How organisations miss warning signs: inside the Pike River tragedy

The methane gas issues at Pike River mine were well known, so why didn't senior management and the board heed them and act? Sean Brady explores the organisational lessons from the Pike River disaster

It's 19 November 2010 at the Pike River underground coal mine in New Zealand. Daniel Rockhouse is deep in the mine, driving a loader en route to pick up gravel for road repairs. He stops at the diesel bay at the pit bottom to refuel the loader with diesel and water. Its engine is running. The time is 3:45 pm. He turns on the water valve, and as he does so, there's a white flash.

Then a pressure wave hits him. He's flung on his back, hits his head, and his first thought is that his loader's blown up. But then he realises it's still running. He gets up and turns it off, then sees debris has fallen from the tunnel roof and walls. The air is filled with a pungent smell, and dense smoke starts flowing around him. The atmosphere gets warmer, and he starts to find breathing difficult.

He moves away from the smoke and walks towards a nearby crushing station. The air is clearer there. He reaches for his self-rescuer, a portable oxygen supply, pulls it from his belt, opens it and puts it on. But it's not working. He gets rid of it, and then moves back towards the loader, but the atmosphere's getting worse. He falls over. He shouts for help. His eyes are watering. His whole body is tingling, and he feels like it's shutting down.

Then he blacks out. Almost an hour later, he regains consciousness. He has feeling in his fingers and toes again, but he's cold and shivering. He tries to move and discovers he's lying in the mud beside his loader.

He rolls over onto his stomach and tries to push himself up, but he can't – he has no strength. He tries again and manages to get to his feet but falls back into the mud. This time he pulls himself upright and grabs hold of the compressed air and water lines that run along the wall. He searches for a valve on the airline and opens it – fresh air flows and clears the smoke around him. It relieves the stinging in his eyes. Then he starts searching for a phone to contact the surface. He finds one and dials the emergency number, triple 5. The phone rings, but no one picks up, and he's connected to an answering service. He hangs up and, this time, dials 410, the number of the mine's control room.

Brady Heywood managing director Sean Brady says putting bonuses in place to drive production, without confirming these targets can be safely achieved, carries great risk

Daniel Duggan, who's in charge of the surface control room, takes the call. The time is approximately 4:40 pm. And as Rockhouse is talking on the phone, the underground mine manager, Douglas White, comes on the line and tells Rockhouse to get to the Fresh Air Base (FAB) and contact them from there.

Rockhouse hangs up and starts following the compressed air and water lines on the wall. They will guide him, along the roadway known as the drift, to the surface, which is almost 2 km away. He walks in the darkness and opens the compressed air valves as he goes, breathing in the air.

Russell Smith

Up ahead, he sees a stationary vehicle in the drift – it's a juggernaut loader. A man is lying on the ground beside it.

Rockhouse approaches him: it's Russell Smith. Smith's eyes are open, but they're rolled back in his head. He can hardly speak. He has no helmet or light. Rockhouse gets Smith's self-rescuer and attempts to put it on him, but he can't get it inserted properly into Smith's mouth, so he drops it, stands up, and starts to drag Smith's body along the drift. It's still hard to breathe, and he's weak, but if he can get to the FAB, it'll have compressed air and spare self-rescuers, and he should be able to contact the surface again.

When they find the FAB, Rockhouse props Smith up into a sitting position against the wall, and says he'll be back in a second. The FAB is an old shipping container designed as a refuge for workers in case of emergencies. But when he gets to it, he discovers it's decommissioned. It's no longer supplied with compressed air, the telephone connection to the surface isn't working, and the spare self-rescuers have been removed.

He's furious. He thrashes around for a while, then walks back to Smith.

He drags Smith along the ground, then pulls him to his feet. He asks him if he can walk. They are still 1.5 kilometres from the surface. As they start moving, Smith falls. Rockhouse pulls him back up to his feet. With one hand supporting him and the other running along the rail of the conveyor belt beside him, Rockhouse walks Smith towards the mine exit.

As they go, they keep stopping to look back behind them, checking for lights. They see only blackness. They keep moving, and Rockhouse tells Smith to think about his family, to keep his legs moving for them. After some time, the atmosphere starts to clear – it's getting easier to breathe. It's been 46 minutes since Rockhouse's phone call.

And then they see it. A blotch of daylight. Streaming in through the entrance. They keep moving. But when they walk out of the mine, they find themselves alone. There's no one there to meet them.

Rockhouse gets onto the comms and calls the control room. Help arrives within minutes.

Both men are given oxygen, but Russell Smith is incoherent. Daniel Rockhouse simply breaks down.

At 5:13 pm, while Daniel Rockhouse and Russell Smith are still making their way out of the mine, Douglas White, the statutory mine manager, decides to investigate what is happening at the mine's main ventilation shaft.

"Pike River knew that drainage would be required – the methane levels in the coal were high and couldn't be managed by ventilation alone"

This involves a helicopter trip from the Pike River admin area to the top of the shaft, located further up the mountain. This shaft plays a critical role in ventilating the mine: the main ventilation fan is located at the foot of the shaft, deep in the mine, while the secondary fan is located at the top.

The helicopter takes off, climbs up over the trees and heads for a position where White can get a clear view of the top of the shaft. And when he sees it, he realises there has been a massive explosion in the mine – one bad enough to knock out the secondary fan.

And 29 people are still missing. Nothing has been heard from them since 3:45pm, almost 90 minutes earlier.

Warning signs not acted upon

In time, a Royal Commission into the disaster would conclude that a methane gas explosion had occurred in the mine. But the factors that led to it didn't suddenly present themselves on 19 November 2010.

For months there had been warning signs that Pike River's gas management was ineffective.

In this article, we explore why these warning signs weren't acted upon and what lessons our organisations can learn from the disaster.

But to start, why is methane an issue, and how is it typically managed?

The dangers of methane

Methane gas occurs naturally in coal mines, forming in coal seams along with other gases. Mining activity disturbs and releases it. If it reaches a mixture (by volume) of 5 to 15 per cent methane to air, it's flammable. And if an ignition source is present, this can result in an explosion. Ignition sources include sparks from mining equipment or miners bringing contraband, such as cigarettes or matches, underground.

This risk is managed in a number of ways. Firstly, gas drainage can remove or decrease the level of gas in the coal before it's mined. That way, the volume of gas released during mining is significantly reduced. Secondly, mine ventilation should provide enough airflow to dilute any gas released and keep it below the explosive range. Thirdly, ignition sources can be removed or managed in areas of the mine where there is the potential for gas.

The overall effectiveness of the gas management system – and it's important to think of it as a system – can be determined by continuously monitoring the percentage of methane in the air. Gas exceedances above 2 per cent are important warning signs that the system may not be working effectively. More than 5 per cent indicates the presence of gas in the explosive range.

The importance of gas drainage

Gas drainage involves drilling boreholes into the coal seam. Over time, gas drains into the borehole from the surrounding coal, then out through a pipeline system that removes the gas from the mine.

And back in 2006, Pike River knew that drainage would be required – the methane levels in the coal were high and couldn't be managed by ventilation alone.

But while Pike River may have been aware of this, they made very little progress in designing or implementing such a system. Even by as late as mid-2010, they had taken very few core samples from the coal, which meant they had no reliable estimates of the quantity of gas they were dealing with. Without this information, they couldn't properly design the system.

Further, any methane drainage that was implemented was more incidental than systematic. Some boreholes were connected for drainage, but the gas level soon overwhelmed the system. Maintaining it had also become an issue. Pipelines were blocked, and there was no method to measure gas flows.

The system was at maximum capacity by April 2010. Several boreholes were free-venting methane into the mine's atmosphere. And in October, McConnell Dowell, a contractor on site, found a whistling standpipe emitting gas. This wasn't addressed by the time of the explosion.

Problems with ventilation

There were also problems with the ventilation system. This system comprised of a ventilation loop, which – at Pike River – drew air in through the drift, past the mining areas, and up the mine's main ventilation shaft.

This loop had two fans. The secondary fan was located above ground. But the location of the main fan was unusual – the Royal Commission found that Pike River was the only coal mine in the world to put its main fan underground.

And there are very good reasons why they're usually above ground. Firstly, if the fan underground is exposed to methane, it can become an ignition source. Secondly, if there is an explosion underground, the fan can be damaged, making it hard to re-establish ventilation. Thirdly, if the fan is undamaged in an explosion, but remains in a methane-rich environment, then its sensors will stop it from operating.

Losing the ability to ventilate the mine in the aftermath of an explosion significantly affects the survival chances of anyone who survives the initial blast.

In addition to these concerns, as we will explore, there was an abundance of information indicating that the ventilation system wasn't effective in managing the amount of gas in the mine.

Concerns raised

The management of methane was clearly failing. And this was well-known and recognised by the workers, who repeatedly raised serious issues and demanded action.

On eight occasions in March 2010, there were reports from Pike River

deputies concerned that the gas drainage system was inadequate for the methane levels predicted and experienced. One deputy wrote in an email that "history has shown us in the mining industry that methane, when given the right environment, will show us no mercy". He went on to say they needed to take gas drainage far more seriously and redesign the entire system.

This concern was echoed by a mining engineer engaged to consult on the drainage system. He wanted work stopped until a risk assessment for continuation occurred.

And there were many concerns about the ventilation as well. In July 2010, a consultant on site, Masaoki Nishioka, found that nobody appeared to be looking after ventilation in the mine. While the ventilation plan called for a dedicated ventilation officer, there was none.

Nishioka noted repeated problems with methane levels, which proved the ventilation system was struggling. He recorded levels that exceeded the

explosive threshold of 5 per cent on nine occasions between 20 September and 15 October.

And the number of exceedances continued to rise. Deputies' handheld detectors reported readings of 2 per cent or higher on 48 occasions in the 48 days leading up to 19 November, the day of the explosion. Of the 48 readings, 21 were 5 per cent or higher – in other words, an explosive level of gas was recorded 21 times over this period.

Some deputies did report these exceedances, but the information in their reports was not reaching or being heeded by management, with part of the problem being no ventilation officer to collate and respond to all the information.

It was against this backdrop that the board of Pike River made a decision: they introduced a bonus for workers to ramp up production.

The production bonus

Each miner would get $13,000 if 1000 tonnes of coal was achieved by 3 September 2010. If it was delayed by one week, it would decrease from $13,000 to $12,000, then $11,000 the following week, and so on. By November, it would be zero.

This bonus would cost the company $2.3 million, but the board took the view that they needed to address credibility problems with production because of over-promising and under-delivering, as they'd shipped only 2 per cent of what they'd initially planned.

But while the board decided to award a bonus, they didn't ensure it could be achieved safely. A number of risk assessments undertaken prior to mining began confirmed that it couldn't: very significant safety issues were identified, some critical systems were not yet in place, and others were not working correctly. With this context, we return to 19 November 2010.

The first explosion

Daniel Rockhouse was deep in the mine, refuelling his vehicle. In the control room, at 3:44 pm, Daniel Duggan activated the start sequence of a pump system that supplied water to the mine. Then he went on the comm to those underground.

He was talking to a worker, Malcolm Campbell, when there was an unidentified sound. Duggan then lost all comms. This was the methane explosion.

Underground, Daniel Rockhouse saw a bright flash and was hit with the sustained pressure wave. It lasted for 52 seconds.

Russell Smith, who'd been late for work and was driving his loader into the mine, was hit by the same pressure wave. He was knocked unconscious, only to be later rescued by Rockhouse.

Both would survive the event – Smith regained consciousness in the ambulance on the way to Greymouth.

The true extent of the disaster, however, would only become apparent when Douglas White took his helicopter trip up the mountain and saw there had been an explosion in the mine. This had damaged and disabled the secondary ventilation fan.

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In time, the consequences of putting the main fan underground would become apparent: it had failed in the explosion, and with the secondary fan also knocked out, there was no way to ventilate the mine.

The subsequent explosions

Rescue now depended on how safe it was to go into the mine. But the methane sensors underground had ceased reporting, and there was no backup system. Samples had to be taken at the top of the ventilation shaft, but they were not representative of the levels of methane deeper in the mine.

To solve this issue, they drilled a borehole to take samples. And on 24 November, 5 days after the explosion, the sampling borehole reached the heart of the mine. The samples showed it was not safe to send in rescue teams.

And at 2:37 pm that very afternoon, there was a second explosion. If any of the missing men had survived the initial explosion, there was no way they could have survived the second.

All 29 men had perished. To this day, their bodies have never been recovered.

The management

Why, despite all of the methane exceedances, did the mine's management team not heed the warning signs?

Normalisation may have played a role, as it does in many organisations. In the months before the failure, methane exceedances were happening daily. And as the number of exceedances grew but didn't result in an explosion, this had the potential to lull those involved into believing that exceedances would never result in an explosion. Normalisation changes our perception of risk rather than the risk itself.

But throughout the Royal Commission's hearings, management personnel insisted that they didn't know about the methane spikes, nor the ventilation problems, because no one brought them to their attention.

Whether or not we believe these claims, it was certainly the case that while there were reports of issues, Pike River didn't have the systems to collate, summarise, analyse, and get this information in front of managers. The lack of an effective system to pull together information and make warning signs clear almost certainly played a role in the mine management's inability to understand the true extent of the issues with the gas management system.

And, the failure of the gas drainage, combined with the inadequate ventilation, produced a situation that could only be addressed by mine management. These systemic issues couldn't be solved by any one individual at the mine.

And it is the management response that creates a sense of inevitability to this tragedy. Without meaningful management intervention, these problems couldn't be resolved. There was simply no way for the workers to 'work safer' or 'try harder' when attempting to manage methane. For every day that mining continued, with the existing systems in place, there was an increased opportunity for a methane exceedance and an ignition source to occur simultaneously.

The health and safety committee

What about the health and safety committee that reported to the board? The committee consisted of the chair of the board, Mr Dow, who was also the chair of the committee, along with another director, Professor Raymond Meyer. The committee's role was to provide strategic oversight on the effectiveness of the company's approach to health and safety, ensure it complied with legal obligations, and receive and respond to reports of significant incidents.

How did it fail to recognise and respond to the warning signs? It would transpire that the committee, which was meant to meet every six months, hadn't met for 13 months before the incident.

But even if it had met, it's doubtful if it would have identified the danger. The chair's view was that it wasn't the committee's job to actively seek out and obtain information on health and safety

in the organisation from other managers, nor to seek independent advice from outside the organisation.

Mr Dow held the view that managers could come to him with any concerns they had regarding health and safety. He told the Royal Commission they could do so at "company dinners or barbecues."

The Board

But what of the board itself? Were they aware of the warning signs? In order to manage the methane risk, they would have needed information on the effectiveness of their crucial systems, such as gas monitoring and ventilation, and analyses of their high potential incidents, to highlight where their systems were vulnerable.

The board, however, didn't receive this type of information. Even though the organisation reported incidents internally, no one reviewed or learned from them. And as with the Health and Safety Committee, Mr Dow believed

that incidents, including high-potential incidents, were operational issues, and, therefore, up to the management team to deal with. Further, many high-potential incidents were simply not reported to the board. And while the board didn't receive the right information, it didn't seek it out either. The prevailing view appeared to be: if no concerns were raised with the board, then there were no concerns.

As with many boards, it received monthly health and safety data from the mine, mainly personal injury rates and lost time incidents. Data that told them nothing about how they were managing the risk of a catastrophic incident. (The causes of these types of incidents differ from those that make up such personal safety metrics).

The Royal Commission would also find several issues with the board's decision to introduce a bonus. The obvious one is that it focused squarely on production rather than safety.

Another was the board didn't give sufficient consideration to mine ventilation – they didn't convince themselves that the available ventilation capacity was sufficient to ensure the bonus target could be met in practice.

Finally, risk assessments undertaken prior to mining began identified significant safety issues: some critical systems were not in place, and others were not working properly. Most of these issues were not addressed before mining began.

Closure

When we examine methane management at Pike River, it is tempting to conclude that the cause of this disaster was simply the mine's failure to manage a critical risk.

But this conclusion tells us very little about the broader learnings we can take from the tragedy. One way to explore these learnings is to consider the similarities between Pike River and our own organisations.

Take our boards. Boards obviously care about health and safety, but are they judging their 'safety' based on personal safety metrics like the Total Recordable Injury Frequency Rate – a metric that provides very little information on the effectiveness of an organisation's management of fatal or catastrophic risk?

And are our boards actively and meaningfully seeking other information to help them understand these larger risks, such as evidence that critical controls are working effectively? And, if they are, how meaningfully are our boards challenging the good news in these reports, and embracing the bad? And how likely are our boards, like Pike River's, to believe everything is alright unless told otherwise?

And do we have health and safety committees that report to our boards? Are they effectively assisting boards to understand the organisation's risks, or are they instead creating one more layer of separation between the board and the front line?

And what of our management teams? Do they have the right systems in place to identify when and why their systems are failing to work as intended? How do our managers collect, analyse, and identify the information and data they need to make good intervention decisions before incidents happen? Or are they only focusing on the information that pertains to the organisation's KPIs? And, if so, what about the warning signs in the rest of the data?

What about incentive schemes?

Do our incentive schemes reward production over safety? Putting bonuses in place to drive production without confirming that these targets can be safely achieved carries great risk. Further, our organisations measure what we care about – and workers know this. We may say 'safety is our first priority', but are our production metrics sending a different message?

A careful analysis of Pike River gives us an opportunity to turn the mirror back on ourselves. Many of the organisational factors that played a role in this disaster are likely at play in our own organisations. ■

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