5.0. TYPES OF EXPLOSIVES AND INITIATING DEVICES THAT ARE USED BY THE NCF.

5.1. EXPLOSIVE TYPES.

5.1.1. M-1 Dynamite. The M-1 military dynamite is a Cyclotrimethylene Trinitramine (RDX) based composite explosive containing no nitroglycerin. The M-1 military dynamite is packaged in 1/2 pound, paraffin-coated, cylindrical paper cartridges which have a nominal diameter of 1.25 inches and nominal length of 8 inches. It will not freeze in cold storage nor exude in hot storage. The composition does not absorb or retain moisture. Shipping containers do not require turning during storage. It is safer to store, handle, and transport than 60 percent commercial dynamite. It is reliable underwater only up to 24 hours. Because of its low sensitivity, sticks of military dynamite must be well compacted to ensure complete detonation of the entire charge. There must not be any voids in loading of boreholes in quarrying. Military dynamite will eventually detonate if set afire in a confined space. Thus, a secondary explosion can result from a borehole with a void in its loading. After the first blast, it may take up to 15 minutes for such an explosion to occur.

5.1.2. Water Gel. The term 'WG explosives' will be used to describe water gel explosives. WG explosives prove to be much safer than dynamite, they contain no nitroglycerin, are sensitive to conventional priming methods, yet much more resistance than dynamite to accidental initiation from abusive impact, shock or fire. Some other advantages are:

- Greater control of borehole density. The borehole density of WG explosives can be greatly increased by slitting or tamping the cartridge.
- Excellent fragmentation.
- Minimized danger of hole to hole propagation.

- Reduced smoke and toxic fumes.
- Elimination of nitroglycerin effects.
- Water resistance.

WG explosives are packaged in a heavy rugged film in diameters from 1 1/2 to 4 inches, and lengths up to 16 inches. They are available in both cap sensitive and non-cap sensitive.

5.1.3. Ammonium Nitrate (ANFO). Free running ammonium nitrate field mixes are ideal for use in highly jointed and dense material. The mixture ratio is critical to the sensitivity of the explosive. A field mix of 94 percent by weight of ammonium nitrate and 6 percent by weight of fuel oil (#2 Diesel) or 50 pounds of ammonium nitrate un-oiled prills and 3 quarts of fuel oil will produce an insensitive explosive capable of filling all the voids in the hole. It must be used in 3-inch or greater diameter holes, confined and adequately primed to develop full strength. The use of blasting agents in 3-inch or greater diameter holes is desirable in dense material due to its low velocity. It is insensitive due to the lack of nitroglycerin in its composition, and therefore requires a high explosive primer.

5.1.4. Detonating Cord. Detonating cord is a core of Pentacrythritol Tetranitrate (PETN) or RDX in a textile tube coated with a thin layer of asphalt. On top of this is an outer textile cover finished with a wax gum composition or plastic coating. It will transmit a detonating wave from one point to another at a rate between 20,000 and 24,000 feet per second. A partially submerged water-soaked detonating cord will detonate if initiated from a dry end. Although it does not lose its explosive properties by exposure to low temperatures, the covering becomes stiff and cracks when bent. Great care is required in using detonating cord primers in Arctic conditions. Detonating cord can...
be used to prime and detonate other explosives charges. When its explosive core is detonated by a blasting cap or other explosive device, it will transmit the detonation wave to an unlimited number of explosive charges.

5.1.5. Detaprime. The development of ANFO products and WG explosives created a need for high-velocity, high energy primers. To meet this demand, compact, high-detonation pressure non-nitroglycerin primers were developed. These non-nitroglycerin primers are more resistant to accidental detonation from impact, shock, or friction than dynamite, but should be handled in the same safe manner as other explosives.

5.2. INITIATING DEVICES. Because all initiating devices are made to explode, they should be treated with the same care and caution used with all high explosives. They should not be physically abused, tampered with or altered in any manner or exposed to sources of extraneous electricity which might result in premature detonation and serious injury.

5.2.1. NONEL. Nonel is a small diameter plastic laminate shock tube coated with a very thin layer of reactive material. It burns at approximately 6500 feet per second. A nonelectric detonation cord initiator is used to initiate the shock tube. This shock wave will propagate through most sharp bends, knots and kinks in the tube. The detonation is sustained by such a small quantity of reactive material, the outer surface of the tube remains intact during and after functioning. NONEL shock tube cannot be initiated by high frequency radio transmissions, static or stray electrical rubber or plastic plug. The plug, securely crimped in the open end of the cap shell, forms a water-resistant closure and firmly positions the leg-wire ends inside the cap shell. The ends of the leg wires are joined together inside the cap by a short length of high-resistant wire called the "bridge wire", which is embedded in the cap's ignition mixture. When sufficient electrical current passes through the system, the bridge wire becomes hot enough to ignite the ignition mixture. In instantaneous electric blasting caps the ignition mixture causes the primer charge to detonate, subsequently detonating a high-explosive base charge. In a delay electric blasting cap the ignition mixture initiates the delay powder train which burns a predetermined time before igniting the cap's primer charge. The burning rate of the delay powder and the length of its column determine the time interval between application of the adequate electrical energy and the detonation of the cap. Blasting caps are available in both instant and delays with delay periods from a few milliseconds to more than 15 seconds. The use of delay blasting will improve rock fragmentation and displacement, provide greater control of vibration, noise and fly rock, reduce the powder factor and reduce blasting cost.
CAUTION: Electric blasting caps of different manufactures should not be used in the same series. Their ignition systems may not be electrically compatible and misfires may occur resulting in serious injury.

5.2.3. Nonelectric Blasting Caps. Nonelectric blasting caps, sometimes called fuse caps or ordinary blasting caps, provide a nonelectric method of initiating explosive charges when properly used in conjunction with safety fuse. The safety fuse conveys a flame at a relatively uniform rate to the blasting cap where it ignites the ignition charge. The Nonelectric blasting cap consists of an aluminum or copper shell approximately 1 3/8 to 1 3/4 inches long, loaded with three charges (fig 7):

- A base charge of High-velocity explosive in the bottom of the shell.
- A primer charge in the middle.
- A charge of ignition powder on the top

The ignition powder insures flame pick-up from the safety fuse, the primer charge converts the burning into detonation and ignites the high explosive base charge. The NCF uses #6 and #8 Nonelectric blasting caps.

CAUTION: Since the ignition powder is exposed in the open end of the shell, Nonelectric blasting caps should not be tampered with or abused in anyway. Such treatment can lead to premature detonation resulting in serious injury.

5.2.4. Safety Fuse. The safety fuse is used in general demolitions. The safety fuse consists of ammonium nitrate black powder tightly wrapped with several layers of fiber and waterproofing material. It may be any color, but orange is the most common. The burning rate may vary for the same or different rolls from 30 to 45 seconds per foot under different atmospheric and climatic conditions. The burning rate should not be less than 30 seconds per foot. A fuse burns appreciably faster when it is confined by tamping or some other means of confinement; the greater the confinement, the faster the burning rate. Conversely, a fuse burns more slowly when it is subject to reduced external pressure. Other factors being equal, a fuse will burn about 2 seconds per foot slower at an altitude of 5000 feet than at sea level. Although a burning rate of approximately 120 seconds-per-yard as measured unconfined at sea level is considered standard for commercial safety fuse in the United States, fuses with different burning rates are manufactured. Do not depend on all fuse burning at 120 seconds-per-yard. Testing each roll prior to using in the area where the charge is to be placed is required. Make sure to cut and discard a 6 inch length from the free end of the fuse to prevent a misfire caused by the exposed powder absorbing moisture from the air. Then cut off a minimum 6 foot length of fuse to check the most accurate burning rate. Take particular precautions if used underwater, as the rate of burning is increased significantly. Test each roll underwater before preparing the charge. It is important to know that the fuse burns at the core and not with its cover. However the cover may burn without the ignition of the core. When properly ignited, the core ignites with a jet of flame called the "ignition spit." This is a jet of flame that shoots out the end of the fuse the moment the powder core is lighted. This spit shows the core is lighted. PRACTICE UNTIL YOU KNOW THE IGNITION SPIT. Persons who do not recognize the ignition spit or who are misled by the burning of the cover have been killed or injured by trying to relight the fuse which has been ignited.

5.2.5. M60 Weatherproof Fuse Igniter. The M60 device is designed to ignite a safety fuse in all sorts of weather conditions, even underwater if properly waterproofed. The fuse is inserted through a sealing rubber grommet and into a split collet which secures the fuse when the end cap on the igniter is tightened. A pull on the pull ring releases the striker assembly, allowing the firing pin to drive against the primer, which ignites the fuse (fig 8).

CAUTION: Since the ignition powder is exposed in the open end of the shell, Nonelectric blasting caps should not be tampered with or abused in anyway. Such treatment can lead to premature detonation resulting in serious injury.

5.2.6. MS-Connectors. MS connectors are Nonelectric short interval, millisecond delay devices for use on delaying blasts which are surface initiated by det cord. MS connectors are made of a molded plastic sleeve, that contains a copper tube delay element in the center portion. Each end of the sleeve is made so the det cord can be looped and locked in the connector with a tapered pin. They are color coded for different time intervals:

- MS-9 (9 milliseconds) blue.
• MS-17 (17 milliseconds) green.
• MS 25 (25 milliseconds) yellow.
• MS 35 (35 milliseconds) red.
• MS 42 (42 milliseconds)
• MS 50 (50 milliseconds)
• MS 65 (65 milliseconds)
• MS 100 (100 milliseconds)

MS connectors are connected into the trunk line by cutting the trunkline at the desired location and bending the cut end of the cord into a 'U' shape. This loop is inserted into either end of the connector, making certain the cord contacts the metal tube, and pressing the tapered pin through the hole in the connector to secure the cord and to keep it in contact with the metal tube. The other end of the cut trunk line is put into the other end of the connector by repeating the same procedure.

Caution: Protect MS connectors from flame, excessive heat sparks, and accidental impact such as falling rocks or other heavy objects.

5.3. BLASTING EQUIPMENT AND ACCESSORIES. The blasting equipment used to test and fire the blast is an important part of any blasting operation and should be of excellent quality. This equipment must be maintained in top condition at all times. Never attempt to use a blasting machine or test instrument that is not in proper operating condition. All electric blasting equipment must be checked for proper operation prior to use.

5.3.1. Capacitor Discharge Blasting Machines. These machines have a capacitor, or bank of capacitors, that stores a large quantity of electrical energy supplied by dry cell batteries. The blaster can discharge the stored energy in the capacitors into the blasting circuit in a fraction of a second through the two terminal posts by pushing down a "firing" switch. Capacitor discharge (CD) blasting machines can fire many electric blasting caps in relation to their weight and size and are the most reliable firing means available.

![Diagram of M60 weatherproof fuse igniter.](image)

**Figure 8**

**IMPORTANT:**

READY-TO-FIRE LIGHTS AND/OR VOLTAGE METERS INDICATE FULL VOLTAGE ACROSS THE CAPACITORS. HOWEVER, THESE DO NOT PROVIDE A CAPACITOR CHECK AND, THEREFORE, DO NOT INSURE THAT THE MACHINE WILL DELIVER ITS RATED ENERGY OUTPUT. FREQUENT TESTING IS RECOMMENDED TO INSURE THAT THE MACHINE DELIVERS FULL ENERGY OUTPUT. SUCH TESTING CAN BE MADE BY A QUALIFIED ELECTRICIAN.

5.3.2. Push-Down Blasting Machine. The DuPont No.50 Blasting Machine is a push-down blasting machine which is designed to fire 50, 30-foot copper wire electric blasting caps in straight series. The No 50 machine can be used to fire more caps provided they are connected in series-in-parallel. Under the most favorable conditions this machine can fire a total of 200, 30-foot copper wire electric blasting caps, connected in five series of 40 caps-per-series wired in parallel.

To operate the push-down blasting machine, it should be set squarely on a solid, level place, and the lead wires should be connected to the terminals. The blaster should position the machine with the terminals on the opposite side of the machine away from the operator. The handle (rack bar) should be lifted with both hands to its full extent and pushed down with a quick, hard strike to the bottom of the box. There should be no fear of damaging the machine by pushing the rack bar down too hard, because only in this
the rack bar down too hard, because only in this manner will the machine develop its full energy. Prior to hooking up lead wires this machine should be warmed up. This can be done by pushing the handle down as in normal use.

5.3.3. No. 10 Twist Blasting Machine. This machine is designed to fire a maximum of 10, 30-foot copper wire, instantaneous electric blasting caps in a series. Housed in a metal case, a special gasket provides a watertight seal between the cover and the case. This machine is used by blasters who never fire more than 10 caps in straight series. This machine should also be warmed up by a few twists of the handle prior to hooking up lead wires.

5.3.4. DuPont SS-240. This machine is manufactured by the ETI Corporation. The outside case construction is of heavy duty nonconductive polyurethane with fully encapsulated solid state circuitry. It is a 330 volt, 17.4 joule unit with the capability of firing 240 two ohm electric blasting caps in six series of 40 caps each connected in parallel to a 3.0 ohm lead line. The power source is four 1.5 volt "C" alkaline batteries.

5.3.5. Rheostat. This instrument will test the efficiency of a generator-type blasting machine. It can also be used to test capacitor discharge (CD) machines. The rheostat consists of a series of coils of varying resistance, each labeled in ohms and in terms of an equivalent number of 30-foot copper wire electric blasting caps. To test the output of a generator machine, a few electric blasting caps (and the equivalent resistance of several caps in the rheostat) are wired in series and energized by blasting machines being tested. Be certain the caps are positioned so that injury cannot occur from shrapnel or flying debris. If all the electric blasting caps fire, the machine's output is sufficient to fire a series of electric blasting caps with the same resistance.

5.3.6. Blasting Galvanometer. The Blasting Galvanometer can measure the resistance in ohms of the blasting circuit:

- to determine if the bridge wires of individual electric blasting caps are intact.

- to determine the continuity of an electric blasting cap series circuit.

- to locate broken wires and connections in a circuit.

To measure resistance with this compact instrument, place each of the two wires from the open end of the circuit on the two contact posts that extend out of the top of the galvanometer. The meter's top scale approximates the circuit's resistance (number of ohms), and the larger numbers on the bottom scale are only reference points and do not relate to the actual number of ohms in the circuit.

Only special silver chloride batteries must be used to power the Blasting Galvanometer. The galvanometer has an adjustment screw on the back of the instrument that can be used to zero the needle when a conductor is placed across the two contact points. The silver chloride cell has become weak, and should be replaced, when the instrument cannot be adjusted to a zero-ohm reading of the top scale and a 25-ohm reading on the bottom scale. The instrument will be checked for proper operation prior to each use. When the cell is exhausted, it must be replaced with the same type of silver chloride cell. Never change batteries in the vicinity of electric blasting caps. Never allow the silver chloride cell, or any battery, to come in direct contact with electric blasting caps. DO NOT SUBSTITUTE ANY OTHER BATTERY FOR THE SILVER CHLORIDE.

- Battery BA-245/6 0.9 volt FSN-6135-128-1632 for temperatures above 0 degrees F.

- Battery BA-2245/6 0.9 volt FSN 6135-833-9909 for temperatures below 0 degrees F.

5.3.7. Blaster's Multimeter. The DuPont Blaster's Multimeter, Model 101, is a compact volt-ohm-millivolt meter specifically designed to measure resistance, voltage, and current in electric blasting operations. Blasters must use only the recommended batteries in these machines. Other batteries will produce a hazardous current level. Never test an electric blasting cap or blasting circuit directly with a battery, recommended or otherwise, and never allow any battery to come in direct contact with electric blasting caps. This versatile meter can be used to:

- Measure the resistances of a single blasting circuit for continuity and the total resistance in a series-
in-parallel circuit with a high degree of precision and accuracy.

- Survey blast sites to determine if extraneous current hazards exist.

- Measure a wide range of resistances necessary to investigate static electricity hazards such as those possible in pneumatic loading operations.

- Measure power line voltages up to 600 volts AC and DC.

5.3.8. **Cap Crimper.** The cap crimper is used to squeeze the shell of a Nonelectric blasting cap around a safety fuse securely enough to keep it from being pulled off but not tightly enough to interfere with the burning of the powder train in the fuse. A stop on the handle limits the closing of the jaws to prevent this. The crimper forms a water-resistant groove completely around the blasting cap. Apply a sealing compound to the crimped end of the blasting cap for use underwater. The rear portion of each jaw is shaped and sharpened for cutting fuses and detonating cords. One leg of the handle is pointed to be used in punching cap wells in explosive materials for easy insertion of blasting caps. The other leg has a screwdriver end. Cap crimpers are made of a soft nonsparking metal, which will not conduct electricity and must not be used as pliers because such use damages the crimping surface. Although there are numerous manufacturers of crimpers, the description described above is that of the Dupont #4 crimper and most commonly found or reproduced. Blasters should visually check the type of crimper for proper operation.

5.3.9. **Tamping Stick.** A 1 inch diameter wooden tamping stick slightly longer than the deepest hole aids in loading. No metal parts are permitted in the stick, with the exception of a nonferrous metal coupling to join sections together. The stick must be inspected carefully before using to insure that no small rock chips are clinging to the end that touches the explosive.