PRODUCT GUIDANCE

Australia Pacific Asia – July 2021

ELECTRONIC BLASTING SYSTEMS DYNAMIC PRESSURE MISFIRE HANDLING

PURPOSE

The objective of this document is to highlight the additional hazards associated with handling and treating misfires caused by dynamic pressure. This document provides an overview of the dynamic pressure failure mechanism, additional hazards introduced by dynamic pressure misfires and offers guidelines for controls to minimise risk of unplanned detonation. The intended audience is all users of Orica's explosive products in mining, quarrying and construction across the Australia, Pacific and Asia region (APA).

BACKGROUND – DYNAMIC PRESSURE MALFUNCTIONS

Dynamic pressure can cause malfunctions in all explosive products; however dynamic pressure malfunctions are most often observed as misfires in electronic blasting system (EBS) detonators. This conclusion is based on incidents analysed by Orica in the past six years across the open cut and quarry markets within Australia Pacific and Asia,

Dynamic pressure misfires in electronic detonators occur when the detonator is exposed to pressure or acceleration, producing forces that exceed the yield strength of the detonator shell or internal components. These misfires often result in a 'shrink wrapped' appearance of the detonator shell. However, misfires due to dynamic pressure also occur without visible shell deformation.

No electronic detonator system provides confirmation that all detonators fired, as fired detonators are unable to communicate. Dynamic pressure misfires occur after the blast box has sent the firing command to the detonators. This is the last step of the firing process and, therefore misfires that occur after this step are not reported by the system. Therefore, dynamic pressure misfires are usually only found when misfired explosives are uncovered during digging.

Electronic detonators that misfire due to dynamic pressure are usually damaged to the point that they will not respond to a later attempt at logging. However, some dynamic pressure failure modes result in a detonator that will respond to a later attempt at logging. See Testing wires of suspected misfires for discussion of testing EBS detonators.

Dynamic pressure detonator malfunctions are only confirmed by dissecting the detonator and examining the internal components. There is no way to positively diagnose a dynamic pressure detonator malfunction in the field without dissecting the detonator. However, electronic detonators confirmed as successfully programmed before firing, and then recovered from a blast, are usually attributed to dynamic pressure malfunction, especially if there is visible shell damage and no other plausible explanation for the misfire.

Dynamic pressure misfires involving detonators present a significant unplanned detonation hazard, as these misfires are usually unknown until discovered during downstream processes, and they contain unfired initiating explosives that may be damaged.

ADDITIONAL HAZARDS ASSOCIATED WITH DYNAMIC PRESSURE MISFIRES

Detonators are safe to handle during normal use due to internal components that protect against unplanned detonation due to electricity. These internal protections can be damaged during the blast, so any detonator recovered from a blast may be more sensitive to friction, impact, electricity, and heat, regardless of its appearance.

Removing a damaged detonator from a booster introduces hazards of unplanned detonation due to friction and static. Handling and storing a damaged detonator introduce impact and heat hazards as well.

Although previously published advice may state there is no risk of unplanned detonation when testing a detonator using approved equipment, testing introduces voltage and current to a detonator. If the detonator is damaged, the safety devices are in an unknown condition. One must therefore assume some probability of unplanned detonation at lower voltages. Even if the likelihood is extremely small, the consequence of unplanned detonation is catastrophic if a person is nearby.

Figure 1: Dynamic pressure misfires can often not be identified until the detonator is removed from the booster

ELECTRONIC BLASTING SYSTEM (EBS) MISFIRE HANDLING GUIDELINES

Misfire treatment is a critical task that demands a detailed risk assessment and specific action plan for each situation. Every misfire is unique and must be managed individually. The following guidelines apply to assessing risk when treating suspected EBS misfires.

- Treat all EBS misfires as though internal protection components in the detonator are not functioning.
- Take appropriate steps to minimise unplanned detonation hazards due to friction, impact, electricity, and heat during each step of the misfire recovery and treatment process. This includes reducing the probability and consequence of unplanned explosion.

TESTING WIRES OF SUSPECTED MISFIRES

Assume any wires uncovered during excavation of a suspected misfire to be connected to a live detonator, with protection mechanisms no longer functioning.

Assess the risk of testing downlines to determine whether it is practical or beneficial to do so. Testing presents risks, and in many cases, these risks or the impacts of controls required to manage the risk will outweigh the benefit of testing. The likelihood that a detonator survives a blast with the ability to communicate is low.

If the risks or impacts of controls required to test downlines safely are deemed unsuitable or, potential hazards cannot be managed, demarcate the area containing downlines as a misfire and treat as per standard site misfire procedures.

Ensure the consequence of unplanned detonation when testing wires is addressed as part of misfire treatment risk assessment. Only test wires when all personnel and equipment are located at a safe distance to reduce the consequence of an unplanned detonation. This is notwithstanding any published advice and procedures that imply there is no probability of unplanned explosion when testing electronic detonators with approved equipment.

Keep mobile phones and radios at least 5m away from suspected misfires

Only test using approved and compatible equipment for the relevant product type.

Use extension wires to extend the downlines so that testing can be conducted from a safe position.

Before attaching extension wires to wires of a potential misfire, take steps to manage hazards associated with static voltage and stray current. Potential steps to reduce these hazards may include

- Connect yourself permanently to the ground. Position an earth spike (metal rod) near the misfired hole and connect it to your wrist with an electrostatic strap.
- Touch the ground with bare hand, not wearing a glove.
- Wear static dissipative shoes with a contact resistance below 35MΩ

Both legs of the wire and the person making the connection should be earthed and at the same potential as the suspected misfire when the connection is made.

After testing wires, do not approach the suspected misfire until after the prescribed “blast abort” wait time and twitch both legs of the wire together to maintain the same electric potential.

If the detonator communicates successfully and the decision is made to refire, conduct a risk assessment for any refiring activities, to ensure all hazards associated with refiring are managed effectively.

REMOVING POTENTIALLY DAMAGED MISFIRED DETONATORS FROM BOOSTERS

Immediate disposal of detonators damaged by dynamic pressure is preferred to disassembly. Recovery, transport, storage, and disassembly present risks, and in most cases, these risks outweigh the value of information to be gained by recovery and examination. Only remove the detonator from a misfired booster when deemed necessary as part of a product or incident investigation process.

The task should be performed by one person. Other people should leave the area and observe from a safe distance.

Wear appropriate PPE (leather gloves, eye protection, face shield and hearing protection)

Assume all misfired detonators are damaged. Assume internal protection components are not functioning, and sensitive elements of the detonator may be exposed.

Keep mobile phones and radios at least 5m away when handling primers containing misfired detonators

Ensure potential for unplanned detonation when removing misfired detonators from boosters is addressed as part of misfire treatment risk assessment.

Take steps to minimise risk of unplanned detonation due to friction, impact, electricity, and heat.

If possible, take photos of each stage of the recovery process. If using a phone, put it in airplane mode.

Disassembly should be performed carefully without tension, force, or harsh movements.

Water reduces the sensitivity of exposed PETN in detonators and sensitising bottles in boosters. Preferably, disassemble after soaking the unit in water, and attempt disassembly with the unit in

water. Consider submersing the primer in soapy water or using WD40 (spray lubricant) or other approved similar options to remove grit to allow easier disassembly of the primer and reduce friction, impact, static and heat potential.

When using cardboard shell boosters, soak the unit in warm water before disassembly. It may then be possible to remove some of the shell to examine the booster for any loose material, cracks, and breaks exposing the detonator. Loose fragments may be carefully removed to expose the detonator and remove it from the booster. Retain any removed booster fragments for examination and careful disposal.

When using non-cardboard shell boosters, inspect the booster shell for damage and loose components or materials that can be removed to assist with the safe removal of the detonator. Retain any removed material or components for examination and careful disposal. If booster segments or components cannot be taken apart easily, do not disassemble the booster, and assess whether the detonator can be easily removed from the primer.

When attempting to remove the detonator from the booster, use slow and gentle movements to prevent potential initiation by friction. Carefully twist the detonator to determine if jammed or sense the presence of grit. If gritty resistance is encountered, reattempt to remove the grit prior to further disassembly. Once the detonator rotates freely, try to pull detonator using 2 fingers at the crimp to avoid increasing damage.

If the detonator cannot be easily removed and successfully disassembled or there is any concern, STOP and follow guidelines for destruction, as per Transport and destruction of mixed class primer assembly

After removing the detonator from the primer, assume the detonator is damaged, regardless of visual appearance. Internal protection components can be damaged during the blast with no visible signs of damage to the external components of the detonator.

- Immediate disposal is strongly recommended instead of extended handling, storage and transport. Recovery, transport, storage and disassembly present risks, and in most cases these risks outweigh the value of information to be gained by recovery and examination.
- Twist both legs of the wire together to maintain the same electric potential.
- When handling the misfired detonator, always wear appropriate PPE (leather gloves, eye protection, face shield and hearing protection
- Keep mobile phones and radios 5m away from misfired detonators.
- Always hold misfired detonators by the wires or the crimped end of the detonator shell and always point the base of the detonator away from people.

TRANSPORT, STORAGE AND DESTRUCTION OF MISFIRED DETONATORS

In situations where disassembly may not be required or may not be possible, consider destroying the primer in-situ or close to the position of discovery. Ensure destruction by firing is risk assessed, and appropriate exclusion zones are in place for equipment and personnel. If the primer assembly must be transported for destruction in a different location, please refer to Transport and destruction of mixed class primer assembly

Transport explosive components according to local laws and site procedures in approved containers and approved vehicles.

Assume detonators recovered from a misfire are damaged and transport them separately from other detonators and explosives in a secure container to prevent unnecessary movement. Add water to the storage container to reduce friction, static, impact or heat during transport and mitigate the consequence of premature explosion.

If storing, carefully clean detonators of explosive residue using a soft, wet tissue. Consider spraying the detonator with a water dispersing compound such as INOX or WD40 to prevent shell corrosion.

Store recovered detonators in a clearly labelled container in a magazine. Store the detonator in water to reduce friction, impact static and heat risks during storage, and to mitigate the consequence of premature detonation.

Do not store damaged detonators with exposed explosive, particularly lead azide. Lead azide can become more sensitive over time. Lead azide can react with copper, particularly in high humidity or wet conditions, to form copper azide, which is a very sensitive explosive.

Conduct a detailed risk assessment before destroying recovered EBS detonators. This risk assessment should address:

- The method of initiation to ensure detonation and destruction.
- The risk of flyrock, airblast and/or vibration.
- Selection and application of suitable exclusion zones
- Potential for misfire or scattering explosives during refiring

If destroying or detonating in-situ, assess the potential for initiating other explosives products that may be in the vicinity of the primer, such as undiscovered columns of misfired bulk explosive. Ensure appropriate controls are in place for increased risk of flyrock.

If destroying or detonating in a separate, safe location (such as a waste dump) ensure appropriate controls are in place during transport of the misfired product. Additional controls may be required to manage exclusion zones and firing processes (clearance of area, radio communications etc.) along with use of buffer material to cover the misfire during firing.

Misfired detonators can be taped to another detonator with the base charge against base charge, or alternatively products can be taped to another primer for destruction. Ensure appropriate care is taken when handling the misfired detonator and attaching to the donor charge.

Misfired products may also be disposed of in a blasthole charged with fresh explosives. Damaged products can be taped to the primer and placed carefully in the hole. Ensure that the misfired product is in intimate contact with a donor primer and that appropriate care is taken when handling the misfired products and attaching them to the donor primer.

TRANSPORT AND DESTRUCTION OF MIXED CLASS PRIMER ASSEMBLY

If a detonator cannot be easily or safely removed from the primer and cannot be safely destroyed in situ, it must be transported to a safe location for storage or destruction.

Transport of a mixed explosives class primer assembly must be risk assessed to ensure all relevant hazards are identified and controls put in place to reduce risk.

Transporting mixed class explosives should only occur on a mine site. Transport on public roads can only be allowed with change management and local regulatory approval. Plan to minimise the distance for any transport.

If the assembly must be transported in a vehicle, do not carry any other explosive products, dangerous goods or flammable material (other than explosive packaging);

Ensure the unit is securely packed in a box (taped to the bottom to prevent movement during transport) or another secure approved container. Alternatively transport the unit in water to further reduce risks of friction, impact, static and heat and to mitigate the consequence of detonation during transport.

Transport the misfired unit directly to a suitable site for destruction and follow guidelines for destruction detailed in Transport, storage and destruction of misfired detonators

MISFIRE SAMPLE RETURN

Only return undamaged units and dissected components free of explosive.

Detonators believed to be damaged by dynamic pressure must not be returned. These detonators cannot be investigated using standard techniques at Orica facilities, so the risks associated with transport to Orica facilities significantly outweigh the value of any information to be gained by analysis.

Detonators believed to be damaged by dynamic pressure should be destroyed following similar guidelines to those in Transport, storage and destruction of misfired detonators

Should you have any queries regarding the above, please do not hesitate to contact your local Technical Service Representative or Territory Manager.