Critical action to control underground fires

Associate Professor David Cliff, Minerals Industry Safety and Health Centre, at the University of Queensland, provides a warning and shares his research on the critical need to control mine fires as soon as detected.

Mr Cliff states that if effective response is not undertaken within five hours, it may well be too late. His research to support his warning is from his presentation at the Flight or Fight seminar, organised by the Department of Mines and Energy in Emerald in May 2006.

Underground mine fires

The size and nature of a mine fire depends upon a number of characteristics including:

- How long it has been burning.
- What is burning.
- Whether the fire has been spontaneous or was externally initiated.
- The air flow to the fire (supply of oxygen).
- The geometry and composition of the material.
- Where the heat goes.

The longer a fire has been burning, the more it will become entrenched. The fire combustion rate will be limited either by the availability of the fuel or by the air supply to the fire.

The availability of the fuel includes the combustibility of the fuel (e.g. whether or not it has to dry out, how permeable it is to air flow, and how much surface area is available to react).

Early detection is the key to minimising the size of a fire. In essence, a fire rapidly expands until it reaches its point of equilibrium.This is why fire is easiest to control or extinguish at the early stages of development.

Spontaneously combusting fires will often take a long time to reach flame temperature (>500°C) from the time initial oxidation commences. Tests in the large-scale spontaneous combustion of coal test facility at Simtars (DME's Safety in Mines Testing and Research Station) has shown that coal can take many months to reach flame, even under optimum oxidising conditions.

Typically, the initial oxidation phase can take months and is difficult to detect. It is followed by a relatively short period of time where gaseous indicators of oxidation are evident (it can be a matter of days) and, finally, an exponential rise in temperature over a much shorter period, typically 24 hours, before ignition.

It is useful to review some of the major mine fire incidents in Australia and overseas to demonstrate how rapidly a significant fire can develop.

Spontaneous combustion fires

While coal is the most common material to spontaneously combust, the problem can also be found in some chemicals such as polyurethane and some mine dusts with a high-pyrites content.

Examples of spontaneous combustion fires include the following.

Ulan Colliery

(NSW, 1991)

Mine operators were concerned about a spontaneous combustion event occurring within the goaf and work was under way to improve the seals around the perimeter of the goaf to exclude oxygen from the heating site.

At 6:15 pm on 8 August, smoke was detected at the face of the working longwall and 700 ppm carbon monoxide measured.

At the same time, and by chance, a crew working in the gate road noticed a red glow in the coal rib.

By 8:05 pm, the carbon monoxide concentration at the main fan had gone from 0 ppm to off scale at over 3000 ppm. Carbon dioxide was about two per cent and methane about two per cent.

By the time the mine was sealed at 8 am the next day, the carbon monoxide had exceeded 7000 ppm and more than one per cent hydrogen was detected. This clearly illustrates how a small red glow can propagate to a raging fire in just two hours.

Westcliff mine

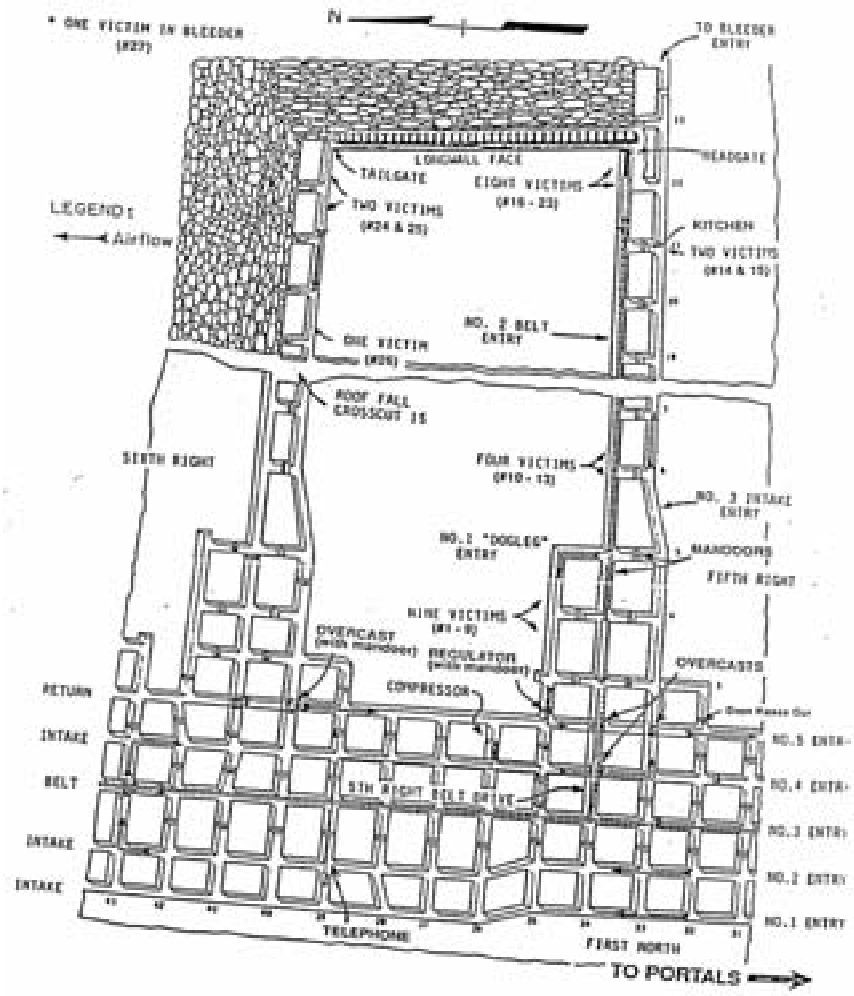
(NSW, 1986)

A spontaneous combustion event occurred when bulk polyurethane resin used to fill a void over longwall chocks self-heated and caused a fire. The products of burning polyurethane are particularly toxic and this type of combustion is extremely difficult to extinguish.

More than 1000 kg of polyurethane had been pumped into a cavity over a three-hour period. Miners had earlier observed that the polyurethane was heating up but the area was treated and the resin seemed to be cooling down.

At 11:45 pm the resin was inspected, its temperature measured, and it was found to be stable and cooling. Within an hour, flames were observed.

Damage caused by an explosion at the Loveridge mine, USA, in 1999.
Photo: SMI



This map indicates the location of victims of the fire that swept through the Wilberg coal mine, USA, in 1984.

Fire at a coal mine near Ipswich, Queensland. The smoke indicates the severity of the fire.

Loveridge mine
(USA, 1999)

A small fire was discovered in an area of the mine. Efforts to extinguish the fire with water and fire extinguishers were unsuccessful.

Within 45 minutes of discovering the fire, the mine had to be evacuated.

Within seven hours, the mine was sealed at the surface.

This in turn caused the fire to ignite methane within the mine, which destroyed the main fans and made re-entry a very complicated process.

Other fire types

Externally catalysed fires, on the other hand, will rapidly reach flame point and propagate into other materials if available.

Avon Colliery
(NSW, 1976)

A Rhino® diesel-engine-powered transport vehicle was parked in a crosscut adjacent to a stopping. Unknown to the driver, the brakes had overheated.

The vehicle was parked at 6:40 am.

By 8:15 am, wisps of smoke were detected in nearby roadways, as the fire spread from the vehicle to the surrounding coal.

By 8.45 am, this smoke had turned to heavy hot grey smoke and filled the roadways, causing evacuation of the mine.

Several explosions were subsequently heard; these turned out to be tyres exploding.

Fire fighting commenced at 9:45 am.

By 8:25 pm that day, the fire had been extinguished, but not until about 700 tonnes of coal had been burnt, as well as the vehicle.

Appin coal mine
(NSW, 1976)

This was a fire in the main drift belt conveyor.

A hot idler on the conveyor belt had been removed earlier in the week and the coal adjacent to it had been quenched with water.

The belt had been regularly inspected, most recently on the Saturday night. >

At 1:40 on the Sunday morning, heavy smoke was detected issuing from the belt portal on the surface, normally an intake roadway.

By the time the fire was extinguished two days later over 900 m of belt had burned through.

Wilberg coal mine

(USA, 1984)

Perhaps the most famous mine fire example is the Wilberg coal mine.

Twenty-seven men died, overcome by carbon monoxide gas and smoke after an air compressor overheated and ignited its oil.

Within 20 minutes, a fire had progressed into the adjacent coal.

Within an hour it had burnt through an overcast, filling the active longwall roadways with smoke and toxic gases.

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Metalliferous mine fires

It is not only coal mines that can have major fires.

In 1972, in the Sunshine underground silver, lead and tin mine in Idaho, USA, 91 men died, overcome by carbon monoxide and smoke after a waste area of the underground workings was ignited.

The fire contaminated the downwind working areas of the mine. In part, this tragedy was heightened because the man controlling the winders for the shafts within the mine became overcome by carbon monoxide.

As there were no ladders in the inseam shafts, men deeper in the mine were prevented from escaping. Remarkably, two men found an area of fresh air in the lower section of the mine and were rescued seven days later.

In 2006, in the underground gold mine in Darasun, Russia, men welding in the main shaft ignited part of the wooden structure. Their initial efforts to extinguish the fire were unsuccessful; the fire spread rapidly, trapping 33 men in the mine.

Twenty-five miners subsequently died from carbon monoxide poisoning. It took over a week to put the fire out.

Quick action

There are many potential sources of fire within a mine: from conveyor belts, electrical equipment, chemicals, vehicles, welding and cutting, or just coal itself.

With the exception of the self-heating of coal, all of these can develop from initiation to raging fire within a few hours. In the self-heating of coal, fire can go from initial detection to out of control within a day.

Modern technology, advances in mine safety management systems, continuous gas monitoring systems and improved training of personnel have reduced the risk of catastrophic events in our mines compared to the past. However, recent incidents show that they can still happen and develop rapidly into serious events.

The need to be able to respond effectively and as quickly as possible to fire has not changed.

Industry's move to longer longwall panels in coal mines and deeper workings in metalliferous mines, fewer personnel underground to carry out inspections, higher voltages underground, increased use of polyurethane type chemicals, and the ever present pressure to maximise production, means we should not become complacent or assume technology alone will protect miners.

Similarly, the traditional approach to rely on mines rescue teams external to the mine staff can, in fact, increase the risk of the fire running out of control. Recent studies indicate that it takes up to five hours before external support is ready to fight an underground fire.

Conclusion

It is vital we learn the lessons from these past fire events. We must ensure that our response strategies are effective in minimising the risk to those responsible for bringing a fire under control.

No underground mine is free from the risk of fire. Effective controls need to be put in place before an event happens.

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