hole at all because the ITL can be taken up through the gap between the cartridge and the blasthole wall.

Depending upon the design of a blast, multiple primers can be used in a blasthole to detonate different sections of intentionally separated explosive charges.

A detonator should be inserted in a primer just before insertion of the assembly in the blasthole for the sake of safety.

If a hole is to be made in a primer cartridge, only non-sparking implements must be used for the purpose so the danger is minimized. Such a hole must be at the center of the cartridge cross section.

Booster cartridges may have only one through hole to carry the ITL through them. Boosters to be used in large blastholes do not have any through hole at all because there exists sufficient gap between the booster cartridge and the wall of the blasthole for the ITL to pass through. Since the booster is invariably placed in the vicinity of the primer, detonation of the primary cartridge automatically detonates the booster also. Thus, the booster cartridge does not need an additional detonator.

Typical placement of a detonator in a primer cartridge is shown in Figure 22.3.

22.2.1 Initiation transmission line

A primer cartridge is always detonated by an initiating device, placed at a very great distance for the sake of safety. It is, therefore, very essential to transmit the initiating pulse from the initiating device to the detonator through a line called the Initiation Transmission Line and abbreviated as ITL. Three types of ITL are used for engineering a blast in mines. They are:

1 Safety Fuse for Transmitting Fire
2 Electric Transmission Wires
3 Detonating Cord for Transmitting Shock

22.2.1.1 Safety fuse for transmitting fire

This is the oldest ITL device. It consists of black powder wrapped in a textile tube so it remains in continuity and is protected from mechanical shocks and abrasion. For protecting it from water or moisture, a waterproofing layer surrounds the textile tube. A flame is used to ignite the safety fuse at one end. The fire travels towards the other end at a burning rate of about 7.5–10 mm/s.

Safety fuse is used when only a few blastholes are to be blasted by using low explosive, as in secondary blasting. The propagating fire does not have sufficient energy to cause detonation of modern high explosives.

Igniter cord is very similar to safety fuse but burns at a rapid rate of 1 to 3 m/s. The core of igniter cord is a pyrotechnic powder mix.

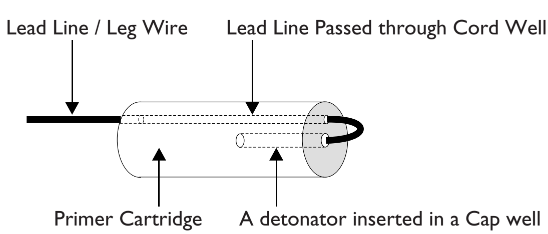


Figure 22.3 Placement of detonator in a primer cartridges.

22.2.1.2 Electric transmission wires

As the name indicates this ITL transmits electric impulses through conductor wires. The conductor wires are normal copper wires used in house electrification.

The electric current required to be passed through the wire to cause ignition is called the ignition current. It can be as much as 25 A.

Electric circuit analysis has to be done to ensure that the blast takes place as planned. To ensure that the wire transmits the electric current surge without burning, wires of adequate gage are chosen.

Table 22.1 gives details of some conductor wires used in large surface mine blasts. Values of resistance mentioned in this table are required to be used in the absence of more authentic values specified by the manufacturer.

22.2.1.3 Detonating cord for transmitting detonation

Detonating cord is meant to transmit a detonation wave. It is made up of a plastic tube with 3 mm outside diameter. The inner diameter of the tube is 1 mm. It is usually filled with PETN in uniform density. When a detonation is initiated at one end of the tube it travels towards the detonator at a speed of 6500 m/s.

The plastic material of the tube has sufficient tensile strength to ensure that it can be easily lowered into a deep blasthole without breaking and has sufficient radial stiffness so it usually does not burst when the shock wave is traveling within it. However, such things depend upon the material density per meter in the detonating cord. Therefore, the manufacturer should be consulted in this regard.

Some bulk explosives, when used in small diameter blastholes, are rather sensitive to the compression caused by the detonating cord. If such is the case, shock tubes described in the next section can be used in the blasthole, in conjunction with detonating cords laid on the ground surface.

Detonating cord as described above is meant to be attached to a detonator. Detonation in the detonation cord at the free end can be initiated through a No. 6 Detonator.

Detonating cords with higher explosive contents must be used for trunk lines that run on the ground surface towards the initiating device. Specifications of some

Table 22.1 Conductor wires used in large surface mine blasts.

Gauge no.	*Diameter of wire in mm*	*Resistance in mΩ/m*	*Maximum permissible current in A*
6	4.1148	1.295928	37
8	3.2639	2.060496	24
10	2.58826	3.276392	15
12	2.05232	5.20864	9.3
14	1.62814	8.282	5.9
16	1.29032	13.17248	3.7
18	1.02362	20.9428	2.3
20	0.8128	33.292	1.5

such detonation cords, made by Explosia S. A. of the Czech Republic are given in Table 22.2.

Table 22.3 gives the recommendations for use of detonating cords with various explosive contents.

The detonation cord makes a lot of noise when the detonation wave travels through the tube. It is therefore necessary to cover the detonating cord laid on ground surface by sandy earth. To ensure complete detonation, a double trunk line or loop system must be used to connect holes in the blast.

Cutting detonation cord with a knife is safer than shearing it off by using pliers or wire stripper.

22.2.1.4 Detonating cord for transmitting shock

This is more often called a shock tube.

In this type of detonating cord a tube made from very special plastic is used. The inner surface of the tube is coated with a fine layer of a high explosive, usually HMX, and a very fine powder of aluminum. The explosive is held on the tube wall by a static charge. When sufficient shock and ignition is delivered to the tube, the dust explodes and the detonation is propagated through the tube in a fashion similar to a coal dust explosion in an underground mine. The tube is very insensitive to impact and atmospheric heat. The shock wave can be caused only by a special pistol-like device. The shock wave travels through the tube at a speed of about 2000 m/s.

Table 22.2 Specifications of commonly used detonating cords.

Cord name	*Color*	*Explosive contents in g/m*	*Velocity of detonation m/s*	*Outside diameter in mm*	*Tensile strength in kg*
Starline 6	Red	6.0 ± 1.0	6500	min 3	50
Starline 12	Green	12.0 ± 2.0	6500	5.0 ± 1.0	60
Starline 15	Blue	15.0 ± 2.0	6500	5.2 ± 1.0	60
Starline 20	Yellow	20.0 ± 2.5	6500	6.6 ± 1.0	70
Starline 40	Orange	40.0 ± 4.0	6500	8.7 ± 1.5	75
Starline 80	Ultraviolet	80.0 ± 8.0	6500	11.5 ± 2.0	75
Starline 100	Ultraviolet	100.0 ± 10.0	6500	13.0 ± 2.0	75

Table 22.3 Recommendations for use of detonating cord.

Cord explosive contents g/m	*Recommended application*
1.5–3	Initiation of Primers and Very Sensitive Explosives
6	Trunk Lines Connecting Blastholes
12–20	Initiation of Conventional and Low Sensitivity Explosives
40	Seismic Exploration
80–100	Contour Blasting and Demolition

Non-electric detonating cords, particularly the shock tube, must be handled very carefully to ensure that they are not subjected to any shock, excessive heat, impact etc., as however insensitive the tubes may be, they must be handled carefully to avoid any inadvertent explosion. They should also not be pulled or stretched unduly.

22.2.1.5 Hercudet tube for transmitting fire

In this system the transmission tube is a simple plastic hollow tube, about 4 mm outside and 2 mm inside diameter. It does not contain any explosive or metal. By means of special straight or elbow connectors the tube forms an airtight circuit, much similar to household piping. Hercudet detonators are a part of such a circuit. When the circuit is completed it is first checked for air-tightness by pumping compressed air into it. Once it is confirmed that the circuit is airtight for pressure up to about 300 kPa, gaseous oxidizer and gaseous fuel mixture is fed into the circuit. When the circuit is completely filled with the mixture the gas is ignited. The fire travels throughout the circuit at a speed of about 300 m/s to detonate all the detonators in the circuit.

22.2.2 Detonator

A detonator is often referred to as an initiating device because it initiates the detonation process in a blasthole. It contains a primer and a secondary explosive. The primer is usually a mixture of lead azide, lead styphnate and aluminum powder abbreviated as ASA. Some manufacturers use DDPN i.e. diazo-dinitro-phenol so as to reduce air pollution by lead. PETN or Pentolite is used as the secondary explosive. With such sensitive explosives, detonators become sensitive and are more prone to accidental detonation. They must be handled very carefully.
There are three basic types of detonators as under:

1 Electric
2 Non-electric
3 Electronic

The above classification is based on the source of energy used for starting detonation in the detonator. All three types of detonators can be instantaneous, or with a delay element built into them.

Usually detonators are made to have a strength level of 6 or 8. Both these contain 0.2 g of ASA. The No. 6 contains 0.22 g of PETN, whereas the No. 8 contains 0.45 g of PETN.

The length of No. 6 detonator is about 35 mm, whereas for No. 8 detonator it is about 42 mm.

22.2.2.1 Delay element

A delay element is in the form of a small tube filled with densely packed pyrotechnic material, usually antimony and potassium nitrate or red lead and silicon. One end of the element is in contact with the primary explosive and the other end is in contact with the initiating element such as an electric spark/heat generator or shock wave transferred by the detonating cord. The pyrotechnic material transfers the fire from one end to the other at a specific speed, which is either 3.3 s/m or 33 s/m (303 mm/s to 30.3 mm/s). Thus, depending upon its length, the delay element delays the detonation of the explosives in the detonator by few milliseconds. Delay elements are also available for insertion between detonation cords.

Commonly used delays are either from short delay series or long delay series. Information about delays is given in Table 22.4. Delays available may differ from manufacturer to manufacturer.

Consideration must be given to factors such as length of explosive column, blasthole diameter, burden, spacing, type of rock and whether the blast is for bench, underground mine, tunnel, shaft etc.

22.2.2.2 Electric detonators

Electric detonators cause the initiation of detonation by an electric current passed through the detonators by electric wires. They have an outer aluminum or copper shell that contains primary and secondary explosives, insulation material, two wires and a delay element if applicable.

Use of an aluminum shell is prohibited in gassy underground mines because it generates a very high quantity of heat and causes high brisance.

Most electric detonators have a diameter of 7 mm.

Table 22.4 Timings for available delays for electric detonators.

	Nominal time in seconds for	
Delay number	*Short delays*	*Long delays*
0	0	0
1	0.5	25
2	1.0	50
3	1.5	75
4	2.0	100
5	0.5	125
6	3.0	150
7	3.5	175
8	4.0	200
9	4.5	225
10	5.0	250
11	5.5	300
12	6.0	350
13		400
14		450
15		500
16		550
17		600
18		650
19		700
20		750

Many developments have taken place in the technology of electric detonators ever since the early modern type detonators made by Gardiner and Smith in 1875. Three different types of electric detonators used in mining blasts, as described here below, have evolved through such developments.

1 Solid Pack Electric Detonator
2 Fusehead Electric Detonator
3 Exploding Bridgewire Detonator

All these use electric current in a different manner to initiate detonation.

Technical specifications of a typical electric detonator are presented in Table 22.5. They are self explanatory and hence not described.

22.2.2.2.1 Solid pack electric detonator

The construction of a solid pack electric detonator is shown in Figure 22.4. As shown there, these detonators contain both primary and secondary explosives. A thin metal

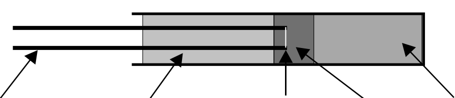


Figure 22.4 Construction of a solid pack electric detonator.

Table 22.5 Technical specifications of an electric detonators.

Specification category	*Aspect of the detail*	*Detail*
Classification	Indian Explosive Rules 1983	Class 6, Division 3
	UN Number	0030
Shell	Material	Aluminum
Specification	Length	42 mm
Detonator	Strength	No. 8
Specifications	Leg Wire Color	White/ White (For all wire lengths)
	Leg Wire Lengths in m	1.8, 3.0, 4.0, 5.0
	Leg Wire Material	Steel
	Leg Wire Diameter	25.5 SWG
	Leg Wire Resistance in ohm/m	0.5 to 0.8
	Fuse Head Resistance	1.6 to 2.2 ohm
	Firing Impulse	3.2 milliwatt.second/ohm
	Firing Current	1.2 A DC for Series 0.8 A DC for Single
	No-Fire Current	0.18 A applied for 300 seconds

wire, called a bridgewire, embedded in the primary explosive, is used for passing electric current. Bridgewire is made from an alloy comprising nickel, chromium and iron. The current heats up the bridgewire and causes detonation of the primary explosive. This in turn causes detonation of the secondary explosive. Later, the main explosive in the blasthole is detonated by the energy released.

Solid pack electric detonators can have a built-in delay element.

22.2.2.2.2 Fusehead electric detonator

In this type of detonator the two ends of the current-carrying wires have a small sheet of insulating material between them for added safety against static electric currents. The bridgewire is soldered across the sides of the insulating sheet. The complete assembly is then dipped in a mixture of potassium chlorate, nitrocellulose and charcoal to form the fusehead.

The fusehead is inserted in a container that has an adequate quantity of primer, and booster explosives and a delay element if required. The mouth of the cap is then sealed. In this manner the fusehead, delay element and cap filled with explosives can be made separately to reduce danger.

A typical fusehead electric detonator is shown in Figure 22.5.

22.2.2.2.3 Exploding bridgewire detonator

The construction of an exploding bridgewire detonator is very similar to that of a solid pack electric detonator. However, the bridgewire in this case is very thin, i.e. about 0.04 mm in diameter. These detonators are to be detonated by high voltage electric charge. Such high voltage electric charge quickly vaporizes the wire rather than heating it. For this reason the exploding bridgewire detonators are far more instantaneous than the solid pack or fusehead type where a little time in some ms is needed for their heating to the requisite temperature.

Apart from being instantaneous in their action, the exploding bridgewire detonators also require high voltage for detonation. Since such voltage is not generated by static electricity, their field use is safer.

Construction of a typical bridgewire detonator is shown in Figure 22.6.

As stated earlier, to ensure that sufficient electric current passes through the electric detonators to cause their detonation, electric circuits containing detonators and conductor wires have to be analyzed. Details of resistance to electric current flow offered by conductor lines has been given through Table 22.1. The resistance offered by electric blasting detonators and the wire attached to them can be found from Table 22.6.

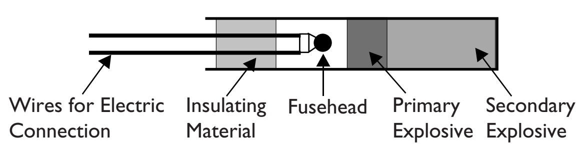


Figure 22.5 Construction of a fusehead electric detonator.

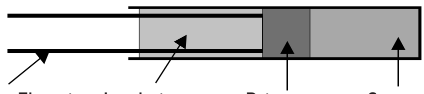


Figure 22.6 Construction of an exploding bridgewire detonator.

Table 22.6 Resistance of electric blasting detonators.

Length of conductor wire in m (ft)	*Copper wire conductor*		*Iron wire conductor*	
	Instantaneous detonators	*Delay detonator*	*Instantaneous detonators*	*Delay detonator*
(4)	1.26	1.16	2.1	2.0
(6)	1.34	1.24	2.59	2.49
(8)	1.42	1.32	3.09	2.99
(10)	1.50	1.40	3.59	3.49
(12)	1.58	1.48	4.09	3.99
(14)	1.67	1.57	4.58	4.48
(16)	1.75	1.65	5.08	4.98
(20)	1.91	1.81	6.06	5.98
(24)	2.07	1.97		
(30)	2.15	2.06		
(40)	2.31	2.21		
(50)	2.42	2.32		
(60)	2.59	2.49		
(80)	2.71	2.61		
(100)	3.11	3.01		

22.2.2.3 *Non-electric detonators*

Non-electric detonators are also called plain detonators. They are fired by detonating cord instead of electricity.

As shown in Figure 22.7, a non-electric detonator consists of a plastic shell filled with primary explosive, secondary explosive and a delay if applicable, and a certain length of detonating cord.

The construction of a non-electric detonator is shown in Figure 22.8. The shell has a long empty space, to accommodate one end of the detonating cord. To ensure that the maximum area of the core touches the delay element, the detonating cord is cut in a plane perpendicular to its length. Upon this the aluminum shell is crimped onto the cord so the detonator becomes waterproof and firmly fixed onto the detonating cord.

Figure 22.7 Non electric detonator with detonating cord.

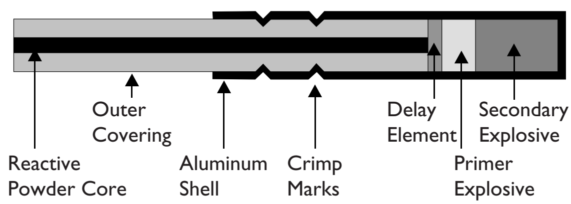


Figure 22.8 Construction of a non electric detonator.

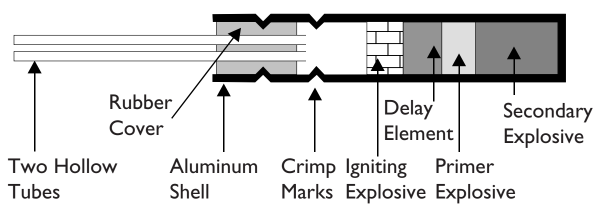


Figure 22.9 Construction of an hercudet detonator.

The Hercudet detonator to be used in The Hercudet system is somewhat special. As shown in Figure 22.9 it contains primary and secondary explosive and additionally a very sensitive igniting explosive. Two gas tubes go inside the detonator. These two tubes facilitate filling the complete circuit with gas.

22.2.2.4 Electronic detonators

As the microelectronic circuits became available easily and cheaply, electronic initiating systems were made by using them. Like electric initiating systems, these systems also use a detonator and electric wires but the detonator in an electronic system works on the basis of digital signals emanating from the initiation device located at a long distance on the ground rather than by electric current. A typical electronic detonator looks like the one shown in Figure 22.10.

The most important feature of an electronic initiation system is that it can be tested in the field without causing actual detonation. Appropriate measures eliminate the possibility of any misfire i.e. explosive in a blasthole not getting detonated along with other blastholes.

In an electronic detonator when the current from the wires enters first, the voltage of the current is evaluated by the over-voltage protection circuit. When the current is within the acceptable range of voltage it is allowed to go further to the integrated circuit chip which actually controls the further sequence of actions. In the case of higher current the protection circuit burns but no detonation is caused by such burning.

Once the current is allowed to pass to the integrated chip, the signals coming from the blasting machine located at far distance are interpreted and only upon receiving a specific code is the capacitor in the detonator allowed to become charged. When the capacitor is charged adequately, the integrated circuit sends a ready signal to the blasting machine. The machine gives an indication about readiness of all the detonators for blasting, and the blasting machine operator can then send a very specific signal to initiate the blast by the release of charge from the capacitor after a preset delay.

The electronic initiation system is considered to be the safest amongst all the initiating systems. Of the numerous advantages of the electronic initiation system, the following are a few:

1 The detonators do not have any energy of their own and therefore no accidental detonation can take place.
2 The integrated circuit must receive specific signals to start a further chain of actions.
3 Pre-detonation testing of the complete blast is possible.
4 Delay timing of any of the detonators can be changed by means of a computer program contained in the blasting machine without actual replacement of the detonators.
5 The initiation system operates on low voltage – usually less than 50 V. It is thus intrinsically safe as the danger of current leakage is low.

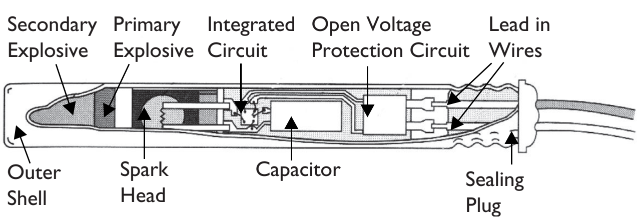


Figure 22.10 Construction of an electronic detonator.

6 The wired round won't fire until all detonators in the circuit are properly accounted for with respect to the current blasting plan layout.
7 Because of the unique design and construction of electronic blasting systems, each must be used according to the manufacturer's instructions.

Electronic initiation systems (electronic detonators) cannot be initiated by a conventional blasting unit, nor can they be activated without entering proper security codes. However, electronic detonators are still susceptible to initiation by lightning, fire, and impact of sufficient strength. Therefore, they must be properly transported, stored and handled as an explosive.

22.3 BLASTING INSTRUMENTS

Apart from the consumables discussed in the previous Section, many instruments and tools are required to be used by a blaster to connect and test the blast circuits in the mine bench. Collectively these are called accessories.

Blasting instruments are of three types as under.

1 Testing Instruments
2 Initiating Instruments
3 Measuring Instruments

Details of these are given here below.

22.3.1 Testing instruments

Every non-electric, electric or electronic circuit, whichever the mode of blasting circuit may be, must be thoroughly tested before initiating the blast. Besides this, the area of blasting must also be surveyed for extraneous current, static voltages and voltages in the nearby power lines. Two very commonly used instruments for this purpose are a Blaster's multimeter and Blaster's ohmmeter.

22.3.1.1 Blaster's multimeter

A Blaster's multimeter is shown in Figure 22.11. It is used to measure voltage, resistance and current in various parts of the blasting circuit.

Blaster's multimeters have better accuracy than commonly used multimeters. Their current delivering range is also wider so they can give higher current when all the detonators in the circuit need it and give very small current when only one detonator is to be tested safely i.e. without detonating it.

22.3.1.2 Blaster's ohmmeter

Sometimes an ohmmeter is preferred by blasters as they are usually more accurate than multimeters for measurement of resistance. Such measurements of the following aspects are of vital importance.

Blaster's Multimeter   Blaster's Ohmmeter

Figure 22.11 Blaster's multimeter and ohmmeter.

1 To determine if the bridgewire of an individual detonator is intact
2 To ensure that the electric detonator circuit has continuity
3 To locate broken wires and connections in a series, or series-in-parallel, circuit

A Blaster's ohmmeter is shown in Figure 22.11.

22.3.1.3 Blaster's tagger

A tagger is a testing instrument used in conjunction with electronic blasting systems. It is shown in Figure 22.12. It is used to send a signal created through pushing its buttons, much like a calculator. The signal is sent through the electric circuit. It is picked up by a particular electronic detonator in the circuit for which it is meant.

The tagger can be used to test an individual detonator, or a part of the blasting pattern, or the entire blast circuit. The tagger, together with blast box, enables initiation of the blast from a long distance. Easy-to-follow screen menus lead the blaster through all on-bench and firing operations.

22.3.2 Initiating instruments

An initiating instrument is an instrument that actually causes an action that leads to detonation of the detonator in the main explosive.

In the primitive days of mine blasting it was a simple match stick. As the main explosives used for mine blasting became more and more insensitive for the sake of safety, the need arose for more sophisticated devices.

An initiating device naturally depends upon the ITL used for the blasting circuit. Generally five different types of initiating devices are used.

1 Safety Fuse Initiator
2 Electric Detonation Initiator
3 Detonation Wave Initiator

Figure 22.12 Tagger used for testing electronic blast circuits.

4 Shock Wave Initiator
5 Hercudet System Initiator

Details of these are as under.

22.3.2.1 Safety fuse initiator

Instances of the use of safety fuse are very rare. The blasts designed with safety fuse are also small, and usually limited to one or two small diameter very shallow blastholes. The safety fuse, even the fast varieties, transmit fire so slowly that a blaster can use special entertainment pyrotechnic fire sticks for starting the burning of the fuse and easily move away from the blast site.

22.3.2.2 Electric detonation initiator

Initiators used for initiating the detonation of electric detonators have the capability of imparting electric current to the blast circuit. This can be done in two ways. The first is the transfer of electricity generated by a small electric generator connected to the blasting circuit. The second is the discharge of electricity stored in capacitors and given to the blasting circuit.

22.3.2.3 Generator type blast initiator

This initiator is actually a small hand-driven generator that produces a direct current pulse to energize the detonator. In actual operation a handle in the machine is either pushed down or twisted. This action must be done very rapidly so the current generated is sufficiently high.

The generator-type machines are usually rated by the number of instantaneous, or delay, caps that they will successfully fire in a straight series. Under certain conditions this type of machine may be used to detonate series-in-parallel circuits, but should never be used for straight parallel circuits.

A typical generator-type initiator looks like the one shown in Figure 22.13.

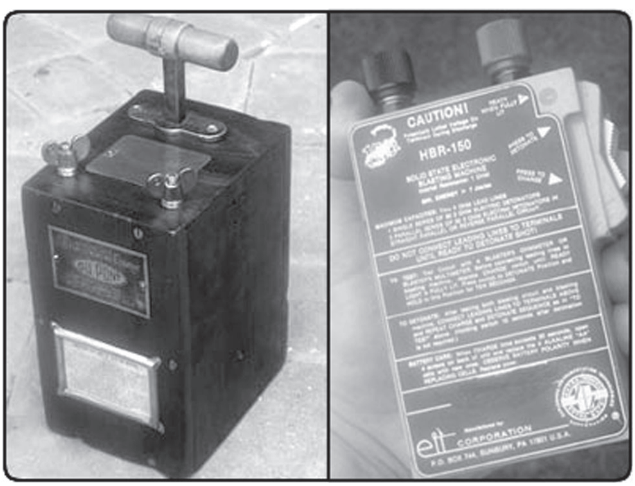
22.3.2.4 Capacitor discharge type blast initiator

Capacitor Discharge, (CD) type machines have one large, or a bank of many small, capacitors that store electric energy. Charging of these capacitors can be done by using a high voltage battery or through an oscillator connected to a low voltage battery. A switch on the machine is used for discharging the charge into the circuit very rapidly – within a few milliseconds.

CD-type blast initiators are small and yet powerful. They are very reliable in firing electric blast circuits. These initiators are rated in terms of voltage and energy. It is therefore essential to verify if the initiator is sufficient for the purpose.

The CD initiators must always be used as per manufacturer's recommendations. Frequent testing of these initiators from an approved tester is also necessary to ensure that the machine delivers its full output of energy.

Some CD-type initiators can energize many separate circuits one after another. They have a timer circuit that ensures the energization of each blast circuit after a time lag. For this reason the unit is called a sequential timer. This facility enables the



Generator Type Capacitor Discharge Type

Figure 22.13 Electric detonation initiators.

blaster to give a longer delay interval than that possible with the delays inserted in the detonators or circuits. They are very useful where it is necessary to limit the amount of explosives per delay in order to control noise and vibration.

Discharge type blast initiators must be used very carefully because the voltages can be in excess of 1000 V and can prove lethal.

A typical discharge type initiator is shown in Figure 22.13.

22.3.2.5 Detonation wave initiator

A detonation cord transmits a detonation wave. It must be initiated at one end. For such purposes a starter gun, as shown in Figure 22.14, is used.

The gun has an integral safety device and uses Shot Shell Primers No. 20 as a primer cap. It is a complete blasting machine, no other equipment being needed to initiate a Nonel tube.

22.3.2.6 Shock wave initiator

A shock wave initiator is more commonly called DynoStart, for it works with Dyno Nobel's Nonal System. It is shown in Figure 22.15.

The DynoStart blasting machine consists of an energy source, a voltage converter, a capacitor for energy storage, a voltage supervision circuit, an electrode and switches for control.

A common 9 V battery is used as a source of energy. Electronic energy is converted into a strong shock wave of high temperature which is applied inside the Nonel tube, by means of the electrode, giving reliable initiation.

22.3.2.7 Hercudet system initiator

In the Hercudet system it is very essential to check the air circuit before actually initiating the detonation.

For this purpose a special machine is used. It is connected to three separate cylinders of nitrogen, oxygen and gaseous fuel.

Figure 22.14 Nonal starter gun.

Figure 22.15 Nonel shock wave initiator.

For the purpose of testing, nitrogen gas is released into the circuit. It displaces the air and builds up pressure. If the circuit is leaky, the pressure reduces as the nitrogen escapes. After taking necessary remedial action and ensuring the circuit is leak proof, oxygen and fuel gas are mixed in appropriate proportions and are circulated through the circuit. The initiator then ignites the gas. The ignition travels through the circuit at a speed of about 2400 m/s and starts the detonation at the detonator.

22.3.2.8 Electronic blast initiator

An electronic blast initiator is used to compose a computer program-like listing that controls the complete blast. Almost every aspect of the blast such as the day, time etc. of the blast, the detonation sequence, the delay intervals, instructions to the operator at every stage of the program, automatic alarm signals etc. can be fed to the initiator.

As the machine has password protection, and a very specific physical as well as computer-coded key the level of safety in blasting is highest.

22.3.3 Measuring instruments

Different types of instruments are required to be used on a blast site for measuring various parameters related to a blast. The following are a few.

1 Hot Hole Meter
2 Burden Measuring Instrument
3 Seismograph
4 VOD Meter
5 High Speed Camera

Details of these are as under.

22.3.3.1 Hot hole meter

On some occasions steam flows into the blasthole from the ground. By how much the temperature of the air in the blasthole rises depends upon many factors.

However, the temperature at the point of intrusion can be as high as 100°C or so. Some explosives, particularly ANFO, are very sensitive to heat and can detonate at such temperatures.

A hot hole meter is a small measuring instrument as shown in Figure 22.16, which when lowered into the blasthole, keeps on measuring the temperature through its thermocouople. It gives warnings at preset temperatures so the blaster can decide in advance about the additional precautions to be taken in charging the blastholes.

22.3.3.2 Burden measuring instrument

Measurement of burden as done by the laser measuring instrument, as described in chapter 6 of this book, was rather indirect because it was computed from the observations made through the instrument. A sonic device can do direct measurement.

Figure 22.16 Hot hole meter.

The sonic device has two components viz. a probe and a detector. The probe is lowered in the blasthole to a desired depth and switched on to emit sonic waves. The detector is kept in contact with the bench face at the appropriate point. It receives the sound waves. From the characteristics of the sound wave received the distance between probe and detector can be calculated.

22.3.3.3 Seismograph

A seismograph system is meant to measure the properties of ground vibrations as well as the sound waves caused by a mine blast.

A typical seismograph system looks like the one shown in Figure 22.17. It consists of a microphone, a geophone and main receiver and analyzer unit. The geophone is buried in the ground to a depth of about 200 mm in a particular way at the point of measurement, so the ground vibrations are received clearly. The microphone is also kept at the point of measurement with as clear a passage as possible for the sound waves.

Once all the connections to the receiver unit are made, the system is switched on two to five minutes before the expected time of blast. When the blast occurs the resulting ground vibrations and sound waves are recorded.

The data gathered can be subsequently analyzed to determine the safe distance for construction of houses etc., or the effects of blast on existing structures.

Figure 22.17 A seismograph.

22.3.3.4 VOD meter

Different techniques for determining the velocity of detonation have been amply described in chapter 21 of this book. An actual instrument used for one type of VOD measurement is shown in Figure 22.18.

Figure 22.18 A VOD meter.

22.3.3.5 High speed camera

A high speed camera is shown in Figure 22.19. Such cameras are capable of filming at a speed of even 1 million frames per second. For most of the applications in mining a speed of 10000 frames per second is sufficient. In other words a camera with this speed photographically records events at every ten thousandth of a second.

Such photographs are of great help in many different types of measurements.

22.4 BLASTING TOOLS AND MISCELLANEOUS ITEMS

Once all blastholes are drilled, first a blaster has to check many things related to charging and then connect all the blasting components required to form a circuit. For this purpose he has to use many tools.

Most of such tools have been described in Table 22.7 and some of them are shown in Figure 22.20.

Figure 22.19 High speed camera.

Table 22.7 Blasting tools and miscellaneous items.

Name of the tool	*Brief description*
Air Horn	Air horn makes sufficiently harsh sound to draw attention of persons at long distance. This proves useful on mining bench where giving adequate warning to people is very important.
Binoculars	Binoculars prove very handy in viewing distantly placed objects.
Ceramic Knife	This knife is to be used for cutting a cartridge of explosive. The knife must be made from ceramic materials so it does not emit any spark and eliminates the chance of inadvertent detonation.

(*Continued*)

Table 22.7 (Continued)

Name of the tool	*Brief description*
Crimper	This is a plier-like tool used for firmly crimping detonating cord or shock tube into a detonator.
Depth Gauge or Water Level Indicator	This consists of a hard plastic tube bound to a flexible measuring tape in such a way that graduations on the tape indicate the depth at which the bottom of the tube lies. At the bottom of the tube an electric circuit closes when the bottom touches the top of the level of water in the blasthole. This gives alarm to the user and he can measure the depth of water level. The markings on the tape are covered by abrasion resistant transparent material.
Goggles	These prove more comfortable than safety glass in bright sunlight.
Helmet or Hard Hat	One of these two items is very essential by a blaster and particularly driller or his assistant. It protects head from falling or flying objects.
Leather Gloves	Leather gloves are used by the blaster to ensure that his hands are protected from the injuries that may arise while working in the field.
Level	This is much like a surveyor's level but somewhat less sophisticated. It is used to measure vertical angles. Due to vernier caliper arrangements they can read angles correctly up to $0.1°$.
Lighting Forecast System	Many systems, that reliably give early warning of stormy weather and lighting, are available. In most of the mining projects this system is installed at the site office.
Measuring Tape	Special abrasion resistant measuring tape made from unstretchable nylon has to be used for measuring distances like burden, spacing etc.
Plexi Mirror	This is a simple aluminum polished or mercury-backed mirror with transparent abrasion resistant coating. It is used to reflect sun rays inside the blasthole. Inner side of the blasthole becomes distinctly visible by the bright sunlight.
Portable Weather Radio	It is very important to know the weather forecast before laying the blasting circuits on a bench because rain, storm etc. can greatly affect the blasting operations. Usually portable weather radio gives weather forecast in more details than predicted through the video news channels. Before relying upon the information broadcast one must verify if the information is applicable for the mine site as it may by far away from the broadcast station.
Safety Cones	Safety cones are required by a blaster to mark the prohibited area when no one is allowed to enter as some operation related to explosive loading is in progress.. These safety cones have a very wide base and are the same as those used for temporarily marking road divides.
Sound Meter	A sound meter measures the sound level of a blast by using more than one sound meters it is possible to extrapolate the sound level at a farther distance away from the origin of the blast.
Stemming Rod	This is a hollow tube of hard plastic with hard plastic caps at both the ends. It is used for tamping explosive in blasthole.
Wood Pricker	When it is necessary to make a hole in the explosive cartridge a non metallic wood pricker is used. It looks like a screw driver and has a ceramic rod on the front. When pushed inside a cartridge it makes a hole without sparking.

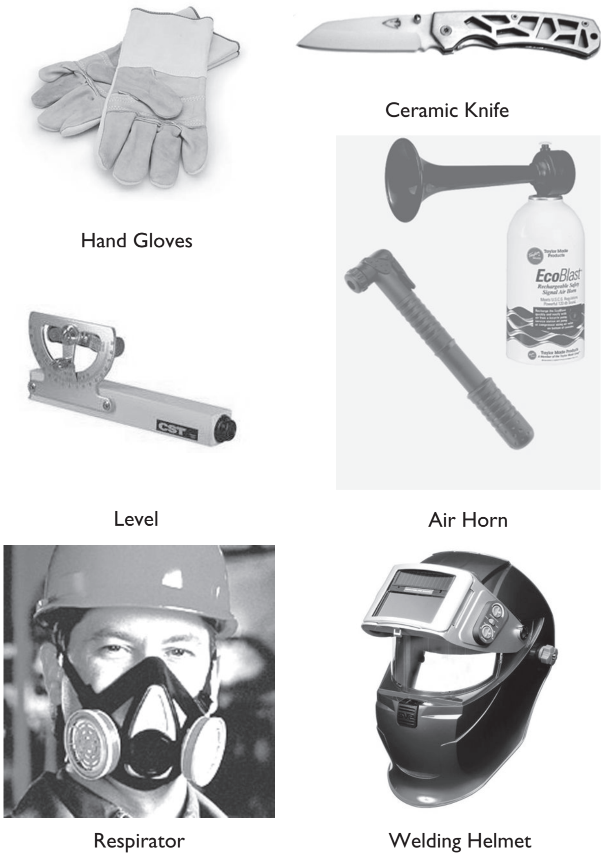


Figure 22.20 Some blasting tools and miscellaneous items.