ISC Safety Lore

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Key lessons from coal mine methane explosions

Introduction

Underground coal mining is and has always been a dangerous job. In addition to the risk of asphyxiation and the danger of falling coal, there is the hazard of an explosion of methane gas, which is continuously expelled by coal seams and becomes potentially explosive when mixed with air. Mines must have good ventilation to prevent methane building up. In addition to that, initial methane explosions can trigger coal dust explosions causing further devastating effects.

Case 1 – Coal mine

On 7 August 1994, an explosion occurred in an underground coal mine. Twenty-one persons were working underground at the time. Ten men from the Northern area of the mine escaped within thirty minutes of the explosion but eleven from the Southern area failed to return to the surface. Those who failed to return comprised a crew of eight who were undertaking first workings for pillar development, and three others, who were also deployed in the Southern side of the mine. A second and more violent explosion occurred on 9 August 1994. Rescue and recovery attempts were thereafter abandoned, and the mine sealed at the surface.

Key learning points

The first explosion originated in the 512 Panel of the mine and resulted from a failure to recognise, and effectively treat, a heating of coal in that panel. This, in turn, ignited methane gas which had accumulated within the panel after it was sealed. The Inquiry concluded that sealing of the 512 Panel after completion of production, resulted in the build-up of methane to explosive concentrations within the panel. Heating arising from spontaneous combustion of coal was present in the panel for some time prior to sealing. The heating was of sufficient intensity to act as a source of ignition for gas in the panel, and this combination was the immediate cause of the first explosion. The Inquiry did not reach a finding regarding the cause of the second explosion. The investigation revealed several contributing factors, such as a failure to prevent the development of a heating within the 512 Panel; a failure to acknowledge the presence of that heating; a failure to effectively communicate and capture and evaluate numerous tell-tale signs over an extended period; and a failure to treat the heating or to identify the potential impact of sealing with the panel consequently passing into an explosive range due to the methane gas accumulating in the panel.

Case 2 – Coal mine

On Easter Monday, April 5, 2010, a powerful explosion occurred in a coal mine. At 3:02 pm a small methane explosion near the longwall tailgate triggered a violent coal dust explosion. Twenty-nine miners died and one was seriously injured in the accident.

Key learning points

The investigation concluded that the ignition point for the blast was the tail of the longwall. As the shearer cut into the sandstone mine roof, the resulting sparks ignited a pocket of methane, creating a fireball. The fireball in turn ignited the methane that had accumulated in the gob during the weekend and leaked onto the longwall face. The fireball travelled into the tailgate area, where accumulations of coal dust provided fuel for a second, more deadly, force. Initial gas mixture at tailgate was 3,000 ft^3 (85 m^3) at 10% methane. Normally such a small explosion would generate a fairly low overpressure. In this case, however, the initial methane explosion triggered a violent coal dust explosion. The mine had experienced inadequate face ventilation on several occasions prior to the explosion. The ventilation system was deficient in that it did not sufficiently dilute the methane accumulation, and insufficient amounts of rock dust had been placed in the mine entries to inert the coal dust and prevent a dust explosion. The company failed to meet federal and state safe principal standards for the application of rock dust. As a result, coal dust provided the fuel that allowed the explosion to propagate through the mine. Water sprays were not properly maintained and failed to function and as a result, a small ignition could not be quickly extinguished. The company's pre-shift/on-shift examination system broke down so that safety hazards either were not recorded, or, if recorded, were not managed.

The ISC believes that leadership across six key functional elements is vital to achieve good process safety outcomes. These elements are:

- 🔵 systems & procedures
- 🔴 engineering & design
- 🟡 assurance
- 🟢 knowledge & competence
- 🟣 human factors
- ⚪ culture

In the *What can I do* section below you can see how each of these elements plays a part.

Figure 1: The ISC Framework

What can I do?		
Management		
🟢	•	Fundamental understanding of all inherent risk parameters is critical for prevention of explosions in coal mines.
🔴🟢	•	Prevention of methane explosions relies fundamentally on eliminating ignition sources and diluting accumulations of explosive methane with adequate ventilation. Dilution of methane must occur as part of the designated function of a bleeder system.
🔵🟢	•	Prevention of coal dust explosions is done by using sprays to reduce the formation of coal dust, rock dust inertisation, trapping of coal dust with hygroscopic salts and coal dust explosion barriers, hygroscopic pastes to bind coal dust, and mine-wide atmospheric monitoring to control both face ignitions explosions and fires in sealed areas.
🟡🟢	•	The finer the coal dust and the greater the coal's volatile matter, the greater is its explosion hazard. If the initiating explosion is strong enough, even wet coal dust can explode and therefore putting in place explosion barriers is necessary.
🔴	•	In highly gassy mines, methane emanates from caved material and surrounding strata, or rubble zone, in concentrations close to 100%. Gas management is a critical point, make sure to monitor air quantity and quality throughout the mines, given special attention to the possibility of methane accumulations in mined-out areas (pillared areas or longwall gobs).
🟡🔴	•	Methane gas is explosive at concentrations between 5% and 15%. Please note, that it is most explosive at about 9.5%. In coal mines, relatively small methane explosions sometimes cause much larger explosions of coal dust which creates lethal concentration of carbon monoxide.
🔵🟢	•	Make sure to develop and implement a spontaneous combustion management plan.
🟢🟣	•	Make sure that employees are trained to recognise indicators of specific mine hazards, such as spontaneous combustion, and their control; and become familiar with mine gases, and associated risks.
🔵	•	Make sure to develop and implement procedures for the setting, resetting, and the noting and acceptance of alarm conditions raised by any gas monitoring system in use at the mine.
Process Engineer/Supervisor		
🟢🟣	•	Potential ignition sources include arcing in the mine electrical system, a diesel engine overheating, contraband taken into the mine, electric motors in the non-restricted part of the mine and frictional sparking caused by work activities. Make sure to rigorously control ignition sources.
🔵🟢	•	Heat in underground mines poses a serious risk to the health of people and to equipment. Diesel engines used in mobile equipment are extremely expensive and high temperatures can shorten their life with major, negative impact on the economics of mining.
🟣🔵	•	People working in high wet bulb temperatures are at risk of becoming dangerously ill with heat exhaustion or heat stroke. In the latter case, the body's cooling mechanisms cease to function and rapid death can result. Wet bulb temperatures of more than 30^0C cause a high risk of heat stroke and above 33^0C conditions may be regarded as extremely hazardous. Make sure to rigorously monitor temperature.
🟣🔵	•	While monitoring you receive methane exceedance notifications, make sure that a thorough investigation of those instances is followed.
🟡	•	Make sure maintaining and checking appropriate ventilation controls (fans, regulators, stoppings and curtains).
🔵🟣	•	In case of a first explosion, be aware that secondary explosions are likely to occur, therefore make sure to take it into account when arrange evacuation and rescue operations.
Operator		
🟣🟢	•	If you detect accumulations of methane report it to your supervisor instantly.
🔵🟣	•	Stop operations when insufficient ventilation conditions are known and inform the supervisor.
🔵🟣	•	Make sure to handle open-flame and spark generating work such as flame cutting and welding with extra care.
🟣🟢	•	Make sure to regularly check methane monitoring devices if they are calibrated and functioning well.