nxburst
ROCK BREAKING CARTRIDGES

TRAINING MANUAL

Warning and Disclaimer

The information and recommendations in this document are provided for reference purposes only and should not be construed as advice to cover every application of the product or variation of conditions under which the product may be used. The recommendations herein are based on the manufacturer's experience, research, and testing, but no warranties are made, expressed or implied with respect to merchantability or fitness for any purpose. Also, the specifications contained herein are all nominal, which represent our current production.

Table of Contents **Page**

List of Appendixes

Introduction

The manual is formulated to provide the Nxburst operator with adequate knowledge and skill to use the product in a safe, economic and self assured manner. Each person at the end of the training session should have a thorough knowledge and understanding of the work procedures and safety practices that must be adhered to whilst using Nxburst™.

The manual provides a step-by-step instruction with general theory, standards and conditions that apply to Nxburst™ usage and handling. Only those people who have had training and are experienced in the use of Nxburst™ should be directly involved when charging and firing Nxburst™ cartridges.

Product Characteristics

1.1 Rock Breaking Mechanism. The Nxburst™ technology is based on a non-detonating chemical compound enclosed in a cartridge, which reacts very quickly when ignited to produce high volumes of harmless gas, consisting mainly of nitrogen, carbon dioxide and steam.

When the cartridge is sealed in a drill hole, the gas generated by the ignition of the propellant enters into the micro-fractures created from the percussive drilling process and into the natural fractures and planes of weakness of the rock to produce a shearing of the rock or concrete often called splitting.

Once a hole is drilled in the rock or concrete to a depth of 70% of the size of the rock, the required cartridge is inserted into the hole. When the cartridge is fully inserted in the rock the hole is then stemmed with dirt or crusher dust and tamped to provide a solid seal that will contain the gas when the cartridge is ignited. The pressure created by the gas exceeds the tensile strength of the rock, causing the rock to fracture.

Fig.1. Nxburst™ Cartridge confined in a drill hole.

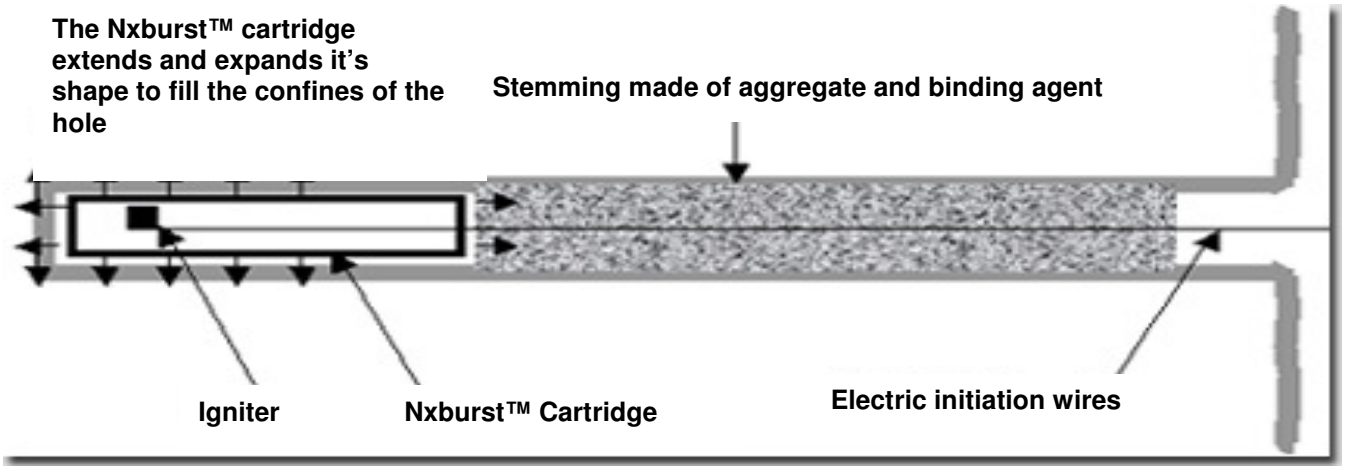


Fig.2. The Nxburst™ Cartridge

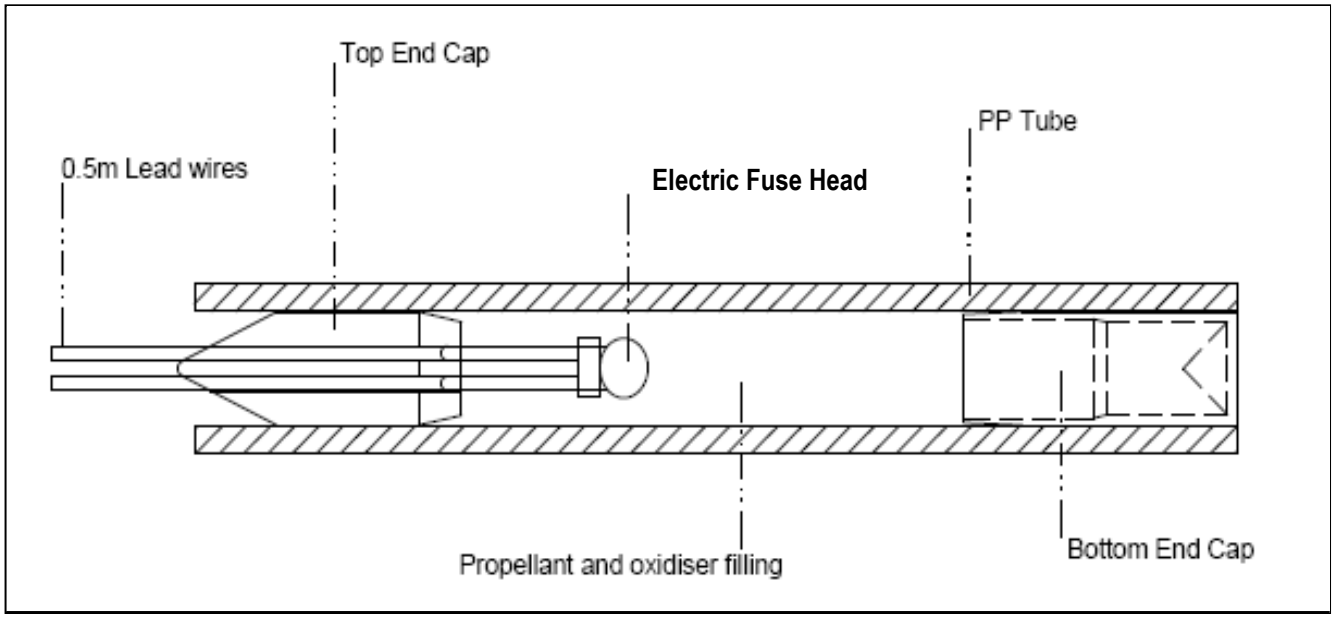


Fig. 3 Sectionised view of the cartridge

1.2.1 Cartridge Components

a. Lead wires – The lead wires consists of various lengths (2m and 3,5m) for the different size cartridges. They are coated with polyethylene to increase the abrasions resistance of the wires so as to protect the core during the process of stemming.

b. The tube – the tube consists of polypropylene and has various wall thicknesses for the different sizes.

c. Top end cap- the top end cap is made of a tough plastic to resist shearing during the build-up of pressure. The top cap has a specific wedge design to enable it to wedge into the stemming aggregate during pressure build up.

d. Electric Fuse Head – the igniter has a specific electrical characteristic to prevent accidental ignition through electro static discharge. The igniter is placed within the cartridge during manufacture.

e. Propellant and oxidizer mixture- the mixture is specifically formulated to prevent the emission of noxious fumes.

f. The bottom end cap- the cap is made of a material designed to fracture under pressure to release the pressure at the bottom of the cartridge. It has a specific conical shape which results in a concentration of the pressure into the corners of the drill hole.

1.3 Difference between Nxburst™ and detonating explosives

The major differences between Nxburst™ and explosives are:

- Detonating explosives have a mass explosion and projectile hazard in their packaged state whereas Nxburst™ cartridges pose no significant hazard in their packaged state.
- Explosives are designed to detonate whereas propellants are designed to deflagrate.
- Explosives produce a destructive shock wave giving rise to high vibration levels, which damage the surrounding rock or concrete mass whereas propellants produce a controllable pressure wave with low vibration levels.
- The rock breaking event produced by explosives is a largely uncontrolled, violent event producing large amounts of fly rock, noxious gases and dust whereas the deflagration of propellant confined in a drill hole is a controlled event which produces minimal fly rock, low concentrations of noxious gases and negligible amounts of dust.

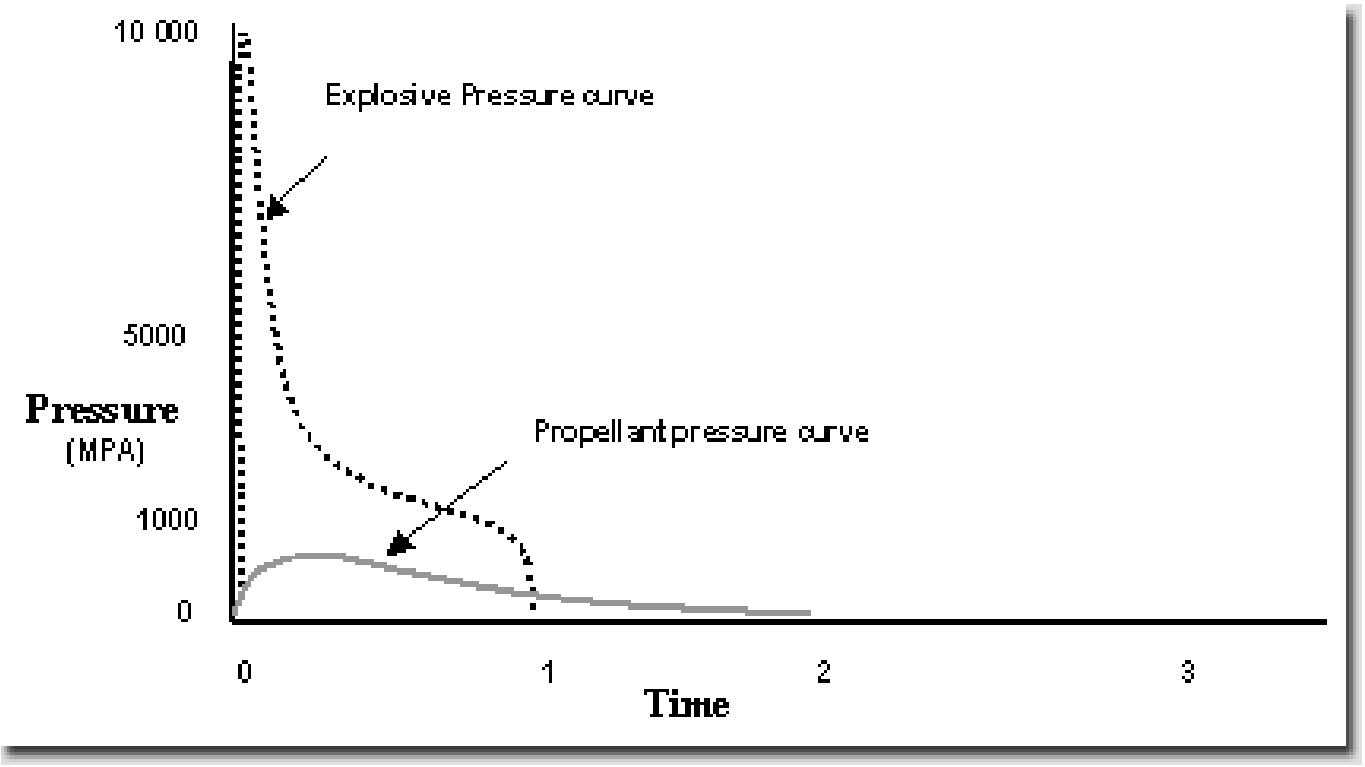


Fig. 4 The energy release from detonating explosives compared to Nxburst™.

The reason why an Nxburst™ cartridge does not explode, is because the velocity of deflagration or burning of the propellant is almost directly proportional to the degree of confinement of the chemical reaction. Thus, in an unconfined environment such as the product's original packaging, the propellant if ignited will only burn at a very low velocity, which is incapable of causing an explosion. In contrast, an explosive, if detonated or initiated in its original packaging, will produce a major explosion - the result of which historically has had fatal consequences. The end result is that propellant based cartridges are much safer to transport, store and use than explosives and for that reason the Regulations relating to the transport and storage of Nxburst™ are considerably less stringent than for explosives such as Ammonium Nitrate/ Fuel Oil (ANFO).

1.3.1 Detonation vs Deflagration

a. Deflagration

Deflagrations are thermally initiated reactions propagating at subsonic speeds that proceed radially outwards in all directions through the energetic material, away from the ignition source. The maximum pressure developed by deflagration is dependent on the energetic materials involved; their geometry; and the strength (failure pressure) of the vessel or structure confining the materials.

b. Detonation

The supersonic reaction speed of detonation develops a shock wave in the explosive, which triggers the propagating reaction. The propagation of the shock wave is accompanied by a chemical reaction that furnishes energy to sustain the shock wave advance in a stable manner, followed by the formation of the final gaseous products and their associated pressures at some time later.

1.3.2 The impact of deflagration on rock breaking

Since the rate of gas emission from either the detonation of explosives or the ignition of propellant, confined in a drill hole, is proportional to the rate of burning, it follows that the build- up of pressure in the hole will also be directly related to the burning or detonation rate. At the point in time at which the rock surrounding the drill hole starts to dislodge, the gas contained in the drill hole is released. In the case of explosives, the pressures in the drill hole are so high, due to the rate of detonation of the explosive, that the release of the gases is a violent event that results in a high level of fly rock, shock waves and a high overpressure which produces a destructive concussion effect especially in confined spaces such as are found in underground mines.

In contrast, a tailored Nxburst™ charge produces an optimal pressurization of the hole, which results in optimal gas release at a relatively low pressure, thus obviating the destructive side effects such as fly rock and concussion effects caused by explosives.

1.3.3 The rock breaking mechanism

The rock breaking mechanism employed by Nxburst™ differs to that of explosives due to the rock being fractured in tension rather than compression. The gas generated by the ignition of the propellant enters into the micro-fractures created from the percussive drilling process and into the natural fractures and planes of weakness of the rock or concrete, initiating cracks and expanding fractures causing the rock or concrete to break.

The tensile breakage mechanism of Nxburst™ uses a much lower amount of energy than explosives for the same application. The Nxburst™ cartridge contains proprietary technology, which enhances the transfer of energy into the rock to increase the rock or concrete breaking ability, which can be optimally adapted to suit the rock or concrete conditions and rock or concrete breaking requirements for any particular operation / application.

Environmental Impacts

2.1 Airblast overpressure

Airblast overpressure is simply the pressure produced by blasting over and above that of atmospheric pressure produced by explosives.

The three main concerns associated with airblast overpressure are human discomfort, structural damage and window damage.

The Nxburst™ method of breaking ensures that expansion gases are contained in the drill hole by effective stemming, which results in very low overpressure levels. Overpressure levels produced by Nxburst™ are extremely low when compared to conventional explosives and are of a shorter duration and less damaging frequency. This gives Nxburst™ a major advantage over explosives in environmentally sensitive areas.

2.2 Noise

Noise is the part of the airblast overpressure wave which falls within the audible frequency region of the human ear. The high frequency portion of the air pressure wave is audible and is responsible for the noise that accompanies a blast. The lower frequency portion is not audible but can excite structures, such as windows, which in turn respond and produce secondary noise such as rattles.

Noise levels produced by Nxburst™ depend largely on the type and nature of the rock being broken, charge weight, burden, depth of the hole and the effectiveness of the stemming used. A well-stemmed Nxburst™ cartridge in granite will generally produce a noise level in the range 80 to 85 dBL at 50 meters from the hole. Noise levels can be attenuated by the use of conveyor belting, or other matting, to cover the holes being fired.

2.3 Ground Vibration

Ground borne vibrations from blasting can cause damage to buildings and infrastructure which are in the vicinity of the blast. The degree of vibration-induced damage caused by blasting is dependent on the magnitude, frequency and duration of the vibration. Generally, low frequency, long duration vibrations are more damaging than higher frequency, short duration vibrations.

The vibration waves produced by Nxburst™ are mostly of a higher frequency, with a mean of 450 Hz, and of short duration and are therefore the least harmful to sensitive structures. In addition, the magnitude of the vibration levels produced by Nxburst™ is particularly low when compared to explosives over the same distance from the shot hole.
When the propellant mixture in a Nxburst™ cartridge deflagrates, the almost instantaneous change from solid to gaseous matter is accompanied by a very sharp increase in the blasthole pressure and temperature. This is accompanied by a pressure wave that radiates from the drillhole, its amplitude decreasing as the distance from the drillhole increases. The primary factors known to influence the level of ground vibration from the Nxburst™ cartridges include:

a. The weight of propellant per cartridge;
b. The distance between the drillholes and the point of measurement;
c. The local geological conditions, and the influence of geology and topography on vibration attenuation.

2.3.1 Vibration Limits for Structures

The degree of vibration-induced damage caused by blasting is dependent on the magnitude, frequency and duration of the vibration. Generally, low frequency, long duration vibrations are more damaging than higher frequency, short duration vibrations.

This general rule is contained in recommendations by both the US Bureau of Mines (“USBM”) and the British Standard (“BS”), both of which are widely used in vibration specifications for rockbreaking near sensitive structures. The USBM criteria are as follows:

Frequencies above 40 Hz
- PPV < 50 mm/s - safe zone
- PPV > 50 mm/s - damage zone

Frequencies below 40 Hz

- PPV < 13 mm/s - safe zone (old wooden house)
- PPV > 19.5 mm/s - safe zone (modern house)

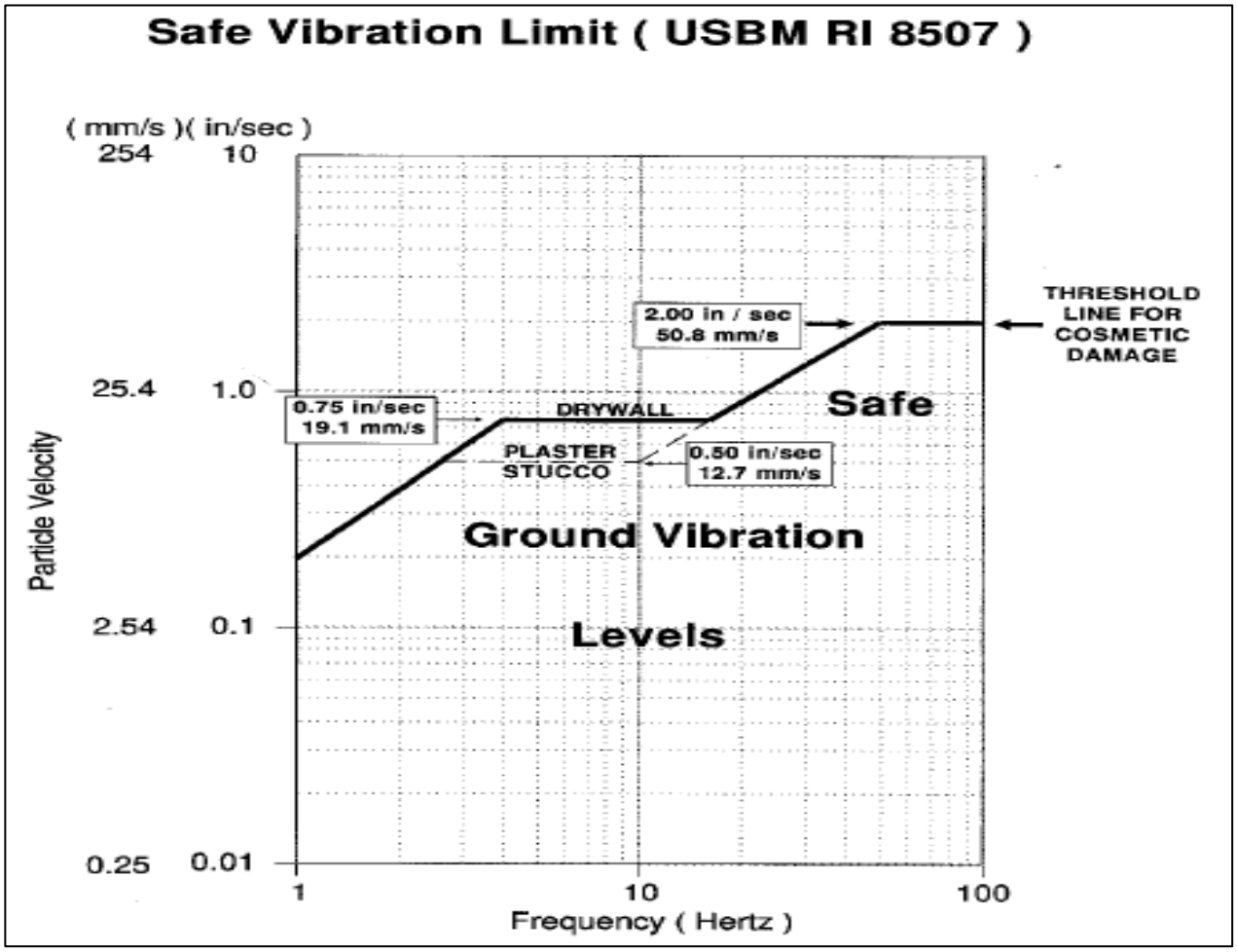


Fig. 5 Safe Vibration limit threshold

As a result of the reduced charge weights used for Nxburst™ rockbreaking and its favourable vibration signature, the vibrations generated by Nxburst™ are well within most imposed restrictions for rockbreaking close to sensitive structures. As can be seen from Figure 6, safe vibration levels for rockbreaking, as defined in the USBM guidelines, can be achieved by Nxburst™ within 5 meters of a sensitive structure.

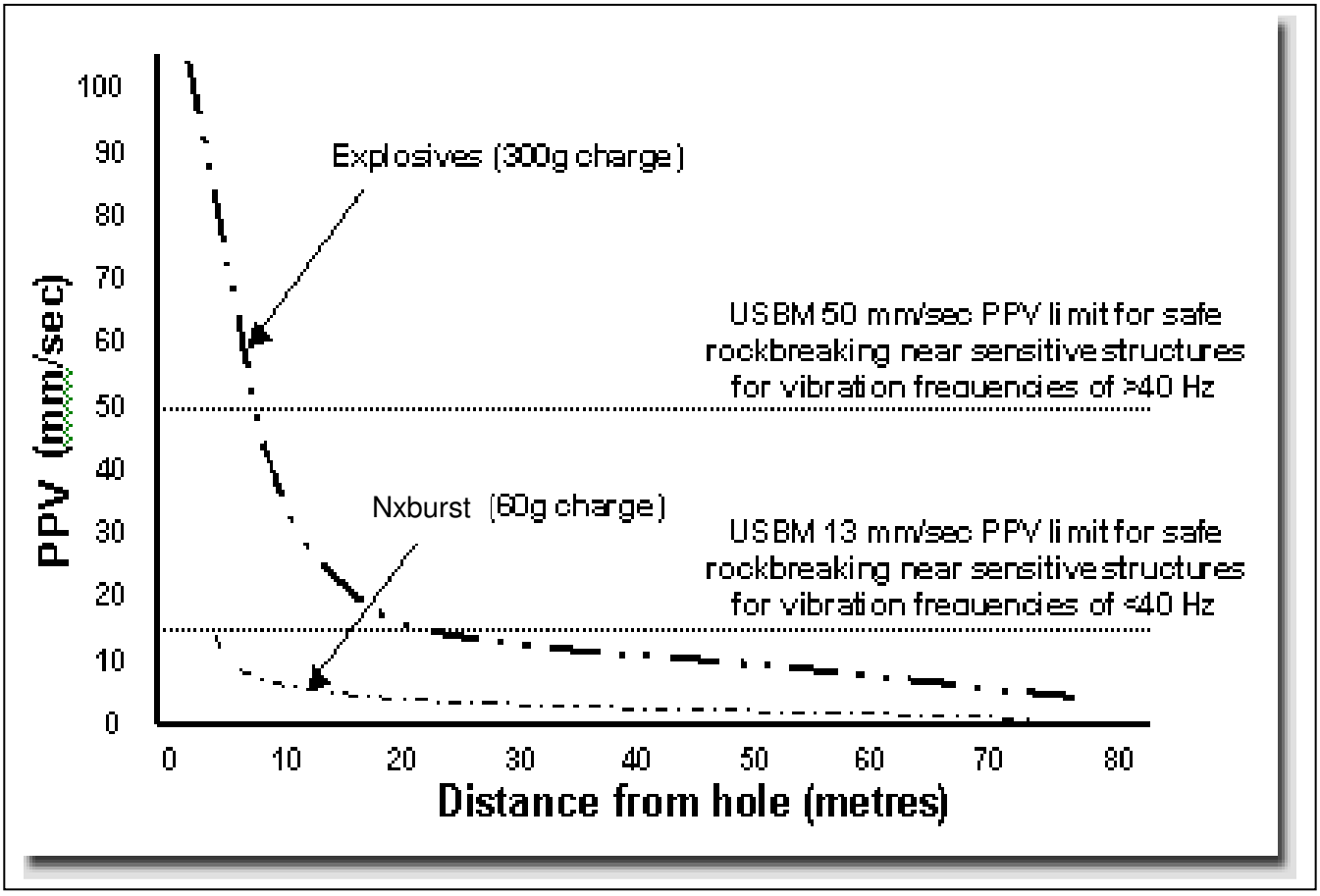


Fig. 6 Comparative vibration results of Explosives and Nxburst

2.4 Noxious Fumes

The Nxburst™ cartridge is oxygen balanced so that sufficient oxygen is available for the chemical reaction to achieve optimal oxidation to produce gases consisting of carbon dioxide, nitrogen and steam and thus avoiding the production of noxious gases such as carbon monoxide and nitrous fumes.

The efficient ignition of the Nxburst™ propellant mixture is represented in the generic formula:

Nitrocellulose + ammonium nitrate (oxidizer) ⟶ steam + nitrogen +carbon dioxide + energy

(X) $C_6 N_3 H_7 O_{11}$ + (Y) NH_4NO_3 ⟶ H_2O + N_2 + CO_2 + energy (joules)

In addition, the quantity of propellant in a Nxburst™ cartridge used to break rock is less than the comparable quantity of explosives that is historically used to break the same amount of rock by a factor of six. A single 180 gram Nxburst™ cartridge can be used in a 1.2 meter long hole, to break a 50cm burden in most rock types; compared to a 1.1kg charge of ANFO that is commonly used for the same application. The reduced quantities of propellant required to break the rock compared to explosives means that considerably less fumes are emitted by the rockbreaking event.
As a result of the degree of oxidation achieved in the deflagration process, through the incorporation of an effective oxidizing agent and the relatively small amount of propellant used in each hole, the

Nxburst™ cartridge produces a negligible level of noxious gases which are cleared in minutes when an adequate standard of airflow (nominally a velocity of 0.25 meters per second) is available.

2.5 Flyrock

Normally, blasting using conventional explosives requires the rockbreaking area to be evacuated for a distance of 500m which means disruption of the production operations and delays to operating equipment. The generation of unpredictable flyrock rules out the use of lay-on charges in any situation where flyrock is restricted.

In contrast, a Nxburst™ cartridge produces an optimal pressurization of the hole for a given burden and type of rock. By controlling the characteristics of the pressure pulse, the velocity and distance traveled by the dislodged rock can be limited.

Controlled gas release from the Nxburst™ cartridge, at a relatively low pressure, results in a minimal quantity of low velocity flyrock, which is generally contained within 10 meters of the rock breaking event.

3. Rock breaking Methodology

a. Study the rock
It is important to know the rock structure that you are working on. Study the rock before commencing with the work. A solid hard rock will break differently from a soft sandstone rock or a well-weathered rock.

In this part we will only give an indication of how to handle the different rock types. We will also give guidelines for cement structures. The student must remember that this is only a guideline, and that the final analysis can only be made after testing and analyzing the rock.

b. Hard rock boulders:
Hard rock boulders are often the easiest to break. Because of the hardness they are brittle and will normally break into multiple smaller pieces depending on the charge that is used.
Hard rocks are also more prone to fly rock. Fly rock can be controlled by the charge weight and by placing blasting mats on the rock before firing.

3.1 Guidelines for a successful break.

3.1.1 Boulders

a. Study the natural cracks in the rock before drilling the hole.

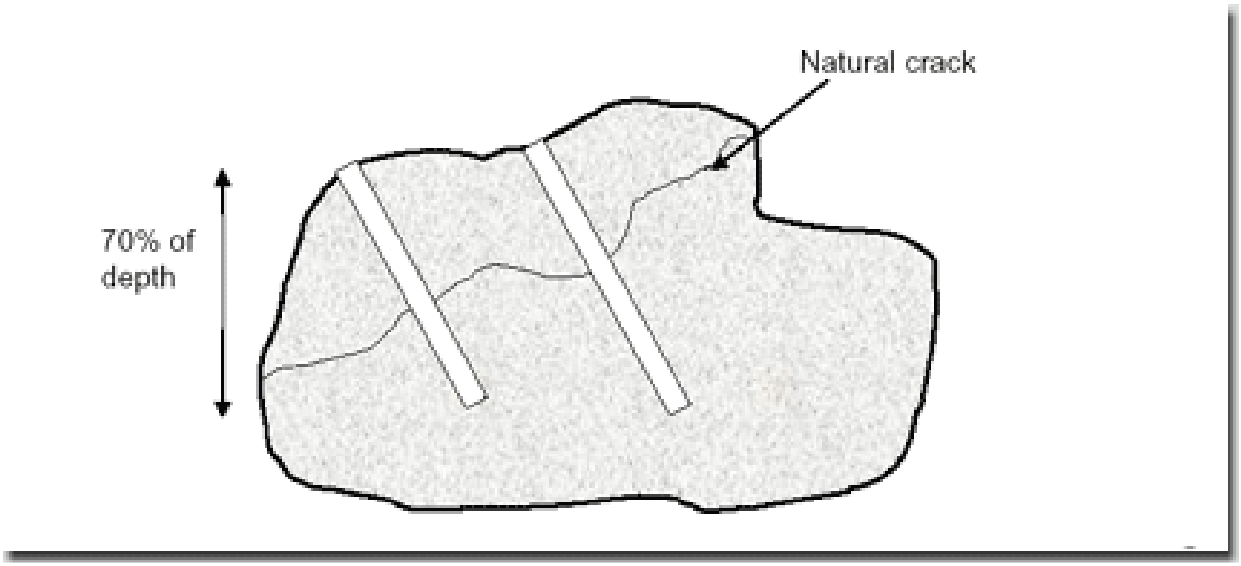
b. Drill the holes perpendicular to the natural crack in the rock (or as close as possible) see Figure 7.

c. Determine the optimum amount of cartridges required for the specific rock type.

d. Balance the amount of holes with the breakage size and the cost. It is better to break the rock into as small as possible pieces with the first shot

than to come back and re-drill and re-blast the rock. A good estimation for the size of the cartridge is 40 gram per ton or cubic meter of rock. This can be done by one 40 gram or two 20 gram cartridges, depending on the size of the break required.

e. Drill the hole depth 70% (2/3) of the size of the rock.



f. It is important to stem the hole properly.

g. If more than 2 holes must be drilled, drill the holes staggered. This will prevent the rock from splitting in one line. The aim is to drill and blast a rock once only.

h. For a small fragmentation keep the burden (distance from the side of the rock) between 350 and 500 mm and the spacing (between holes) 700 mm (figure 7). This is a general pattern and must be adapted to suit the situation.

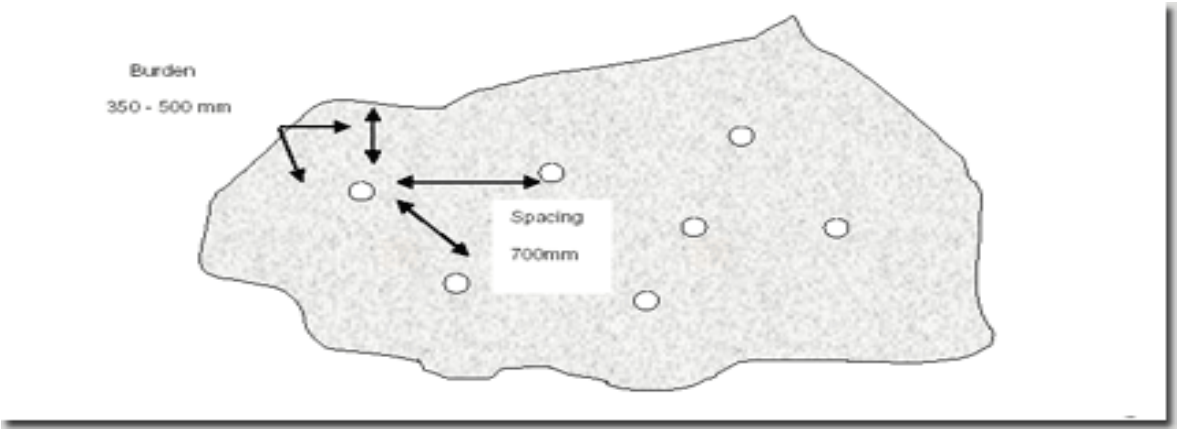


Fig. 7 Horizontal Spacing

3.1.2 In situ rock

It is always difficult to judge the depth of in situ rock. If you drill too deep the gas will simply blow out in the bottom of the hole.

Guidelines to break in situ rock:

a. Never drill more than 1.2 m deep holes at a time. If the bottom of the hole blows out drill a new hole but only 600mm or less. Reload and blast.

b. Drill the first row so that there is always a free face of max 500mm.

c. It is advisable to have not less than 500mm stemming on top of a cartridge.

d. Holes can be drilled at an angel to facilitate a breaking point. See Figure 8.

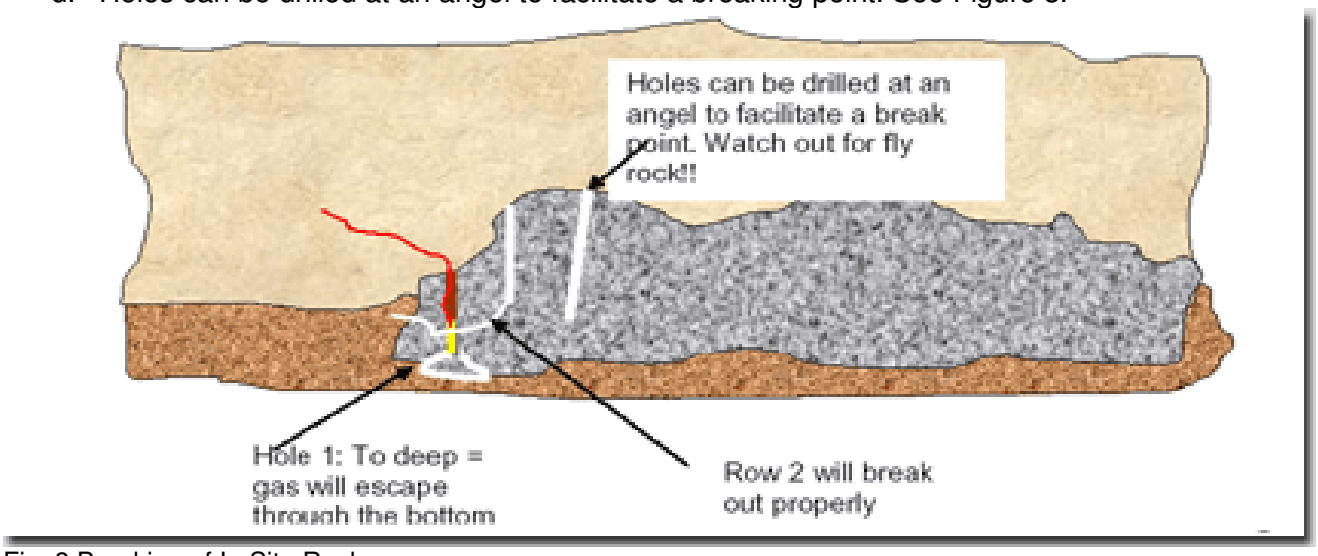


Fig. 8 Breaking of In Situ Rock

3.1.3 Concrete

Nxburst™ cartridges work exceptionally well in the breaking of concrete. The low vibration and no shock waves makes this application an easy and safe way of breaking concrete.

The standard staggered drill pattern is used for the concrete application. Depending on the size of the block that must be removed, a burden of 350 mm and a spacing of 350 to 500 mm is recommended for concrete. A 60 - 80gram cartridge will be sufficient for this application.

The biggest problem for concrete is that steel reinforcement can hamper the drilling process. The drill operator should try to guess the pattern of the steel and then drill accordingly. A few test holes will help.

4. Technical Data

4.1 Nxburst™ Series Circuits

4.1.1 Description of a series connection

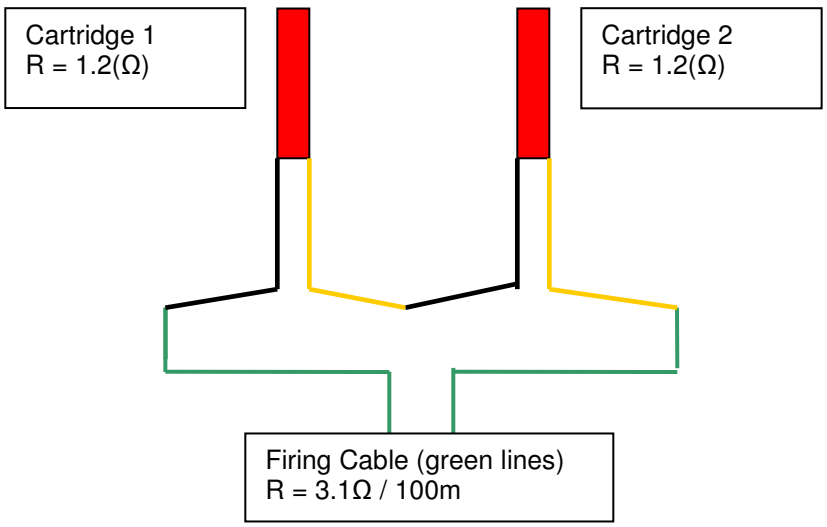
Series connections can be described as a circuit in which each cartridge is connected in such a manner that there is only one pathway through which the charge can traverse the external circuit. Each charge passing through the loop of the firing circuit will pass through each cartridge in consecutive fashion. An example is given in figure 9.

4.1.2 Characteristics of series connections

Resistance.

An important consideration in series initiation of Nxburst™ cartridges is the total resistance (Rt) of the circuit. The resistance in the circuit will influence the capacity of the shot exploder to initiate the cartridges successfully. Total resistance is determined by adding the resistance of the cartridges plus the resistance of the firing cable.

Figure 9. Layout of a series circuit.



To calculate the total resistance the formula is as follows:

R (total) = R1 (Cartridge 1) + R2 (Cartridge 2) + R3(Firing cable)

Therefore: R(t)= R1(1.2Ω) + R2 (1.2Ω) + R3 (3.1Ω)

= 5.5Ω

4.1.3 The resistance specifications for various Nxburst™ cartridges are as follows:

12/13mm Range	= 1.20 Ω to 1.71 Ω (0,5m lead wire)
28/34mm Range	= 1.23 Ω to 1.85 Ω (1,8m lead wire)
25034mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)
42mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)
60mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire

4.1.4 The resistance for the firing cable may vary. Basic factors influencing the cable resistance are the following:

a. The diameter of the core of the wire. The thicker the conductor is, the less the resistance.

b. The material of the conductor. Copper is for example a better conductor than steel.

c. Damages to the firing cable. If the wire is flattened, stretched or damaged by rock the resistance of the wire can increase.

4.1.5 Specifications for the standard firing cable are the following:

Nxburst™ Blasting Wire Specifications

3/0.69 mm TWIN TWISTED

OLD IMPERIAL SIZE -	3/22gge
WIRE SIZE -	3 STRANDS X 0,69mm
THICKNESS OF COVERING -	0.5 mm
OUTSIDE DIA -	2.6 mm
AREA PER WIRE SQ. MM -	1.122 mm
RESISTANCE OF ANNEALED WIRE (1000M) -	31.65 LOOP RESISTANCE
LAY LENGTH -	130 mm

4.1.6 Continuity. The single pathway which the current follows in a series connection will cause none of the cartridges to fire if there is no continuity in the circuit. If the circuit is tested for resistance and continuity prior to the blast and there is no resistance or continuity it will mean that one of the following or a combination has occurred:

a. A connection between cartridges is loose.

b. The connection between the firing cable and the cartridges is broken.

c. The firing cable is damaged.

d. A cartridge wire is damaged.

4.1.7 To reduce the possibility of breaks in continuity of the firing circuit the following must be adhered to:

a. Test the resistance of the cartridge prior to inserting them into the drill hole. The resistance must be within the specifications in paragraph 4.1.3

b. Test the resistance of the cartridge in the drill hole after stemming. The resistance must be the same as in paragraph 4.1.3.

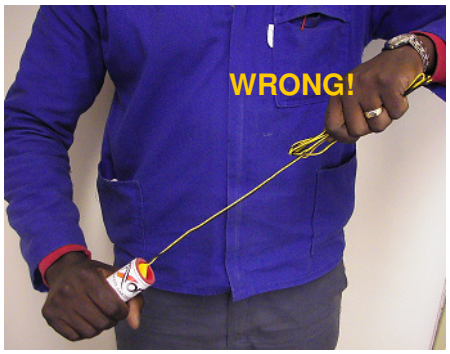
c. Test the resistance of the firing cable prior to every blast. The resistance should be within the supplier's specifications.

d. Test the total resistance and continuity of the series circuit prior to the blast. Bear in mind that the resistance might not be exactly the same as calculated. The reason for this is due to the connections. If the resistance is much higher the cause could be poor connections or wire damage. If the resistance is much lower than calculated it is due to a short in the firing circuit.
.

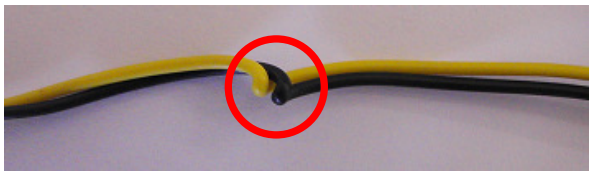
4.1.8 Measures to prevent breaks in continuity or resistance variances

Unwinding the cartridge wires:

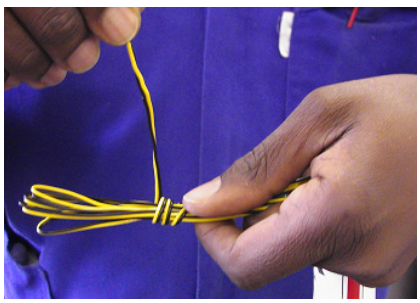
a. Do not pull the cartridge in order to unwind the wire. This will cause kinks in the wire which could result in resistance variances or continuity breaks.



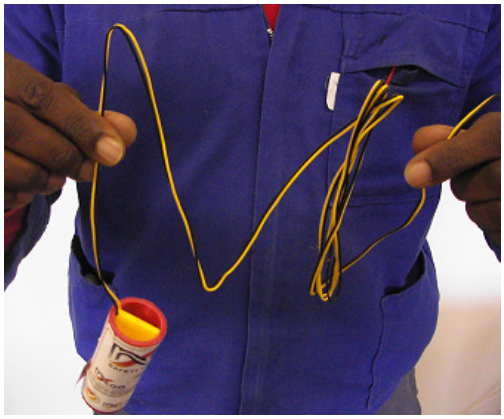
Kinks in the wire.



b. The following steps must be followed to unwind the wire:



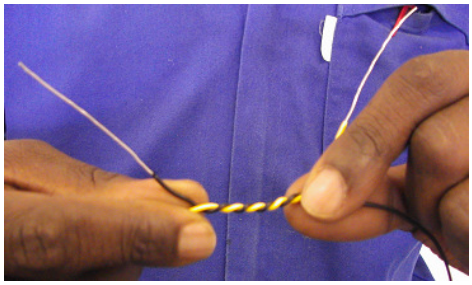
Step 1. Unwind the wire around the coils



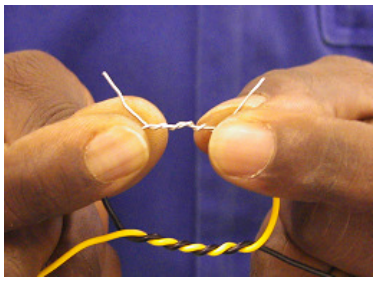
Step 2. Gently pull the wire apart. The figure of eight pattern in which the coils are wound will allow for the wire to unravel without forming kinks.

Joining the cartridge wires:

A quick and effective method of joining the wires without putting strain on the connection is the following:



Step 1. Wind the two wires around each other four to six times.



Step 2. Wind the two ends together four to six times

c. The same method can be followed when joining the cartridge circuit to the firing cable.

d. In wet conditions electrical connections must be waterproofed.

4.1.9 Stemming the holes.

a. It is important to take care during the stemming process to ensure that the cartridge wires are not damaged.

b. Keep the wires to the side of the drill hole when stemming.

c. Always test the cartridges for resistance and continuity after stemming.

4.1.10. Covering the holes with matting

a. Avoid running the cartridge wires over sharp edges.

b. Do not drag the mats over the holes.

c. Avoid soil which contains rocks when covering the holes.

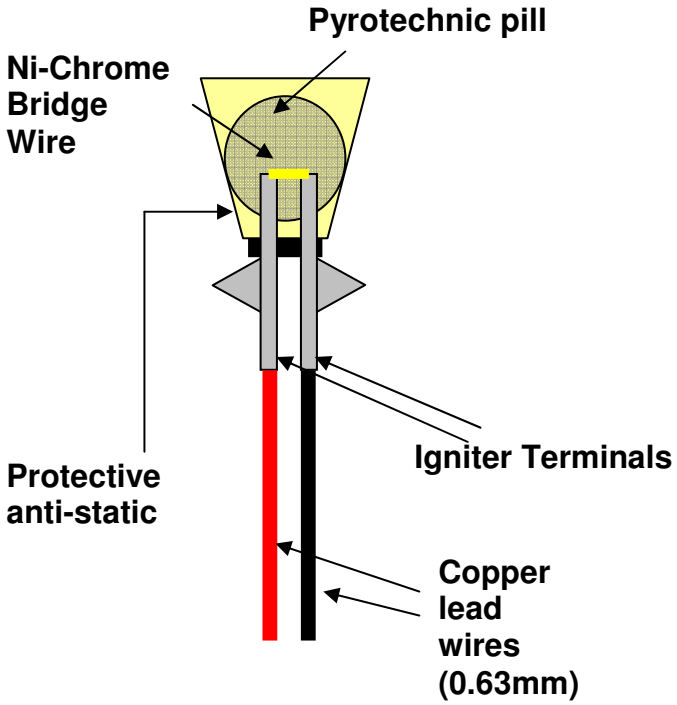
4.2. Technical Data of Nxburst™ Igniter

Parameters	Nominal Values
Appearance	Consists of two electrodes bridged by a wire. The wire and electrodes are coated with a pyrotechnic composition.
Length of terminals	From 1.0m to 3.5m depending on the Nxburst Cartridge size
Type of lead terminals	2 x.0.63mm core PE insulated copper wire twisted together
Resistance of bridgewire	1.25 Ω
Resistance of Igniter Assembly	1.2 – 1.95 Ω depending on lead terminals
No fire current for 5 min	Not less than 1.1 Amps
Recommended min current (DC)	6.6 Amps
Static electricity threshold	10 kV: 2 000 pF
No Firing impulse	50 mJ/Ω
All Firing impulse	70 mJ/Ω
Recommended min firing impulse	120mJ/Ω
Manufacturer of Igniter Assembly	NXCO Mining Technologies (Pty Ltd, P O Box 529, Broederstroom 0240, South Africa Tel: +27 12 305 5237 Fax: +27 12 305 5247

4.2.1 Lengths of Lead Wires

12mm Range: Green and White (1.0m length)
28mm Range: Grey and White (2.0m length)
34mm Range: Grey and White (2.0m length) Grey and Red (3,5m)
42mm Range: Grey and Red (3.5m length)
60mm Range: Grey and Red (3.5m length)

Electric Igniter Assembly



4.3 Nxburst™ Cartridge Range Data

Product Code	Description	Charge weight (g)	Outside Diam (mm)	Length (mm)	Hole Diam (mm)	Quantity per Box	Weight per box (kg)	EXPL Weight per box (kg)
0513	0513 Nxburst Cartridge	5	13	70	16	100	2.43	0.5
1013	1013 Nxburst Cartridge	10	13	140	16	100	2.43	1.00
2028	2028 Nxburst Cartridge	20	28	70	30 - 34	100	6.28	2.000
4028	4028 Nxburst Cartridge	40	28	140	30 - 34	100	11.5	4.000
6028	6028 Nxburst Cartridge	60	28	180	30 - 34	80	11.2	4.800
8028	8028 Nxburst Cartridge	80	28	220	30 - 34	50	8.5	4.000
10028	10028 Nxburst Cartridge	100	28	260	30 - 34	40	7.8	4.000
12028	12028 Nxburst Cartridge	120	28	300	30 - 34	40	9	4.800
2034	2034 Nxburst Cartridge	20	34	70	36 - 42	100	10.2	2.000
4034	4034 Nxburst Cartridge	40	34	100	36 - 42	100	11.3	4.000
6034	6034 Nxburst Cartridge	60	34	133	36 - 42	80	11.4	4.800
8034	8034 Nxburst Cartridge	80	34	167	36 - 42	50	9.08	4.000
10034	10034 Nxburst Cartridge	100	34	200	36 - 42	40	8.63	4.000
12034	12034 Nxburst Cartridge	120	34	211	36 - 42	40	9.09	4.800
14034	14034 Nxburst Cartridge	140	34	245	36 - 42	40	10.43	5.600
16034	16034 Nxburst Cartridge	160	34	270	36 - 42	40	11.47	6.400
18034	18034 Nxburst Cartridge	180	34	300	36 - 42	40	12.44	7.200
25034	25034 Nxburst Cartridge	250	34	460	36 - 42	40	17.89	10.00
6042	6042 Nxburst Cartridge	60	42	7	45 – 51	50	8.26	3.00
8042	8042 Nxburst Cartridge	80	42	92	45 – 51	50	9.51	4.00
12042	12042 Nxburst Cartridge	120	42	143	45 – 51	50	12.13	6.00
18042	18042 Nxburst Cartridge	180	42	207	45 – 51	40	14.44	7.2
24042	24042 Nxburst Cartridge	240	42	277	45 - 51	40	17.92	9.60
20060	20060 Nxburst Cartridge	200	60	142	64-76	24	11.50	4.800
30060	30060 Nxburst Cartridge	300	60	180	64-76	24	13.75	7.200
40060	40060 Nxburst Cartridge	400	60	220	64-76	24	16.80	9.600
50060	50060 Nxburst Cartridge	500	60	260	64-76	24	18.38	12.000

5. Legislative Requirements

5.1 General

a. All Nxburst™ products must be stored in their original packaging in a secure locked area or box. Any Nxburst™ products that are left over after opening a box must be returned in their original packaging to the designated secure locked area or box.

b. Keep the various cartridges in their original containers.

c. Old or damaged Nxburst cartridges should not be returned to any storage area; they should be removed and destroyed by authorized personnel.

d. Nxburst should not be stored at any time with other explosives or in a magazine that has been permitted for high explosives unless, approved by the relevant authority.

e. While on the site Nxburst must not be stored closer than 10m from electrical installations, substations, electrical boxes or near open flames.

f. The ideal storage temperature for Nxburst is 2º- 35º Celsius. Prevent temperature fluctuations below 0° and above 45 º Celsius.

5.2 Transport of Nxburst

The following regulations must be adhered to when transporting Nxburst:

a. The Nxburst cartridges must be locked in a secure container during transit. The container can be a utility box equipped with a secure locking mechanism.

b. The Nxburst GHSSDS sheets must be carried in the vehicle transporting the cartridges at all times.

c. Nxburst should not come into contact with any sources of heat.

d. The transport of Nxburst should comply with the applicable regulations pertaining to the transport of dangerous goods.

5.3 General Safety Instructions

a. Only Nxburst trained and certified operators will be allowed to use Nxburst cartridges.

b. Nxburst operators must supervise the drilling of the holes, charging operations, personally initiate the circuit and personally inspect the result and declare the area safe.

c. All equipment must be tested and inspected for serviceability.

d. Precautions must be considered against possible fly rock.

e. The safe operating instructions must be adhered to.

f. Nxburst operators must adhere to the required national regulations pertaining to the transport, storage and use of Nxburst.

Appendix A

Method Statement for Breaking Boulders

Nxburst is effective to break loose rocks which are close to buildings or machinery, both in civil construction and mining sites.

Procedure:

1. Measure the size of the rock.

2. Select the correct size of cartridge from the table below:

Nxburst 13mm Rock Popper Cartridges	Charge Weight (g)		Boulder Size (mm)	Hole Depth (mm)	Cubic Meters m^3	Powder Factor kg/m^3
0513	5		500x500x500	300	0.125	0.040
1013	10		750x750x750	600	0.422	0.024

Nxburst 28mm and 34mm Cartridges	Charge Weight g		Boulder Thickness mm	Hole Depth mm	Cubic Meters m^3	Powder Factor kg/m^3
2028 / 2034	20		750x750x750	495	0.422	0.047
4028 / 4034	40		1000x1000x1000	660	1.000	0.040
6028 /6034	60		1250x1250x1250	825	1.953	0.031
8028 / 8034	80		1500x1500x1500	990	3.375	0.024
10028 / 10034	100		1750x1750x1750	1155	5.359	0.019
12028 / 12034	120		2000x2000x2000	1320	8.000	0.015
14034	140		2200x2200x2200	1452	10.648	0.013
16034	160		2400x2400x2400	1584	13.824	0.012
18034	180		2600x2600x2600	1716	17.576	0.010
25034	250		3000x3000x3000	1980	27.000	0.009

Nxburst 42mm Rock breaking Cartridge	Charge Weight g		Boulder Thickness mm	Hole Depth mm	Cubic Meters m^3	Powder Factor kg/m^3
6042	60		1250x1250x1250	825	1.953	0.031
8042	80		1500x1500x1500	990	3.375	0.024
12042	120		2000x2000x2000	1320	8.000	0.015
18042	180		2600x2600x2600	1716	17.576	0.010
24042	240		3000x3000x3000	1980	27.000	0.009
Nxburst 60mm Rock breaking Cartridge	**Charge Weight g**		**Boulder Thickness mm**	**Hole Depth mm**	**Cubic Meters m^3**	**Powder Factor kg/m^3**
20060	200		2800x2800x2800	1848	21.952	0.009
30060	300		3000x3000x3000	1980	27.000	0.011
40060	400		3300x3300x3300	2178	35.937	0.011
50060	500		3500x3500x3500	2310	42.875	0.012

TABLE FOR BREAKING LOOSE ROCKS

2. Select the correct size of drill bit:

For 13mm cartridges = 16 mm drill bits

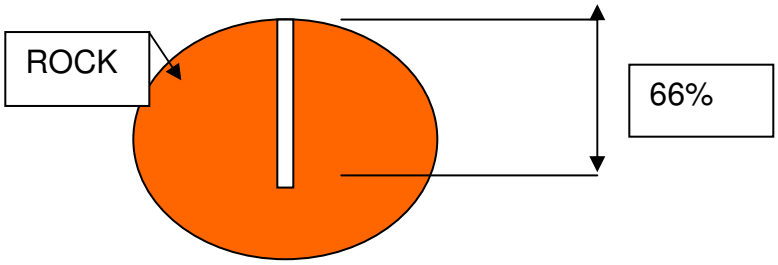
For 28mm cartridges = 32mm drill bits

For 34mm cartridges = 38mm – 42mm drill bits

For 42mm cartridges = 45 – 50mm drill bits

For 60mm cartridges = 72 mm drill bits

3. Drill the holes 66% of the thickness of the boulder:

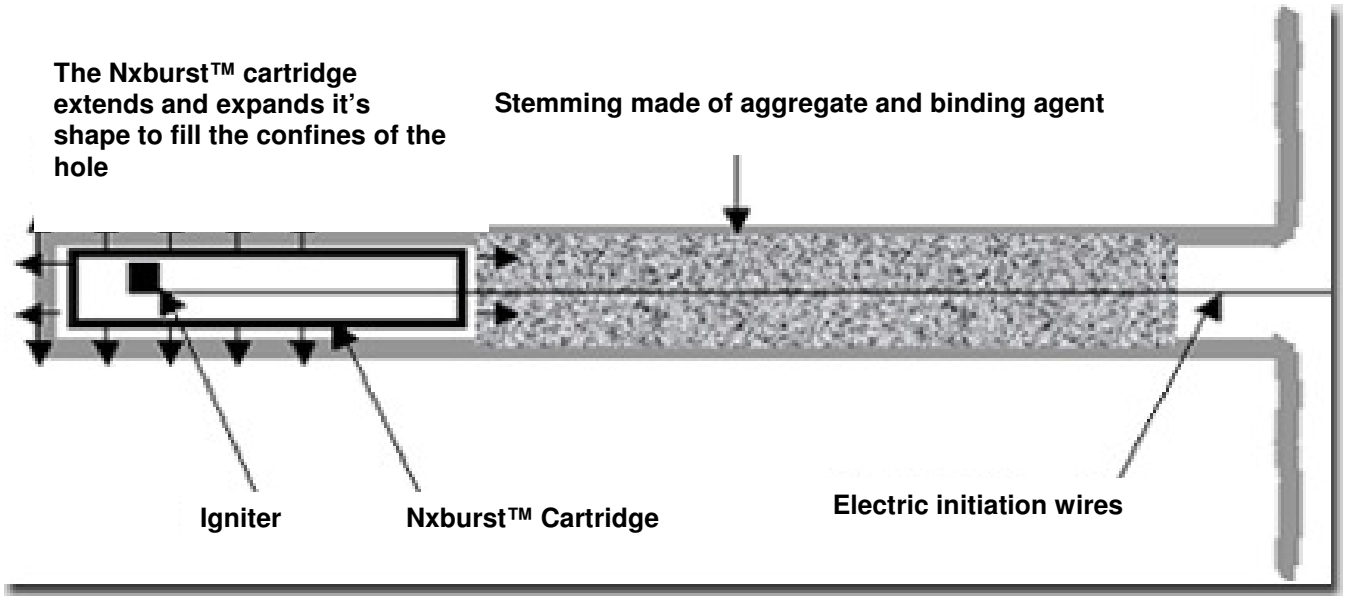


4. Blow the holes clean with air.

5. The cartridge resistance must be tested prior to inserting the cartridge into the hole. The correct resistance reading for the cartridges is:

13mm Range	= 1.20 Ω to 1.71 Ω (1.0m lead wire)
28/34mm Range	= 1.23 Ω to 1.85 Ω (2,0m lead wire)
25034mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)
42mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)
60mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)

6. Insert the cartridge to the bottom of the hole with a charging stick. Begin to stem the hole using 6mm unwashed crusher dust which is moistened. Stem the hole in 100mm to 150mm segments. Tamp each segment until the stemming is solid and a hollow sound can be heard from the hole. Continue to stem and tamp until the hole is solidly packed to the collar.



7. Test the resistance of the cartridge with a authorized tester, to make sure that the wires were not damaged during the loading process.

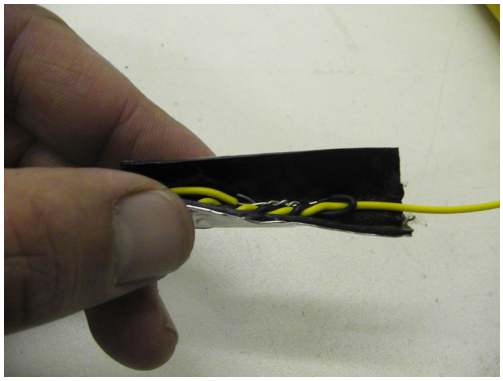
Charging Up Procedure

1. Make sure that the area is safe. Place guards and warning signs 50m from the blast site to ensure that no unauthorized personnel enter the danger area.

2. Make sure the Shot exploder is with the responsible person and that the firing cable is not yet connected to the Shot exploder.

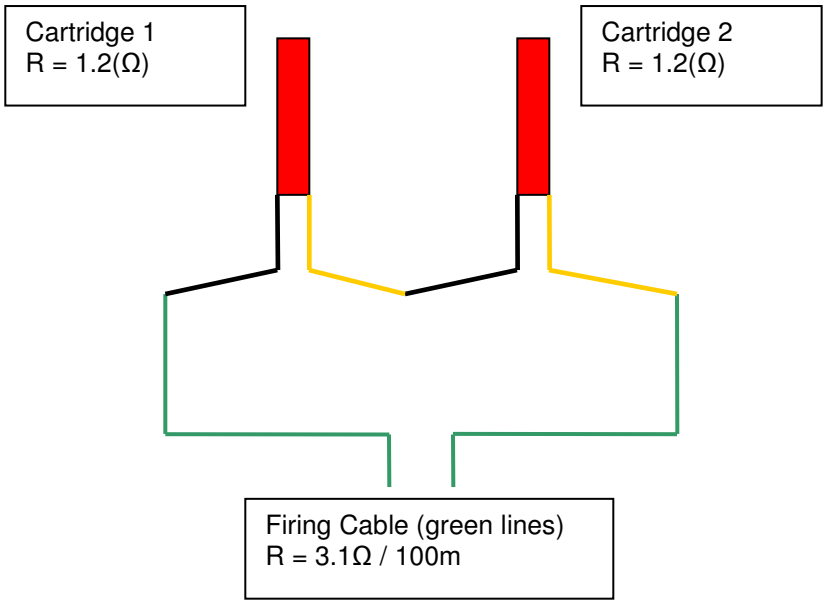
3. Pack up all unused cartridges and equipment. Move all vehicles from the area and ensure that the general area surrounding the charged site is secure; a safe distance is at least 30 m.

4. Connect the cartridges in series. Connections must be insulated and protected against moisture or water ingress.



5. Ensure that the far end of the firing cable is shorted. Connect the firing cable to the circuit and ensure the connections are insulated.

6. Move to end of the firing cable which must be at least 30m away from the cartridges and test the circuit for continuity and correct resistance. The resistance is calculated as follows:



To calculate the total resistance the formula is as follows:

R (total) = R1 (Cartridge 1) + R2 (Cartridge 2) + R3(Firing cable)

Therefore: R(t) = R1(1.2Ω) + R2 (1.2Ω) + R3 (3.1Ω)

= 5.5Ω

7. If the circuit test correct in terms of resistance, proceed with the firing procedure. If not inspect the following:

    a. Electrical connections for loose connections

    b. The resistance on the firing cable.

    c. The resistance on the cartridges.

Firing Procedure

1. Make sure the area is safe before connecting the firing cable to the shot exploder.

2. Connect the wires to the Shot exploder.

3. Be sure that the area is clear before sounding the firing signal which could be by whistle or siren.

5. Insert the key or magnetic key

6. Give a fire warning "**READY TO FIRE!"**

7. Fire the circuit.

Post firing procedure

1. Ensure that no one enters the area until the Nxburst operator has declared it safe.

2. Remove the key from the shot exploder.

3. Remove the firing cable from the shot exploder.

4. Inspect the break.

a. Post-Blast holes could have wires protruding from them and have no indication if they have fired should be inspected. Connect the lead wires to an Ohm meter or Continuity meter and test the resistance or continuity. If the cartridge shows no continuity or the resistance value is 1, the cartridge has fired. However, it is possible that the gases have escaped into voids in the rock or fired through the bottom in the case of a boulder. In very unlikely circumstances, the match has burned but failed to ignite the contents of the cartridge.
b. Fill the hole with water in order to dissolve any AN and render the NC propellant useless.
c. **Caution!! Do not insert a moil into the hole or attempt to drill the same hole.**
d. If the hole cannot be flushed and the cartridge retrieved, drill an adjacent hole 3 to 10 inches (100 to 300mm)parallel to the existing hole.
Take special care to prevent the drill to track into the existing drill hole.
e. Charge and stem the hole and blast the partially deflagrated or misfired cartridge out.
f. If mechanical means such as an excavator is used to excavate bedrock, personnel must stay clear of the machine since the bits on the excavator could ignite the cartridge.

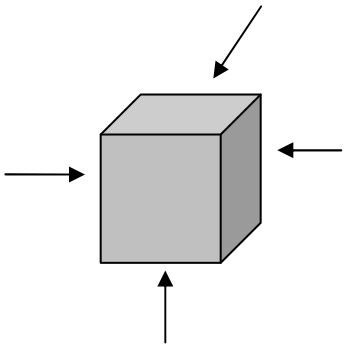
5. If the Nxburst operator is satisfied that all the cartridges have fired, he may allow personnel and equipment to enter the area.

6. Collect all spent cartridges and packaging and dispose of in an appropriate manner.

Appendix B

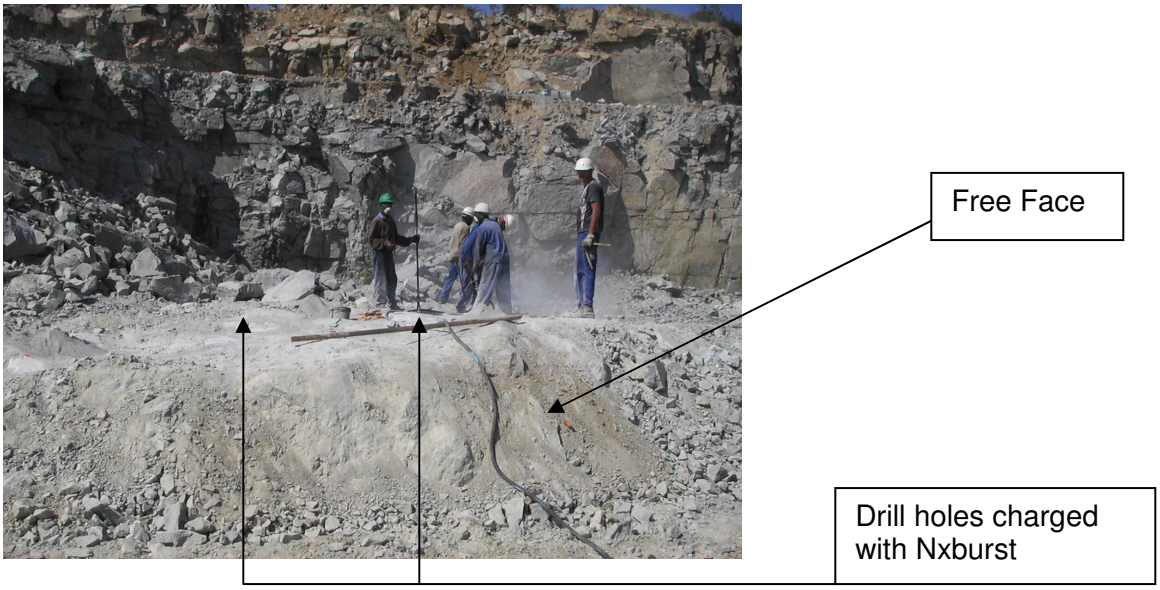
Method Statement for Breaking In Situ Rock with Nxburst™

In Situ (meaning rock covered with earth rock on four sides)

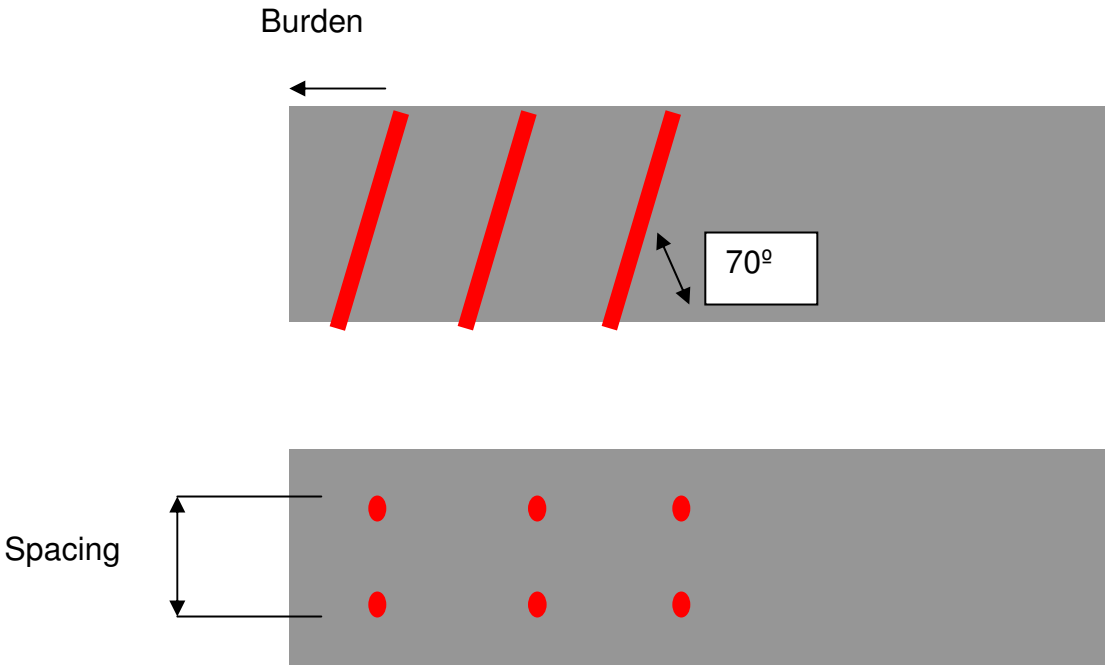


Instructions for breaking in situ rock

In situ rock must break in to “free face”. A free face is the area to which the rock can break into:



The holes drilled into in situ rock must be angled at 70º to the horizontal plane:



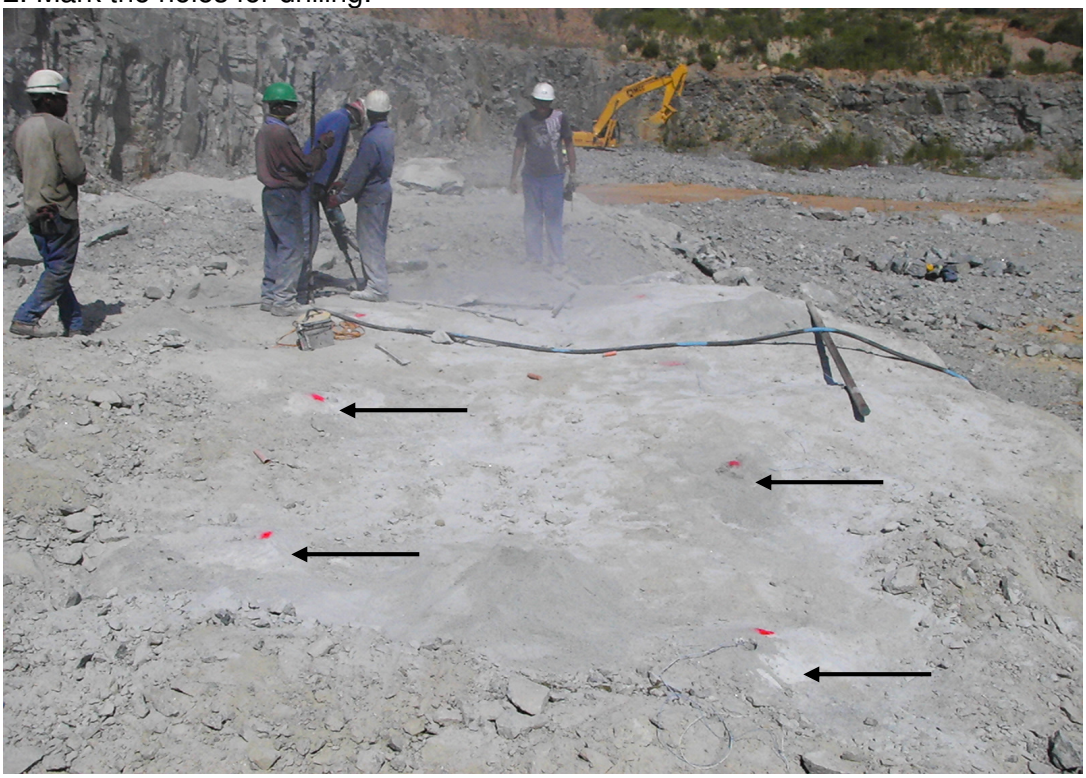
1. Choose the correct cartridges from the table below:

Nxburst 13mm RockPopper Cartridge	Charge Weight g		Burden mm	Hole Spacing mm	Hole Depth mm	Cubic Meters m^3	Powder Factor kg/m^3
0513	5		200	200	300	0.012	0.417
1013	10		200	200	400	0.016	0.625

Nxburst 28mm and 34mm Cartridges	Charge Weight g		Burden mm	Hole Spacing mm	Hole Depth mm	Cubic Meters m^3	Powder Factor kg/m^3
2028 / 2034	20		250	250	400	0.025	0.800
4028 / 4034	40		300	300	500	0.045	0.889
6028 /6034	60		350	350	600	0.74	0.816
8028 / 8034	80		350	350	800	0.098	0.816
10028 / 10034	100		400	400	800	0.128	0.781
12028 / 12034	120		400	400	900	0.144	0.833
14034	140		400	400	1000	0.160	0.875
16034	160		450	450	1100	0.223	0.718
18034	180		450	450	1200	0.243	0.741
25034	250		500	500	1500	0.375	0.667

Nxburst 42mm Rock breaking Cartridge	Charge Weight g		Burden mm	Hole Spacing mm	Hole Depth mm	Cubic Meters m^3	Powder Factor kg/m^3
6042	60		350	350	600	0.074	0.816
8042	80		350	350	800	0.098	0.816
12042	120		400	400	900	0.144	0.833
18042	180		450	450	1200	0.243	0.741
24042	240		500	500	1500	0.375	0.640
Nxburst 60mm Rock breaking Cartridge	**Charge Weight g**		**Burden mm**	**Hole Spacing mm**	**Hole Depth mm**	**Cubic Meters m^3**	**Powder Factor kg/m^3**
20060	200		500	500	900	0.225	0.889
30060	300		600	600	1000	0.360	0.833
40060	400		700	700	1200	0.588	0.680
50060	500		750	750	1500	0.844	0.593

2. Mark the holes for drilling.



3. Select the correct size of drill bit.

For 13mm cartridges = 16 mm drill bits

For 28mm cartridges = 32mm drill bits

For 34mm cartridges = 38mm – 42mm drill bits

For 42mm cartridges = 45 – 50mm drill bits

For 60mm cartridges = 72-76 mm drill bits

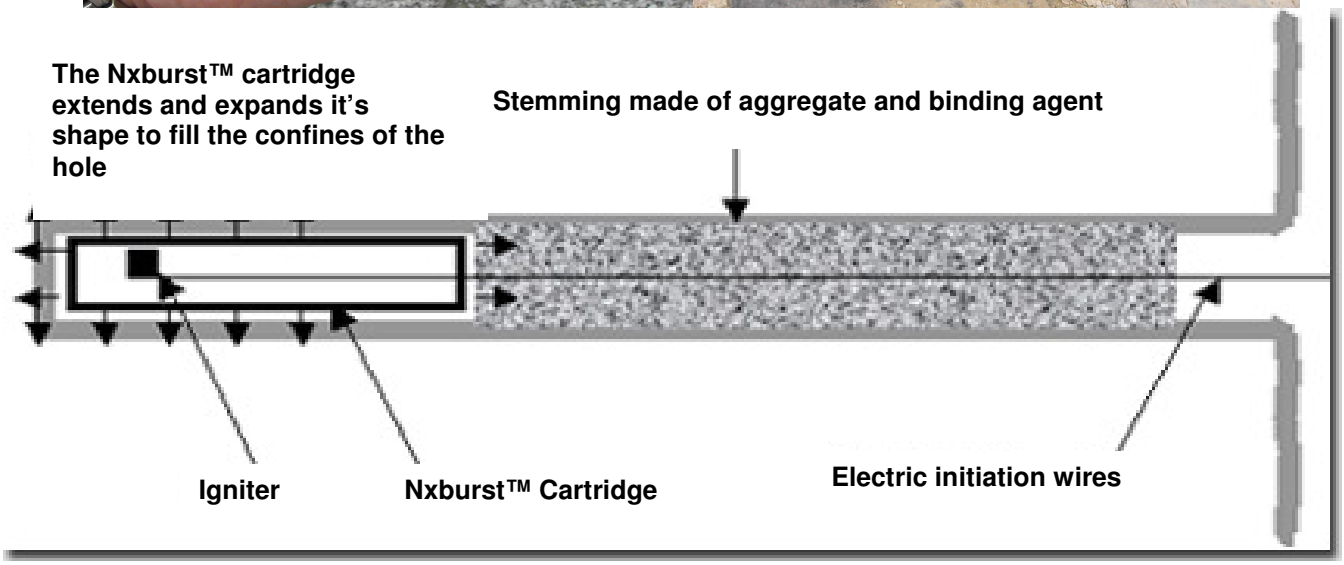
3. Drill the holes at 70º.

4. Blow the holes clean with air.

5. The cartridge resistance must be tested prior to inserting the cartridge into the hole. The correct resistance reading for the cartridges is:

13mm Range	= 1.20 Ω to 1.71 Ω (1,0m lead wire)
28/34mm Range	= 1.23 Ω to 1.85 Ω (1,8m lead wire)
25034mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)
42mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)
60mm Range	= 1.42 Ω to 1.95 Ω (3,5m lead wire)

6. Insert the cartridge to the bottom of the hole with a charging stick. Begin to stem the hole using 6mm un-sifted crusher dust which is moistened. Stem the hole in 100mm to 150mm segments. Tamp each segment until the stemming is solid and a hollow sound can be heard from the hole. Continue to stem and tamp until the hole is solidly packed to the collar.



7. Test the resistance of the cartridge with a authorized tester, to make sure that the wires were not damaged during the loading process.

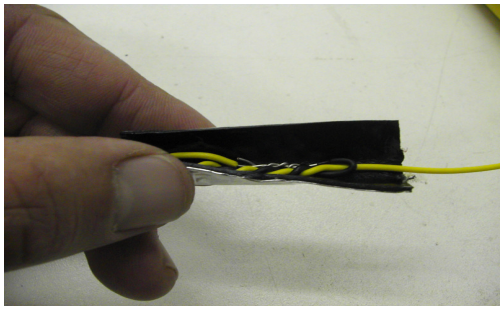
Charging Up Procedure

1. Make sure that the area is safe. Place guards and warning signs 50m from the sight to ensure that no unauthorized personnel enter the danger area.

2. Make sure the Shot exploder is with the responsible person and that the firing cable is not yet connected to the Shot exploder.

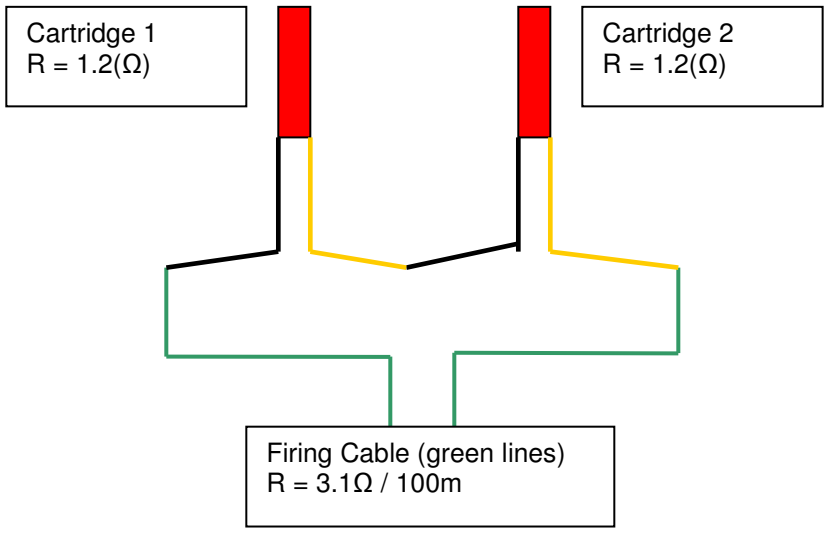
3. Pack up all unused cartridges and equipment. Move all vehicles from the area and ensure that the general area surrounding the charged site is secure; a safe distance is at least 30 m.

4. Connect the cartridges in series. Connections must be insulated and protected against moisture or water ingress.



5. Ensure that the far end of the firing cable is shorted. Connect the firing cable to the circuit and ensure the connections are insulated.

6. Move to end of the firing cable which must be at least 30m away from the cartridges and test the circuit for continuity and correct resistance. The resistance is calculated as follows:



To calculate the total resistance the formula is as follows:

R (total) = R1 (Cartridge 1) + R2 (Cartridge 2) + R3(Firing cable)

Therefore: R(t) = R1(1.2Ω) + R2 (1.2Ω) + R3 (3.1Ω)

= 5.5Ω

7. If the circuit test correct in terms of resistance, proceed with the firing procedure. If not inspect the following:

a. Electrical connections for loose connections

b. The resistance on the firing cable.

c. The resistance on the cartridges.

Firing Procedure

1. Make sure the area is safe before connecting the firing cable to the shot exploder.

2. Connect the wires to the Shot exploder.

3. Ensure that the area is clear before sounding the firing signal which could be by whistle or siren.

5. Insert the key or magnetic key

6. Give a fire warning "**READY TO FIRE!"**

7. Fire the circuit.

Post firing procedure

1. Ensure that no one enters the area until the Nxburst operator has declared it safe.

2. Remove the key from the shot exploder.

3. Remove the firing cable from the shot exploder.

4. Inspect the break.

a. Post-Blast holes could have wires protruding from them and have no indication if they have fired should be inspected. Connect the lead wires to an Ohm meter or Continuity meter and test the resistance or continuity. If the cartridge shows no continuity or the resistance value is 1, the cartridge has fired. However, it is possible that the gases have escaped into voids in the rock or fired through the bottom in the case of a boulder. In very unlikely circumstances, the match has burned but failed to ignite the contents of the cartridge.
b. Fill the hole with water in order to dissolve any AN and render the NC propellant useless.
c. **Caution!! Do not insert a moil into the hole or attempt to drill the same hole.**
d. If the hole cannot be flushed and the cartridge retrieved, drill an adjacent hole 3 to 10 inches (100 to 300mm)parallel to the existing hole.
   Take special care to prevent the drill to track into the existing drill hole.
e. Charge and stem the hole and blast the partially deflagrated or misfired cartridge out.
f. If mechanical means such as an excavator is used to excavate bedrock, personnel must stay clear of the machine since the bits on the excavator could ignite the cartridge.

5. If the Nxburst operator is satisfied that all the cartridges have fired, he may allow personnel and equipment to enter the area.

6. Collect all spent cartridges and packaging and dispose in an appropriate manner.

INSTRUCTION FOR DISPOSAL OF NXBURST CARTRIDGES

Application Restrictions

1. This procedure is only to be performed at a blasting site by a qualified Nxburst operator.

Risks

2. The main charge of Nxburst™ consists of a flammable composition. This composition will burn fast when confined, but will burn with a moderate rate unconfined.

3. The igniter consists of “match head” sized pill of very energetic material which burns rapidly when exposed to heat.

4. Both these compounds will ignite when exposed to an open flame or to excessive impact or friction.

5. The process of destroying cartridges poses the risk of veld fires and should therefore be performed in a suitable open area (at least 5m radius free of vegetation).

Procedure

1. The cartridge wires are cut 10mm from where the wire exits the cartridge.

    a. Using a sharp partition knife only, cut through the red tube 50mm from the top of the cartridge around the circumference. (This excludes 2028, 2034 and 13mm units). **Do not use a hacksaw!**

    b. 2028 and 2034 units will be cut 25mm from the top of the cartridge. The 13mm units will be cut 10mm from the top of the cartridge.

    c. Separate the cartridge by bending the cartridge on the cut.

    d. Empty the contents of the cartridge in a straight line of not more than 10mm x 10mm in dimension.

    e. If the contents are stuck, remove by tapping the tube on the side when emptying the contents. **Do not scrape the contents from the cartridge.**

    f. Cut the fuse head from the wire 10mm from the connection and place on the emptied contents.

    g. Ignite the line from a down wind direction and move back 5m.

    h. When the burning is completed, wet the area with water.

    i. Rinse the remaining tube with water and dispose of the tube in an appropriate manner. **Do not leave the tubes at the site.**

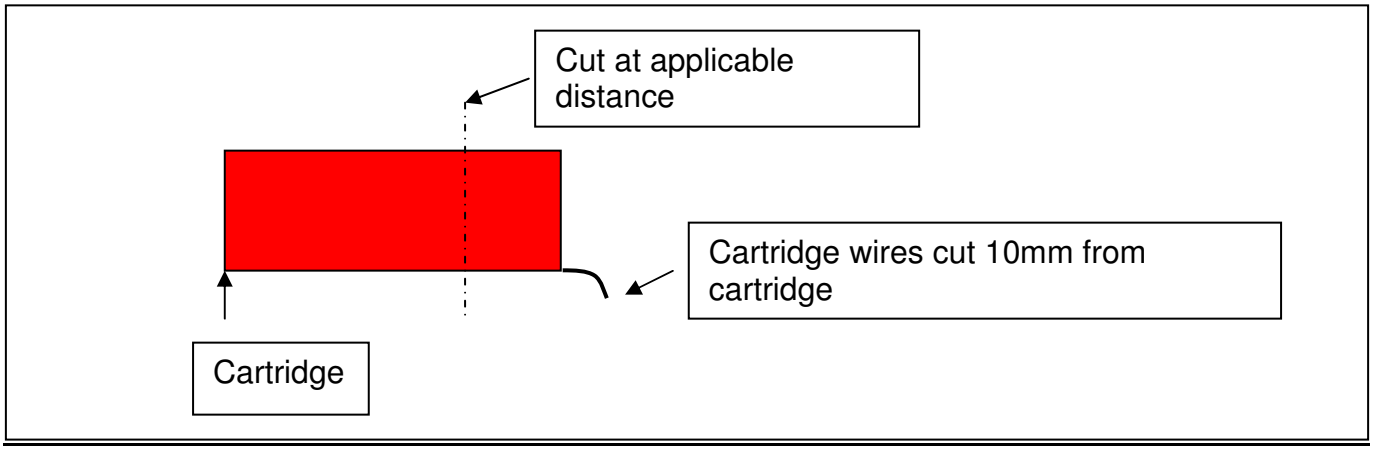


Figure 1: Cutting locations

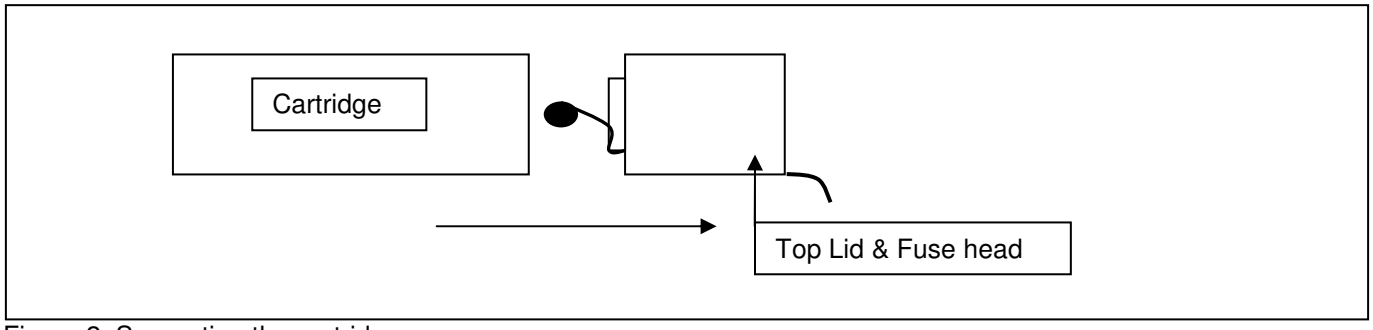


Figure 2: Separating the cartridge

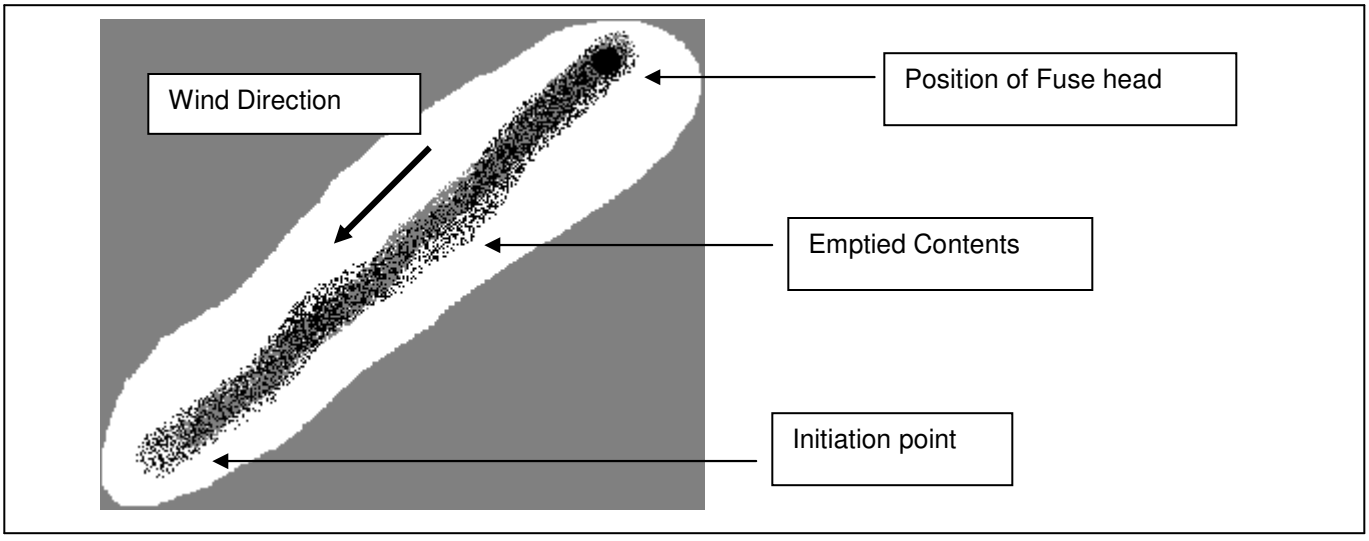


Figure 3: Destroying the contents

Equipment required to operate as a RBC Operator:

1. Shot exploder
2. Ohm Meter
3. Main Firing Cable (100m)
4. Red Warning Flags
5. Danger Boards
6. Siren
7. Personal Protection Equipment