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# NXBURST™: FREQUENTLY ASKED QUESTIONS

**Q. What is Nxburst™?**

A. The Technology is based on a non-detonating propellant compound enclosed in a cartridge, which reacts very quickly when ignited to produce high volumes of harmless gas, mainly consisting of nitrogen, carbon dioxide and steam. When the cartridge is sealed in a drill hole, the high pressure 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, expanding the fractures and propagating cracks towards the nearest free face of the rock. The number of cracks propagated is related to the maximum pressure and peak pressure rate achieved by the expanding gasses within the drill hole. The gas pressure, within the drill hole and propagated cracks, then causes the fractured rocks to heave apart, producing a shearing of the rock often called splitting.

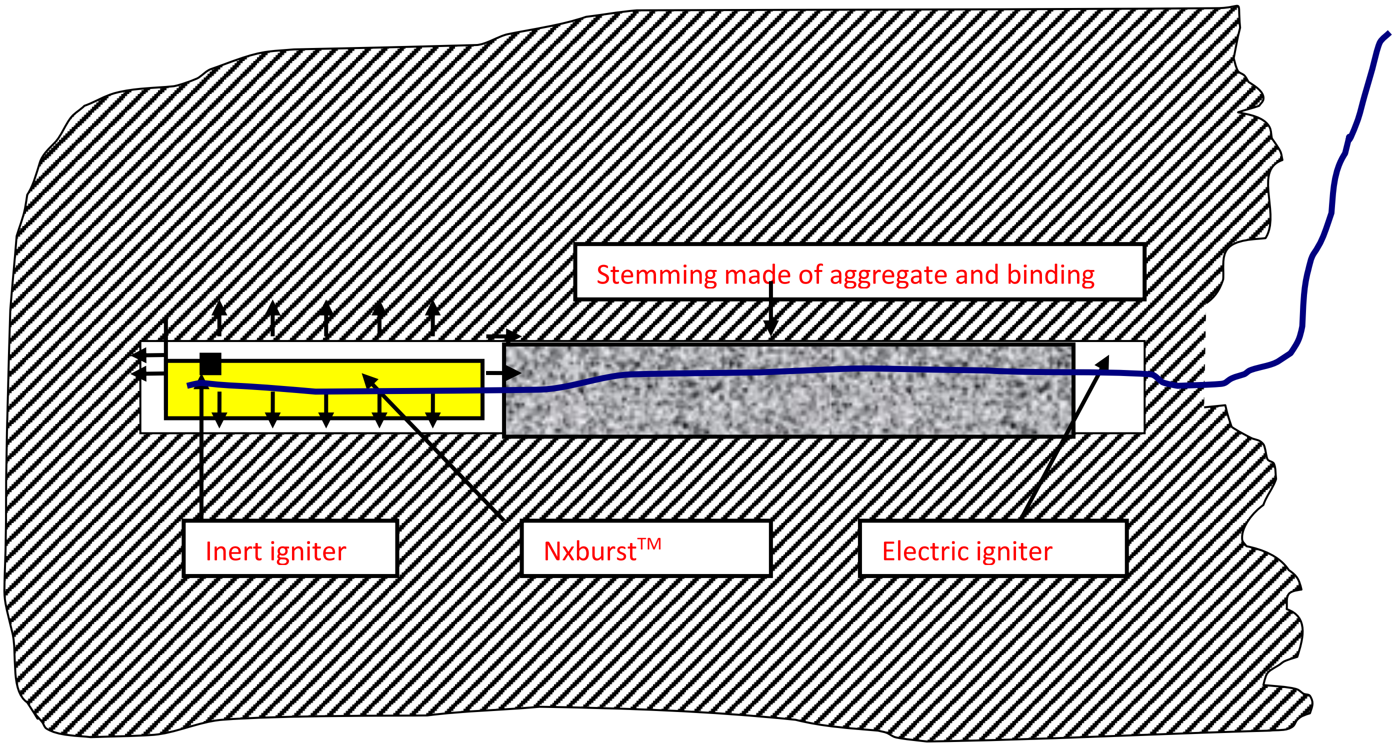


Figure 1: The Nxburst™ Cartridge inserted in a drill hole

**Q. What is Nxburst™ used for?**

A. The Nxburst™ rock breaking technology was developed to solve problems associated with specialist excavations and rock breaking in sensitive conditions. The collateral damage associated with excavations using explosives in poor rock conditions or in blast sensitive areas often creates a larger problem than the original explosive solution set out to address.

Problems of blast damage in highly jointed rock and collateral damage to sensitive installations and infrastructure have persisted in the industry for many years due mainly to the absence of credible alternative methods to address such situations. Nxburst™ offers the industry a solution, which allows a controlled approach to excavation in these difficult situations without the vestiges of damage associated with traditional methods of rock breaking using explosives.

The Nxburst™ rock breaking method, developed by NXCO Mining Technologies, has recently been applied to several applications in a wide variety of rock conditions. The Nxburst™ technology allows a tailored rock breaking ("TRB") approach whereby energy can be applied more efficiently to break and dislodge the rock in a controlled fashion, which can be optimally adapted to suit the rock breaking requirements of any particular situation in all types of rock conditions.

## ADVANTAGES & DISADVANTAGES OF NXBURST™

**Q. What are the advantages of using Nxburst™?**

A. (1) Nxburst™ is environmentally sensitive
   a. minimal fly rock (< 10m)
   b. minimal vibration
   c. lower noise and overpressure levels than conventional explosives
   d. negligible noxious gasses

(2) Similar yields to small-diameter conventional blasting can be achieved with Nxburst™ using smaller charge weights. Primary rock breaking yields typically around $1m^3$, in hard in-situ rock pavements, can be achieved using a 100g Nxburst™ cartridge. Significantly greater secondary-breaking yields are produced when breaking boulders rather than in-situ rock

(3) Only localised clearance of personnel is required with Nxburst™. Production is optimised as no downtime to loading and hauling equipment is experienced due to site evacuation during initiation.

(4) Nxburst™ is safer to transport, store and use than conventional explosives.

(5) Nxburst™ can be used with low capital, lightweight equipment – One small hand-held drill rig is all that is needed to drill the hole.

**Q. What are the Nxburst™ cartridge sizes?**

A. Nxburst™ cartridges come in a range of diameters and charge weights:

| CARTRIDGE DIAMETER | HOLE SIZE DIAMETER | NXBURST CHARGE WEIGHT | CARTRIDGE SIZE INTERVALS |
|---|---|---|---|
| 13mm | 14mm - 16mm | 5 - 10g | 5g |
| 28mm | 30mm - 34mm | 20g - 120g | 20g |
| 34mm | 36mm - 42mm | 20g - 250g | 20g up to 180g and 250g |
| 42mm | 45mm - 51mm | 60g-240g | 60g (80g cartridge introduced on request) |
| 60mm | 64mm - 76mm | 200g - 500g | 100g |

**Table 1: Nxburst™ Cartridge Sizes**

**Q. Is Nxburst™ an explosive?**

A. The Nxburst™ cartridge is classified as a 1.4 S product under the United Nations hazardous substances classification, in the same category as small arms ammunition. This classification is given to products that do not explode when ignited in their original packaged state and as such the classification defines Nxburst™ as a non-explosive product for transport and storage purposes.

An explosion is basically any rapid expansion of matter into a volume much larger than the original. The rapid expansion of a gas from the bursting of a latex balloon can be classed, according to some definitions, as an explosion. Equally, the bursting of a pneumatic tyre or the rupturing of a pressurised gas tank can be termed as explosive events. As mining engineers we are more attuned to the term explosion being applied to the exothermic chemical reaction caused by the initiation of an explosive.

In general, the term explosive is used to describe a material that can undergo an exothermic chemical reaction resulting in a rapid expansion of the reaction products into a volume larger than the original.

A. wider term, energetic material, is mostly used to comprise all materials that can undergo exothermic chemical reaction releasing a considerable amount of thermal energy, which may or may not cause an explosion. A widely used classification of energetic material is illustrated in figure 2.

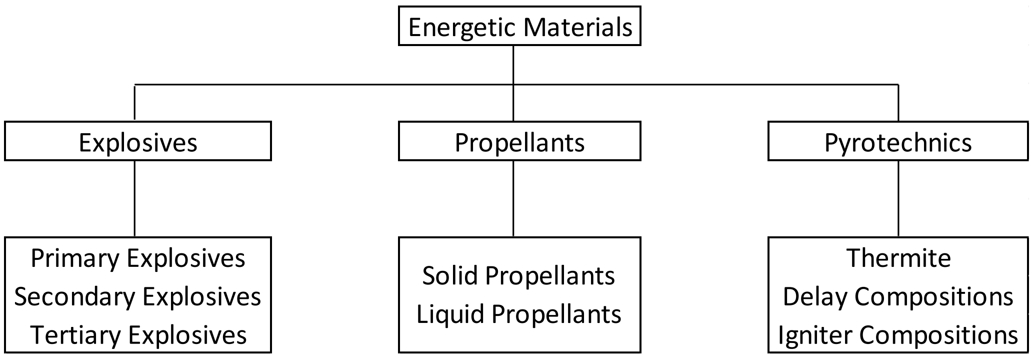


**Figure 2: Classification of Energetic Materials (After Per-Anders Persson)**

The reason why a Nxburst™ cartridge does not explode and is therefore not an explosive in its packaged state, is that 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).

**Q. Does Nxburst™ detonate?**

A. One of the most salient features distinguishing Nxburst™ from high explosives is that explosives detonate whilst the propellant used in a Nxburst™ cartridge deflagrates.

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. Deflagration speeds of propellants are in the order of 200 to 1000 metres per second producing pressures reaching 1000 Mpa, which are developed in thousandths of a second.

High explosives are defined as materials intended to function by detonation (2). The reaction speeds of detonation are higher than the speed of sound in the explosive material. The speed of sound through a material is dependent on the density of the material; the higher the density, the higher the speed of sound will be through it. A reaction speed of 1000 metres per second is set as the minimum speed that distinguishes detonations from deflagrations (2). Detonation speeds are in the order of 1000 to 10 000 metres per second producing pressures from 1500 to 15 000 Mpa which are developed in millionths of a second.

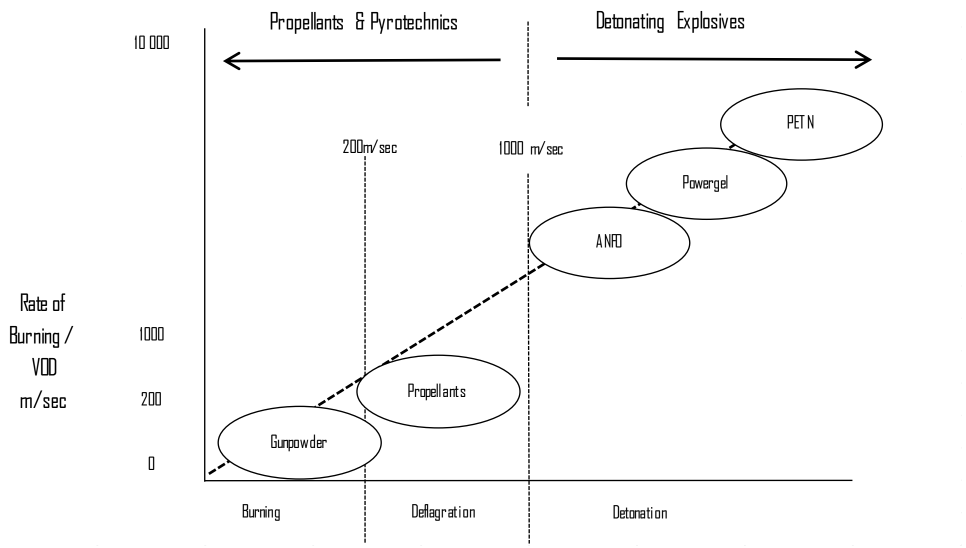


**Figure 3 – Burning, deflagration and detonation of commonly known energetic materials**

The effects of detonations are very different from those of deflagrations. 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. Conversely, deflagration produces no shock wave and only those pressures produced by the formation of gaseous products are present.

The rock to which an explosive detonation is applied will experience a supersonic blow from the detonation front's pressure pulse followed quickly by a prompt release of pressure and then followed immediately by a build-up of pressure imparted by the gaseous products of the explosion, which will be applied in a more or less sustained manner. Deflagration produces only the last effect as it does not produce a shock wave.

In Figure 3 a range of energetic materials used for rock breaking is shown in ascending order of burning or detonation speeds. Pyrotechnics such as black powder are represented in the lower end of the scale with a burning speed of less than 200 metres per second, whilst propellants occupy a range of burning speeds from 200 to 1000 metres per second. The higher order propellants are double based or composite propellants. Blasting agents such as ANFO and AN slurries are represented in the 3200 to 3500 metres per second range whilst Powergel has a VOD of approximately 4 000 metres per second. High explosives such as TNT and PETN have VODs in the range 6500 to 7 000 metres per second.

In general, the higher the VOD of the explosive, the greater the shock wave produced, which is responsible for the shattering action of the blast. In high VOD explosives much of the energy is disseminated in the detonation shock wave whereas in propellants and pyrotechnics, as well as explosives with lower VODs, most of the energy is used in the heaving action produced by the gaseous products pressurising the drill hole.

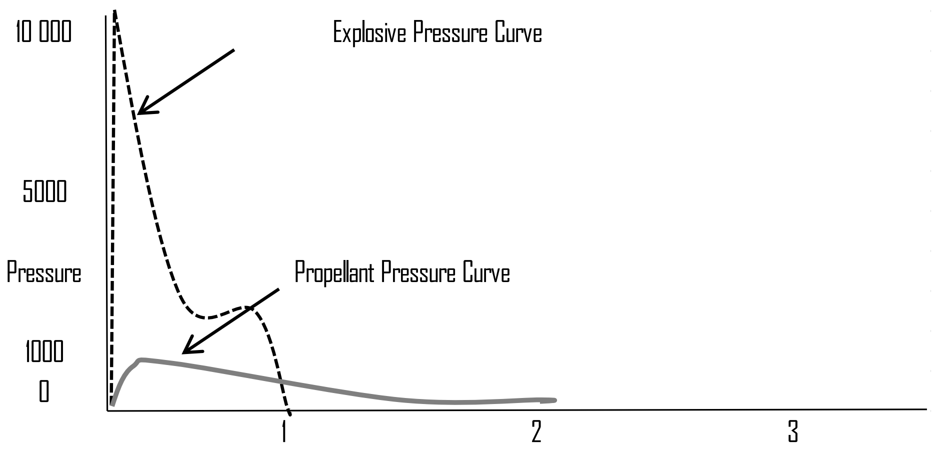


**Figure 4 – Increase of pressure over time curves for explosives and propellants confined in a drill hole in rock**

Figure 4 illustrates the vast difference in drill hole pressures developed by detonating explosives compared to deflagrating propellants – a difference in the order of 10 to 20 times. As a result of the relatively low-pressure regime developed by a propellant in a drill hole, the shock wave inherent in rock breaking using high explosives is avoided, which allows propellant-based rock breaking methods to be used in situations where high explosives are prohibited.

## ADVANTAGES OF USING NXBURST™ OVER CONVENTIONAL EXPLOSIVES

### Q. How does Nxburst™ rock breaking differ from rock breaking using conventional explosives?

A. The major difference between Nxburst™ and explosives can be summarised as follows:

- Explosives can explode in their packaged state whereas Nxburst™ cartridges do not explode in their packaged state.
- Explosives are designed to detonate whereas Nxburst™ cartridges are designed to deflagrate
- Explosives produce a destructive shock wave giving rise to high vibration-levels, which damage the surrounding rock mass whereas Nxburst™ cartridges 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 a Nxburst™ cartridge confined in a drill-hole is a controlled event which produces minimal fly rock, low concentrations of noxious gases and negligible amounts of dust.
- Rock breaking using Nxburst™ cartridges can be carried out continuously with re-entry periods measured in seconds whereas explosive blasting using conventional explosives requires the mine to be evacuated for up to 4 hours after each blast.

**Q. What are the transport and storage requirements for Nxburst™?**

A. The Nxburst™ cartridge is classified according to the United Nations Classification of Hazardous Substances as a Division 1.4 S hazardous substance. The UN classification system is used by most countries of the world to classify hazardous products according to the danger that each of the products poses whilst in storage and transport. The 1.4 S classification that applies to Nxburst™ cartridges is the same classification as that applied to small arms ammunition.

The Nxburst™ cartridge was tested by a UN accredited testing agency and subsequently classified under UN1.4S as a “Cartridge Power Device”. The UN 1.4S classification is defined as follows:

“Articles and substances that present no significant hazard”

This division comprises articles and substances, which present only a small hazard in the event of ignition or initiation during transport. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected.

Articles and substances in this Division are placed in Compatibility Group S when they are so packaged or designed that any hazardous effects arising from accidental ignition are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder fire-fighting or other emergency response efforts in the immediate vicinity of the package”.

The 1.4 S classification described above is awarded to only those products that attain the classification by undergoing a series of strenuous testing under the supervision of the SABS. The successful outcome of the testing requires that the product is incapable of an explosion whilst in its packaged state even if it is accidentally ignited or otherwise initiated by external means.

## ENVIRONMENTAL ADVANTAGES OF NXBURST™

**Q. What are the environmental benefits of Nxburst™?**

A. Environmental Benefits of Nxburst™ rock splitting Nxburst™ rock splitting produces low vibration resulting in significantly reduced damage to surrounding rock and infrastructure; minimal fly rock resulting in minimal scatter of blasted rock; low overpressures resulting in minimal concussion effects; and minimal fumes and dust allowing operations to be carried out continuously without the need to evacuate the mine as is the case with conventional explosives blasting. These benefits are explained below.

**Q. What vibration levels are produced by Nxburst™ rock breaking?**

A. When an in situ rock splits / breaks up on tensile, the movement of rock causes minimal vibrations to its environment.

Should the rock which breaks be attached to a wall (without a foundation for example,) the movements created by breaking are likely to impact upon the wall, which will probably crack. However these are mechanically induced vibrations, not vibrations induced by a shock wave initiated by detonation.

The physics has not been studied, however, the application of vibration monitors close to the Nxburst initiation proves that these minimal to low vibrations are a fact.

**Q. Do the same low vibrations impact underwater?**

A. Yes, divers only need to withdraw about 20 metres, because no shock wave is produced; as a result there is minimal damage done under the water, fish are safe and the environment protected

**Q. What are the noise levels produced by Nxburst™ rock breaking?**

A. Noise measurements should not be confused with overpressure measurements. Noise measurements are made with standard sound level meters, which record air vibrations falling in the audible frequency region only. There are times when relatively high overpressures are not audible because their frequency is outside the audible frequency region.

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 metres from the hole. Noise levels can be attenuated by the use of conveyor belting to cover the holes being fired, together with earth cover on top. Noise is then reduced to a murmur in the earth.

**Q. What are the fly-rock effects of Nxburst™?**

A. The Nxburst™ breakage process drastically reduces the potential for fly rock due to the controlled manner in which the rock is broken. Fly rock that does occur is of a lower velocity and is normally confined to a distance within 10 metres of the hole. As a result, Nxburst™ rock breaking can be used with a minimal clearance zone from the point of initiation. A personnel clearance zone of 30 metres normally provides a sufficient factor of safety from inadvertent fly-rock, subject to the discretion and judgement of the Nxburst initiator.

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 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 pressurisation of the hole for a given burden and type of rock. Additionally, fly rock may be controlled 100% by adequate covering. Even a mass initiation well covered results in a ‘heaving’ of the soil cover.

**Q. What local clearance is required for Nxburst™ rock breaking?**

A. The Nxburst™ cartridge provides similar hole-breakage performance to standard explosives in terms of burden and spacing; but has the important distinction that it produces low vibration, low fly-rock, minimal concussion effect and negligible fumes and dust. As a result, Nxburst™ does not require the mine to be evacuated during the firing of the cartridges and allows rock breaking to be carried out safely on a continuous basis during the shift with only localised clearance of the rock breaking area to a distance of 30 metres required.

**Q. Does Nxburst™ produce noxious gasses?**

A. 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 (fuel) + ammonium nitrate (oxidiser) → steam + nitrogen +carbon dioxide + energy

*(X)* C6 N3 H7 O11 + *(Y)* NH4NO3 → H2O + N2 + CO2 + 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 metre 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 rock breaking event.

As a result of the degree of oxidation achieved in the deflagration process, through the incorporation of an effective oxidising 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 metres per second) is available.

**Q. What are the dust levels produced by Nxburst™ rock breaking?**

A. Due to its tensile breakage mechanism, Nxburst™ produces a much coarser fragmentation when compared to the smaller particles produced by the crushing effect of explosives. A major advantage of the coarse fragmentation is that the dust emitted is significantly reduced.
Due to the absence of large compressive stresses on the walls of the drill hole, which explosives use to pulverise the immediate rock zone around the drill hole; and the tensile nature of the Nxburst™ rock breaking mechanism, which is achieved by propagation of cracks by the emitted gases, the dust produced in the Nxburst™ rock breaking process is significantly less than the dust produced by blasting using detonating explosives.

## *APPLICATIONS*

**Q. What applications is Nxburst™ used for?**

A. Nxburst™ is used in a wide variety of rock breaking applications, which include the following:

(i) Secondary breaking (i.e. breaking of oversize rocks) in surface mines d quarries and underground.
(ii) Civil excavation and demolition on environmentally sensitive sites.
(iii) Slyping or stripping of underground tunnels & excavations
(iv) Shaft sinking
(v) Mass rock breaking
(vi) Underwater demolition

## *NXBURST™ OPERATIONS*

**Q. What is involved in the drilling and breaking cycle?**

A Nxburst application is simple, however in the modern world today, accurate planning, method statement and risk assessment is part of the process' The operating team must be properly trained and certificated, led with discipline and experience, adequately clothed and protected by regulation PPE, follow due safe process and procedures.

**HOW TO FIND OUT MORE**

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