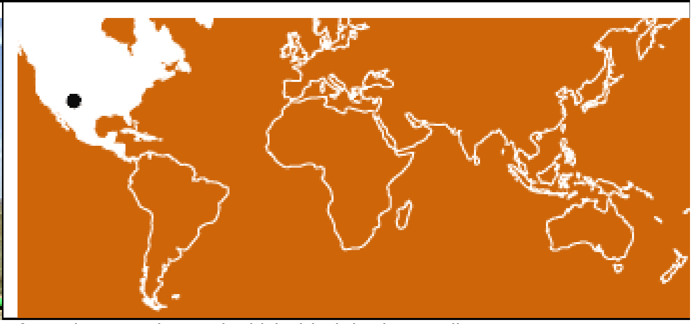
Safety Case Studies

Bleederless longwall ventilation at San Juan Underground Mine manages risk of fire and explosion

Safety



Mechanised drainage unit removes excess methane from the caved area (gob) behind the longwall

For more than 20 years, the San Juan Coal Company (SJCC) in our New Mexico Coal Operations in the USA has fuelled the San Juan Generating Station with up to 6.3 million tonnes of coal annually. As the original open-cut mining became too costly, it was decided to replace it with an underground longwall mining system, which commenced operation in 2002. Early in the feasibility study for the new mine, it was recognised that mine ventilation was going to be one of the most challenging parts of the mine design. Historical experience from surface mining at SJCC indicated that the coal had a tendency towards spontaneous combustion. To manage mine ventilation risks, an innovative bleederless system was developed and implemented.

The Challenge

Coal is a combustible material. If it absorbs oxygen from the air, heat can be generated, creating the potential for spontaneous combustion. Indications of spontaneous combustion of reserves to be mined underground at SJCC were confirmed by drill-hole samples. In addition, the coal seam and surrounding strata is a reservoir for methane gas. The existence of these conditions is problematic because the oxygen in normal air, the methane and the possible spontaneous combustion of the coal (an ignition source) are all the ingredients for fire and explosion. To manage the risk in the new underground mine to an acceptable level, various ventilation systems were evaluated, including bleeder and bleederless systems. An enhanced bleederless system proved to be safest.

The most common ventilation systems in the USA are bleeder systems. In concept, they are special air courses that force air into and around the perimeters of gobs (mined-out spaces) to dilute gases to allowable concentrations, before being exhausted from the mine. However, the air forced into the gob also contains up to 21 per cent oxygen and could stimulate a spontaneous combustion event, with obvious risks. As such, bleeder systems were rejected.

Bleederless longwall ventilation systems are more attractive from a risk management perspective. These systems focus on isolating the gob from atmospheric oxygen and allowing it to become oxygen deficient and therefore inert, even when high levels of methane exist. Only the gases produced by the gob as a result of barometric pressure variation must be mitigated at the longwall. However, even a traditional bleederless system may not prevent potentially explosive compositions of methane and oxygen immediately behind the longwall face, particularly behind newly constructed seals. Something more is required to manage risk to its lowest level. The answer lies in understanding the fundamentals of the danger.

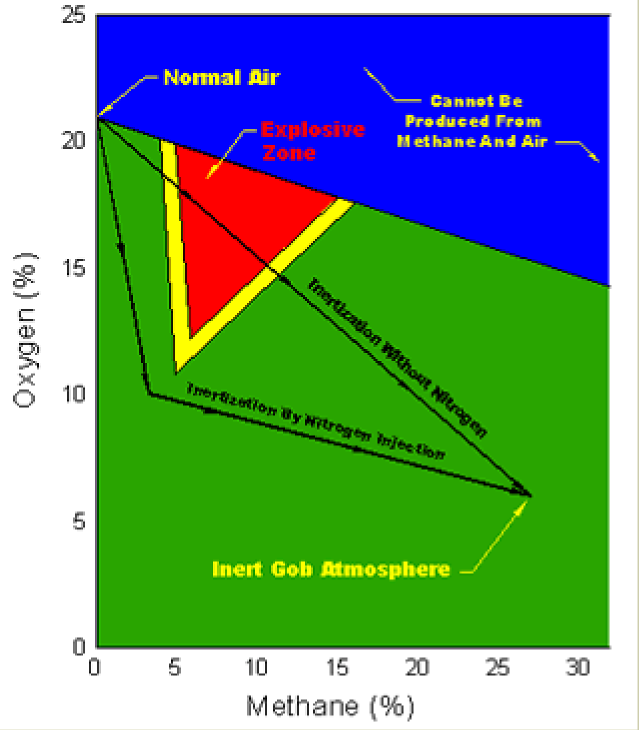
The Plan

It is well understood that various combinations of methane and oxygen can make an explosive mixture that can be ignited by very small sources of energy. Atmospheric mixtures with too much or too little of either gas are not explosive. The challenge is to enable a transition from normal air to nearly pure methane behind the longwall without being exposed to the hazard of explosion. Because the methane evolution is largely beyond control, the focus is on controlling oxygen. By forcing the oxygen concentration from 21 per cent to below 11 per cent, before methane levels rise above 5 per cent, the explosion hazard can be eliminated, as indicated in the following graph.

This oxygen suppression can be achieved by injecting pure nitrogen gas behind the longwall at the headgate and allowing the pressure difference across the face to disperse the nitrogen to all vulnerable areas. Nitrogen is inert and composes 78 per cent of the air we breathe every day.

Nitrogen injection also helps mitigate another hazard, the introduction of oxygen to the gob during periods of rising barometric pressure, when the bubble of gob gas is shrinking. At this time, additional nitrogen is injected to provide compensation volume for the barometric shrinkage. As a final step, gob vent boreholes are a means of expelling gas volumes created by continuing methane evolution and periods of falling barometric pressure (increasing gas volume).

The nitrogen gas used by SJCC is sourced from a nearby plant, which was specifically constructed near the mine to supply nitrogen for emergency purposes and to serve the owner's other customers in the surrounding area, such as pipeline operators, oil and gas producers and microchip manufacturers.



Eliminating explosion hazard by reducing oxygen concentration before methane levels rise

The Implementation

SJCC started longwall operations in October 2002. Since then, three longwall panels have been mined, producing over 13.6 million tonnes of coal. The bleederless longwall ventilation plan, with nitrogen injection and gob vent boreholes, has been used without any serious events in the gob or on the face.

The typical SJCC longwall plan calls for a seal to be constructed in crosscuts adjacent to each gob passed by a longwall mine. Each seal is equipped with piping to inject and control nitrogen flow. By progressively sealing a gob as it is created and then injecting nitrogen to depress the oxygen concentration, the hazard of explosion and spontaneous combustion in the gob is greatly diminished.

The success of the sealing and injection is confirmed through continuous sampling of key locations, using the tube bundle system and electrochemical sensors, as well as by periodic examinations by mine personnel. During these examinations, handheld meters with pumps are used to confirm air quality readings behind seals, and bag samples are drawn for further confirmation through gas chromatograph analysis.

The tube bundle system, mentioned above, consists of sample tubes that can be applied throughout the mine to sample atmospheres wherever they are of concern. The tube bundle constantly monitors the gas compositions to alert operators to any potential change of environmental conditions. Although common in Australian mines, SJCC's tube bundle, consisting of 30 sample tubes, is the first modern system of its type in the USA. All of the monitoring systems are coordinated in a central control room that is staffed at all times during mining operations.

As described above, during periods of rising barometric pressure, additional nitrogen injection prevents oxygen being introduced into the gob and minimises the risk of spontaneous combustion. During periods of falling barometric pressure, a fleet of six mechanised drainage units is available to evacuate gas from as many as 14 boreholes from the surface into the gob.

Each mechanised drainage unit resembling a space exploration rover, features state-of-the-art technology, including solar panels for power supply, remote-control operation, and radio data telemetry. The gas (a mixture of methane, nitrogen and oxygen) can be captured in a pipeline for commercial use or vented into the atmosphere as a last option.

As a proactive step, SJCC is also using in-seam drilling to capture methane in advance of mining. At present, nine in-seam holes have been completed, with individual lengths up to approximately 1400 metres (4600 feet). In-seam drilling has several benefits, including reduced methane exposure during development and longwall mining, improved pre-drainage of water, limitation of greenhouse gas emissions through the ventilation system, and production of a more commercially attractive gas composition. A direct consequence is improved productivity, cost and safety.