PRODUCT BULLETIN

Australia Pacific Asia – May 2021

DETONATOR MISFIRES DUE TO DYNAMIC PRESSURE OPEN CUT & QUARRIES

PURPOSE

The objective of this bulletin is to highlight to all relevant stakeholders (particularly drill and blast personnel) the importance of understanding the dynamic pressure mechanisms to avoid potential misfires when using electronic detonators. This bulletin highlights the complexities of the failure mechanism, contributing factors and offers six key recommendations.

BACKGROUND

Dynamic pressure can cause malfunctions in all explosive products.

Based on incidents analysed by Orica in the past six years across the open cut & quarries markets within Australia, Pacific, and Asia regions (APA), malfunctions due to dynamic pressure are uncommon, but have most commonly been observed as misfires in electronic detonators.

The incidents analysed over the six-year period included several that resulted in multiple detonators being affected. Orica has committed significant resources in conducting a detailed investigation, with the primary objective of minimising these events re-occurring. Raising awareness should result in a safer industry.

DYNAMIC PRESSURE MALFUNCTION MECHANISM

Blasting generates high pressures from each explosive charge that can affect nearby undetonated explosive charges. This pressure can impact on both the initiation system and bulk or packaged explosives product, causing either a misfire, sympathetic detonation, low-order detonation, or delayed firing.

Dynamic pressure failures in electronic detonators are often referred to as 'shrink-wrapping' due to the detonator shell's appearance in some of these types of misfires. Misfires due to dynamic pressure can also occur due to damaged internal components of a detonator without visible shell deformation (see Figure 1)

When using electronic blasting systems, 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 any misfires that occur after this step are not reported by the system.

No electronic detonator system can provide confirmation that all detonators have fired, as once initiated, they are no longer able to send any commands to the blast box. This type of misfire presents a significant unplanned detonation hazard, as these misfires are usually unknown until discovered during downstream processes.

Figure 1: Misfired caused by dynamic pressure, can occur both with and without obvious external shell deformation.

KEY CONTRIBUTING FACTORS

Dynamic pressure malfunctions in detonators can occur when the detonator is exposed to blasting pressures that exceed the yield strength of the detonator shell or internal components. Pressure pulses from blasting may also expose the detonator to acceleration forces that exceeds the yield strength of the internal components.

The total pressure a detonator is exposed to is a result of many factors but mainly attributed to:
(a) the pressure pulse produced by each charge firing nearby, before the detonator of concern.
(b) the distance and time taken for this pressure pulse to dissipate; and/or
(c) the number, size, and length of pressure pulses that a detonator is exposed to before firing.

Each of these contributing factors is highly complex and can be impacted by multiple blast parameters, which can only be assessed on a case-by-case basis. Localised geology is likely to have a significant influence on the risk for dynamic pressure misfire, and therefore recommendations for prevention that will be effective in every situation are challenging to provide.

Although highly complex, there are three significant risk factors that Orica's research indicates may increase the risk of dynamic pressure misfires when using electronic detonators, each of these is discussed in more detail below:

(a) The presence of pressure transmission paths between charges (between or within blastholes)
(b) Blasting in saturated ground or wet blastholes; and
(c) Charges firing close together in time and space.

PRESSURE TRANSMISSION PATHS BETWEEN CHARGES

Pressure transmission between charges is the key contributing factor for misfires caused by dynamic pressure. This mechanism is highly complex, as multiple factors can contribute to transmission of the pressure pulse throughout the rock mass, and therefore increase the likelihood that it will cause a misfire in a nearby charge.

Transmission paths take different forms and can increase the transfer of pressure between charges. These may include:

a) geological structures (cracks, joints, faults, soft bands etc.) between blastholes; and / or
b) an inert deck between charges in the same blasthole.

Pre-conditioning from surrounding holes or previous blasts may also provide a path for transmission. Transmission may also occur through competent, solid rock between closely spaced blastholes or in very soft ground where the entire rock mass fluidises when exposed to high pressure.

Misfires due to dynamic pressure have been rare in the APA open cut & quarries markets. Of the dynamic pressure misfires analysed by Orica in the APA open cut & quarries markets, 95% have occurred in decked blastholes. This is influenced by five large scale incidents in decked blasts resulting in multiple misfires.

Using the collated incident data, Table 1 summarises misfire occurrence based on distances between blastholes and decks, using the hole diameter as the unit of measure. Distances at which dynamic pressure misfires have occurred vary significantly. The presence of water, path of transmission and localised geology may significantly alter distances required for pressures to reduce to levels to avoid misfires. Reduced separation distances may increase misfire risk. (acknowledging that suitable separation distances to prevent misfire are highly variable and location specific).

Distance Between Decks	<=15 x hole diameter	≈ 84% of cases
	15-30 x hole diameter	≈ 15% of cases
	>30 x hole diameter	<1% of cases

Distance Between Holes	<=30 x hole diameter	≈ 80% of cases
	30-35 x hole diameter	≈ 20% of cases
	>35 x hole diameter	No reported cases

Table 1 Open cut & quarries markets misfire cases vs. charge separation distances

BLASTING IN WET OR SATURATED GROUND

As water is incompressible, pressures produced by blasting do not attenuate as quickly in wet ground as they do in dry ground, and therefore much higher pressures between charges can be observed. When combined with the presence of a path for pressure transmission, blasting in wet ground has an increased risk compared with blasts in dry ground.

Of the dynamic pressure misfires analysed by Orica in the APA open cut & quarries markets. 99% occurred in wet blastholes. Dynamic pressure misfires have also been reported in dry holes.

CHARGES FIRING CLOSE TOGETHER IN TIME AND SPACE

The pressure experienced by a detonator before firing is a combination of the pressure pulses produced by the surrounding charges when they fire. Pressure from multiple charges arriving at a single detonator simultaneously will increase the total pressure on the detonator via superposition, causing cumulative damage. Travel time between charges, amplitude and pulse duration are heavily dependent on localised geology. In areas where there is an increased risk of dynamic pressure misfire, initiation designs must be adjusted to minimise the risk of multiple pressure waves arriving at a detonator at the same time.

RECOMMENDATIONS

ALWAYS ensure relevant site stakeholders are aware of the dynamic pressure malfunction mechanisms and associated risks and, in particular, drill and blast personnel assess the risk of dynamic pressure misfire for all blasts. The attached risk assessment template provides a guideline to assist with this process.

ENSURE all relevant site procedures, management plans, work instructions and risk assessments for using explosives, designing blasts and handling misfires consider and include the potential hazards and controls to prevent and handle dynamic pressure malfunctions.

ALWAYS ensure appropriate controls are in place to minimise the risk of unplanned detonation in areas where there is potential for misfires, including changing the blast design and communicating the risk rating to stakeholders. The attached guidance document provides additional details regarding contributing factors and potential control measures.

Following a misfire, **ALWAYS** conduct a risk assessment to identify all potential hazards and implement appropriate controls to minimise risk when dealing with misfires due to dynamic pressure (including testing downlines). The attached misfire handling guideline document provides details to assist with this.

Consider conducting field pressure testing studies when blasting in high-risk areas to help quantify risks and determine appropriate operating parameters to minimise the risk of misfire. Orica can assist with this if required. Contact your local Technical Services Representative for more information.

Communicate all misfires caused by dynamic pressure to Orica. This ensures trends can be identified and that the Orica technical and product teams can assist with guidance, investigation, and recommendations.

Should you have any queries regarding the above, or any of the attached documents, please contact your local Orica Technical Service representative or Territory Manager.

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