NSW GOVERNMENT

NSW Resources Regulator

INVESTIGATION REPORT

DANGEROUS INCIDENT

Unplanned movement of continuous miner

Ashton Coal Mine on 30 May 2019

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Executive summary

Overview of incident

On 30 May 2019, a dangerous incident involving an unplanned movement of a continuous miner occurred within an underground roadway at the Ashton Coal mine (the mine) located in Camberwell near Singleton NSW. Yancoal Mining Services Pty Ltd (mine operator) was the nominated mine operator for the mine having held the nomination since 31 March 2016.

The roadway was under development and was designed to run approximately 205 metres in length with an average upward grade of 1:10. At the time of the incident, approximately 112 metres of the initial first pass mining of the road had been completed with an average overall uphill grade of 1:8. The roadway conditions were generally wet and slippery with varying uphill grades that were in some areas quite steep but did not exceed the continuous miner's safe operating limits as stated by the original equipment manufacturer (OEM).

During afternoon shift, a deputy, continuous miner driver (CM driver) and a mining technician (cable hand) were operating a Joy 12CM12 continuous miner identified as CM04 to trim a small 10-15 metre section of roadway floor leading up to the face.

While attempting to tram forward and trim the floor, the continuous miner (CM04, miner) lost traction causing it to slide backwards down the sloped roadway. When CM04 first began to slide, the cable hand was standing approximately 10 to 15 metres behind it. The CM driver was operating remotely while positioned on CM04's right-hand side operator platform with the shift deputy standing next to him.

Once the CM04 began to slide, the CM driver immediately attempted to apply the brakes using the remote, but it had no effect on stopping its movement. The CM driver and deputy then alerted the cable hand to get out of the way. The cable hand slipped and fell to the floor while attempting to turn and run clear of the path of the approaching continuous miner. The CM04 continued to slide down the road with its rear bumper contacting the cable hand before coming to rest after travelling approximately 10 to 15 metres. As a result of the incident, the cable hand suffered psychological trauma and sustained soft tissue injuries to the back of his shoulder, his hand, thumb, chest and legs.

Investigation findings

The investigation determined the following key findings:

- The section of underground roadway involved in the incident contained areas that were wet, slippery and steep in grade, however remained within the safe operating limits of the continuous miner as stated by the OEM.
- Testing of the continuous miner and its remote did not identify any functionality issues, mechanical, electrical or hydraulic faults attributable to the incident.
- The incident was most likely caused by the environmental conditions of the roadway including:
  - steep longitudinal grade
  - slippery floor conditions
  - hard stone floor substrate.
- The mine operator had identified the general risk of workers being struck by a continuous miner during tramming but had not foreseen and considered the risk of a continuous miner losing traction and sliding down the steep grade of an underground roadway.
- To manage the risk of workers being struck by a continuous miner during tramming, the mine operator primarily relied on key controls which included:
  - incorporating safety systems into the design of its 12CM12 continuous miners
  - implementation of safe standing zones
  - implementation of maximum grade limits for underground roadways
  - trained and competent worker requirements.
- The safe standing zones implemented by the mine operator had not accounted for the possibility of a continuous miner losing traction and sliding backward in excess of the two metre control zone perimeter.
- The mine operator had implemented roadway design rules that prescribed a maximum 1:5 longitudinal grade limit, which provided a higher factor of safety compared to the OEM's stated 1:3.5 safe operating limit for CM04.

- Deputies were required to inspect roadway conditions to ensure grade compliance, but some were unaware of the mine's maximum road grade design rules.
- Workers involved in the incident had been trained, deemed competent, and generally understood the mine's safe standing zone requirements and operating procedures, but were unaware of CM04's safe operating limits as stated by the OEM.

Recommendations

It is recommended that mine operators:

- review operational risk assessments to ensure appropriate consideration is given to the risk of mobile plant slippage due to underground roadway conditions including:
  - steep roadway grades
  - slippery floor conditions
  - hard stone floor substrates.
- review and risk assess the design and configuration of continuous miners operated on site, and where reasonably practicable, ensure they are fitted with appropriate equipment that allows workers to readily identify the pitch and roll positioning of the miner chassis
- review and update operating procedures to ensure safe standing and pedestrian access zone perimeters account for the possibility of a continuous miner losing traction and sliding down steep underground roadways
- ensure that underground roadways with steep grades (including those under development) are appropriately sign posted to alert workers of hazardous conditions and the potential for machine slippage
- ensure that all workers involved in the operation of continuous miners are provided:
  - appropriate information, instruction and training in identifying hazardous roadway conditions that could increase the likelihood of machine slippage
  - appropriate equipment, information and/or suitable means to readily identify the pitch and roll positioning of the miner chassis.
- ensure that all workers required to inspect underground roadway conditions are provided:

- appropriate information, instruction and training in the mine's maximum road grade design rules
- appropriate equipment, information and/or suitable means to readily identify roadway grade compliance during inspections.

Contents

1. Purpose of the report

This report describes the mining workplace incident investigation conducted by the NSW Resources Regulator into the cause and circumstances of a dangerous incident involving an unplanned movement of a continuous miner on 30 May 2019 at the Ashton Coal Mine, located in Camberwell near Singleton NSW.

2. Investigation overview

2.1. The Regulator

The NSW Resources Regulator investigates major workplace incidents in the NSW mining, petroleum and extractives industries. Our role is to carry out a detailed analysis of incidents and report its findings to enhance industry safety and to give effect to our *Compliance and enforcement approach.*

2.2. Legislative authority to investigate

Investigators are appointed as government officials under the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and are deemed to be inspectors for the purposes of the *Work Health and Safety Act 2011* (WHS Act). The Regulator has also delegated some additional functions to investigators, including exercising the power to obtain information and documents for the purposes of monitoring compliance with the WHS Act.

2.3. Regulator response

The incident was reported to the Regulator on 30 May 2019. We deployed inspectors to the site to undertake an initial assessment of the incident. The investigation commenced on 4 June 2019.

3. The incident

3.1. The mine

The Ashton Coal Mine is located at Glennies Creek Road, Camberwell about 14 kilometres northwest of Singleton in the Hunter Valley region of New South Wales. The mine's operations consist of underground development, mining and coal handling and preparation.

3.2. Incident location

The incident occurred with an underground roadway in an area identified as the Watagan operations-underground region situated within the boundaries of mining lease (ML) 1533. At the time of the incident, the roadway was under development and was identified as the longwall 203A installation roadway (LW203A road).

3.3. Parties involved

3.3.1. Mine operator and holder

Since 31 March 2016, the mine has been managed and operated under a services agreement between Yancoal Australia Limited (YAL), Watagan Mining Company Pty Ltd (WMC) and Yancoal Mining Services Pty Ltd. WMS and Yancoal Mining Services Pty Ltd are wholly owned by YAL. As part of the agreement, Yancoal Mining Services Pty Ltd is the nominated mine operator for the mine, having held the nomination since 31 March 2016.

The mine's operations are conducted under mining leases ML1533, ML1529, ML1623 and ML1696. The nominated holder for each mining lease is White Mining (NSW) Pty Ltd (WMNSW) who is wholly owned by WMC.

At the time of the incident, the workers involved were employed by the mine operator and Ashton Coal Operations Limited who are wholly owned by WMC.

3.3.2. Original equipment manufacturer (OEM)

At the time of the incident, four Joy 12CM12 model continuous miners formed part of the mine's operations. The continuous miners were manufactured and supplied to the mine by original equipment manufacturer Joy Global Australia Pty Ltd. In July 2016, Joy Global Inc, including its subsidiary Joy Global Australia Pty Ltd, were acquired by Komatsu Limited and commenced trading in Australia as Komatsu Mining Corp.

3.3.3. Injured worker

The injured worker was 36 years of age at the time of the incident. The worker commenced employment at the mine as a mining technician in July 2018. The worker had over seven years' experience working in underground coal mines, including operating various mobile plant items including continuous miners and shuttle cars.

3.4. Mobile plant involved

The incident involved a Joy Global Australia Pty Ltd manufactured continuous miner model number 12CM12 with mine identifier CM04. The continuous miner (CM04, miner) was equipped with a cutter head, roof and rib bolting systems, conveyor and operator platforms. It was able to be operated via remote control and trammed in forward and reverse directions via two continuous metal track circuits. Each track circuit was able to operate independently, allowing the continuous miner to slew in both clockwise and anticlockwise directions. CM04 weighed approximately 79 tonnes (unloaded), measuring approximately 11.8 metres in length from head to tail. CM04 was first delivered to the mine in 2010 and after completion of introduction to site protocols was integrated into the underground mining operations. At the time of the incident, the mine operator held operational control and management of all continuous miners on site including the inspection, service, maintenance and repair work conducted on CM04. Figure 1 below depicts CM04 during testing conducted at the mine in the course of the investigation.

Figure 1 CM04 positioned for functionality testing

3.5. Details of the incident

3.5.1. Leading up to the incident

On 20 May 2019, an authority to mine (ATM) was issued by the mine operator giving approval for workers to commence the development of the LW203A road. In accordance with the ATM, the roadway was designed to run between the MG203 and MG202 roadways travelling approximately 205 metres in length with an average upward grade of 1:10.

On 22 May 2019, the development of the road commenced with work crews using a continuous miner to breakaway and mine between the existing roadways with the extracted material removed via shuttle car.

On 28 May 2019, approximately 104 metres of the initial first pass mining of the roadway had been completed without incident.

Between the day shifts of 29 and 30 May 2019, work crews continued to develop the LW203A roadway. During this time, mine deputies noted within their statutory reports that they encountered slippery ground conditions and steep floor grades. Mine workers were also aware of instances of rubber tyred shuttle cars having difficulty maintaining traction within the LW203A roadway.

To address these hazards, shift supervisors/deputies modified the existing safe standing zone requirements, with some providing verbal instructions to crews to not stand within a 50 metre radius of the shuttle car and others providing additional directions to remain on the uphill side whenever a shuttle car was in the LW203A road. No changes were implemented with respect to safe standing zones in proximity to continuous miners in the roadway.

3.5.2. Day of the incident

On 30 May 2019 at approximately 2:30 pm, the mine operator's C Crew workers began the afternoon shift. A crew of workers, consisting of a deputy and four continuous miner operators/mining technicians, electrician and fitter (203A crew), were assigned to continue work on the development of the LW203A road. During start of shift meetings, the 203A crew were tasked with installing rib support and trimming (also known as grubbing) the roadway floor close to the exposed mining face using continuous miner CM04. After the start of shift meetings, the 203A crew were transported underground where they completed a shift changeover meeting and routine prestart inspection and operational checks of CM04 and its remote, with no issues identified. The crew then spent approximately six hours installing rib support bolts in the roadway. During this time, no operational issues with CM04's ability to tram, brake or maintain traction along the LW203A road were identified.

Once rib bolting had been completed, the CM driver, shift deputy and cable hand commenced the task of trimming the 10 to 15 metre section of roadway floor leading up to the install face.

To trim the floor, the CM driver using the remote positioned the CM04 approximately 10 to 15 metres from the face. He lowered the cutter head and shovel and then trammed the miner forward slightly, sinking the cutter head into the floor removing its top layer. Once at the face, the CM driver then raised the cutter head and shovel and reversed the CM04 back to the initial starting point and repeated the process. While trimming the floor, the deputy and the CM driver were positioned on the right-hand side operator platform with the cable hand standing on the ground behind the miner managing the length of cable as the miner trammed in forward and reverse. The workers completed approximately three passes without incident or issue.

At the commencement of the fourth pass, the CM driver reversed the CM04 back to the initial starting point, approximately 10 to 15 metres from the face and stopped. The CM driver then lowered the cutter head and shovel to the floor and with the cutter head rotating attempted to tram forward. The CM04 initially trammed forward approximately half a metre and then stopped moving despite the CM driver maintaining the tram forward function on the remote. At this point, the CM driver noticed that the CM04's right hand side tramming tracks were still spinning and were not maintaining traction with the floor. To regain traction, the CM driver stopped tramming and then slightly lifted the cutter head and shovel approximately 2.5 centimetres off the ground. The CM driver then attempted to again tram

forward. The CM04 did not move forwards and the CM driver recalls noticing that the right hand side tracks were spinning. A few seconds after attempting to tram forward, the CM04 began to slide backwards down the uphill grade of the LW203A road.

The CM driver immediately ceased tramming and attempted to apply the brakes and switch off power to the CM04 using the remote, but it had no effect on stopping its movement. The CM driver and deputy then alerted the cable hand to get out of the way who had been standing approximately 10 to 15 metres from the back of the CM04 when it first started to slide backwards.

The cable hand slipped and fell to the floor while attempting to turn and run clear of the path of the approaching continuous miner. The CM04 continued to slide back down the roadway with its rear bumper contacting the worker before coming to rest after travelling approximately 10 to 15 metres. The CM driver and deputy immediately rendered assistance to the cable hand who had been pushed to the ground by the continuous miner when it contacted him. When the CM04 came to rest, the cable hand was partially underneath the rear of the miner but was not trapped (see figure 2). The cable hand was provided with first aid, transported to the surface and later to the hospital for precautionary scans and treatment.

As a result of the incident, the cable hand sustained soft tissue injuries to the back of his shoulder, hand, thumb, chest and legs. The cable hand also suffered psychological trauma as a result of the incident requiring ongoing treatment and has not yet been able to return to work.

Figure 2 Position of rear of CM04 after the incident

4. The investigation

4.1. Investigation activities

The investigation examined the incident including the factors leading up to it, the potential cause/s, risks to health and safety, implemented controls and actions taken to prevent a similar incident from occurring. Activities undertaken as part of the investigation included:

- an incident scene assessment, which included:
  - survey, photographs, videos and measurements
  - seizure and examination of exhibits
  - retrieval of available data from CM04
  - coordination and completion of OEM inspection and functionality testing of CM04 and its remote control.
- interviewing key witnesses and other mine workers and supervisors
- service of statutory notices to obtain relevant information and documentation from the miner operator and OEM
- review of the mine operator's relevant procedures and systems of work.

5. Investigation findings

5.1. CM04 functionality

During the investigation, inspection and functionality testing was conducted on the CM04 and its remote control. The notable results of the inspection and testing process were as follows:

- The CM04 continuous tracks used for tramming were functioning as designed with no faults identified. The tracks were reasonably maintained, undamaged and were able to move freely in forward and reverse, maintaining traction at varying operating speeds.
- The CM04 braking system was functioning as designed with no faults identified. Brakes were reasonably maintained and observed to apply immediately on remote command with no delays and minimal braking distances recorded.

- The CM04 remote control was inspected and tested and observed to be in good working condition, undamaged and functioning as designed with no faults, interference or relay delays identified.
- The CM04 mode lighting and audible tramming indicators were observed to be functioning as designed with no defects identified.
- Data log information retrieved from CM04 did not identify any braking, traction system or any other system faults, trips or alarms attributable to the incident.

5.2. Cause of the incident

The investigation determined that the incident was most likely caused by the combined effect of the following environmental conditions of the LW203A roadway's:

- steep longitudinal grade
- slippery floor conditions
- hard stone floor substrate.

5.2.1. LW203A roadway grade

Within the CM04's operational manual, the OEM prescribed that the maximum grade in which the miner could safely operate on was 1:3.5 (longitudinal also known as pitch) and 1:10 (cross grade also known as roll). In accordance with the mine operator's Roads or other vehicle operating areas underground (ROVOA) management plan the maximum longitudinal grade limit permittable for the underground roads was 1:5 (longitudinal grade) and 1:8 (cross grade).

Prior to the incident, the mine had planned for the LW203A roadway to travel approximately 205 metres with an overall longitudinal grade of 1:10. When the incident occurred, approximately 112 metres of the first pass mining of the roadway had been developed with survey data indicating an approximate overall longitudinal grade of 1:8 well within both the mine's ROVOA management plan and the OEM's stated safe operating limits for CM04.

As part of the investigation, a survey was undertaken determining the longitudinal and cross grades of the involved section of roadway (see figure 3).

The results of the survey indicated the following:

- The approximate location where the CM04 most likely first lost traction and commenced sliding back had a longitudinal grade of 1:5.9 and cross grade of 1:23 which was within both the mines ROVOA management plan and the OEM's stated safe operating limits (see figure 3).
- The steepest section of roadway which the miner slid down had an uphill grade of 1:3.8 over a span of 5.3 metres. This section of roadway did not comply with the mine's ROVOA management plan but was still within the OEM's stated safe operating limits for the CM04.

Figure 3 LW203A road longitudinal grade survey

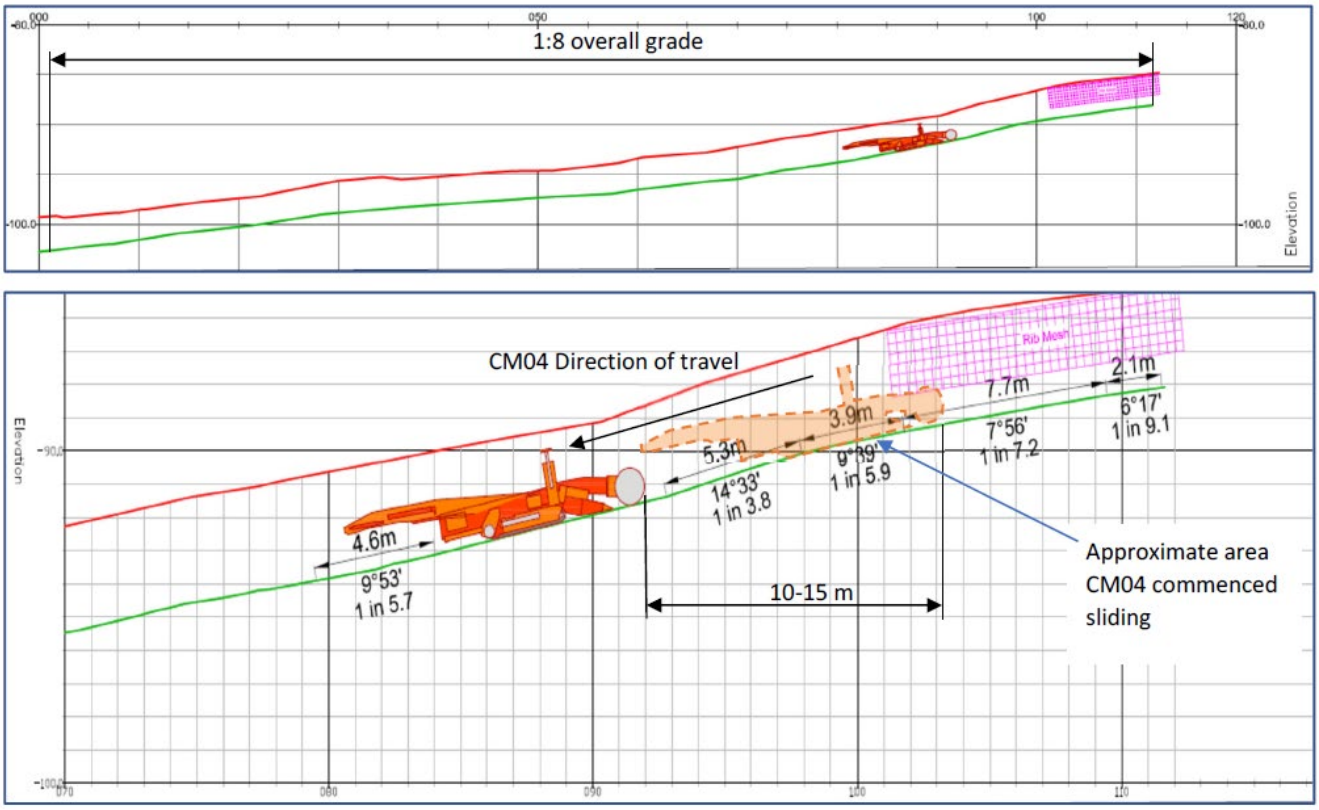


Figure 4 Front view of CM04 after the incident

5.2.2. Slippery ground conditions

In the days leading up to the incident, the deputy's statutory shift reports had recorded that sections of the LW203A roadway were slippery and had steep grades identifying the need for additional care and adherence to safe standing zone requirements. During interviews, mine workers also stated that in the lead up to the incident they were aware of instances of rubber tyred shuttle cars encountering difficulties in maintaining traction along sections of the roadway.

5.2.3. Hard stone floor substrate

In accordance with the LW203A road ATM, the immediate floor cutting horizon near the start of the roadway was expected to generally contain medium-high strength mudstone and siltstone. The ATM also noted that closer to the end of the roadway the floor substrate material was expected to be comprised of very high strength siderite and high strength sandstone.

Examination of the track marks left by the CM04 after the incident identified areas where stone floor substrate was exposed. During interviews, mine workers stated that they had observed sections of the roadway which contained exposed hard stone floor substrate.

Workers also stated that they observed that continuous miners generally had greater difficulty cutting uphill in hard stone face and floor conditions and that it had on occasions caused the tramming tracks to spin and lose traction but were unaware of it ever resulting in the miner sliding down the roadway grade.

5.3. Risk to health and safety

Mine workers were potentially exposed to the risk of death or serious injury by being struck by a continuous miner experiencing an unplanned movement caused by a loss of traction while tramming (with or without the cutting head operating). The risk had the potential to cause multiple deaths in a single event, meeting the definition of a principal hazard as prescribed within clause 5 of the Work Health Safety (Mines and Petroleum Sites) Regulation 2014 (WHSMR).

5.4. Identification and assessment of the risk

5.4.1. Mine operator

5.4.1.1. Roads or other vehicle operating areas (ROVOA) risk assessment

Pursuant to clauses 9(2) and 23 of the Work Health and Safety Mines and Petroleum Sites Regulation 2014 (WHSMPR), the mine operator engaged an external consultant to facilitate and undertake a formal risk assessment relating to the mine's roads and other vehicle operating areas in June 2016. The risk assessment was facilitated by the consultant and consisted of ten participants from a representative cross-section of the workforce.

Notable results of the assessment included the following:

- Vehicle and pedestrian collision within production face areas was identified as a health and safety risk to workers with the potential to result in a fatality or permanent total disability. The risk was classified as being unlikely to occur and was assigned a high-risk rating. Implemented controls were deemed as being effective and focused on:
  - trained and competent workers
  - mobile plant incorporated safety systems

- safe standing zones and operating procedures
- mine inspection, hazard and risk identification processes.

- Unplanned movement of mobile plant was identified as a health and safety risk to workers with the potential to cause serious injury/permanent disability. The risk was classified as being unlikely to occur and was assigned a moderate-risk rating. Implemented controls were deemed as being effective and focused on:
  - mobile plant maintenance, inspection, testing and defect management procedures
  - mobile plant incorporated safety systems
  - trained and competent workers
  - safe standing zones and operating procedures.
- Less than adequate work area inspections prior to operating mobile plant was identified as a health and safety risk to workers. It was identified that the risk could result in minor personal injury to plant operators or pedestrians. The risk was classified as having a possible likelihood and was assigned a moderate risk rating.
- Less than adequate roadway design due to grade was identified as a risk of disrupting operations. The assessment did not identify that the risk could result in harm to people, but rather, presented only a potential to cause damage to assets.

5.4.1.2. 12CM12 operational risk assessment

Between March and May 2019, the mine operator also conducted a review of its existing operational risk assessment for its 12CM12 continuous miner fleet. The risk assessment was facilitated by the same external consultant and consisted of fourteen participants from a representative cross-section of the workforce.

During the assessment process, the mine's prior internal incidents (since September 2015) as well as recent Regulator issued safety alerts and publications were considered and reviewed. It is noted that none of the reviewed incidents or safety alerts/bulletins had identified an instance of a continuous miner experiencing an unplanned movement caused by a loss of traction during tramming.

Notable results of the assessment included the following:

- Slip, trip, fall and crush hazards around the miner during cutting operations was identified as a health and safety risk to workers with the potential to cause death or serious injury. The risk was classified as being an unlikely occurrence and was assigned a high-risk rating.
- Collision between a miner and pedestrian during tramming was identified as a risk to the health and safety of workers with the potential to cause death or serious injury. The risk was classified as being an unlikely occurrence and was assigned a high-risk rating.
- Safe standing zones were identified as existing controls to manage both risks which had been deemed an effective measure.

5.4.1.3. LW203A road condition hazards

In the days leading up to the incident, mine workers and deputies had reported that sections of the LW203A roadway were steep and slippery with instances of rubber tyred shuttle cars having difficulty in maintaining traction along the road.

To address this hazard mine supervisors implemented more stringent safe standing zone requirements to prevent workers from being positioned where they could potentially be struck by a shuttle car if it lost traction and slid down the roadway grade. When assessing the hazard, the possibility of a continuous miner sliding down the roadway was not foreseen or considered.

5.4.2. Original equipment manufacturer (OEM)

As part of the investigation, inquiries were conducted with the OEM with regards to the incident's circumstances and the OEM's identification and assessment of the risk. The results of these inquires indicated the following:

- The OEM design risk assessment for the 12CM12 continuous miner originated over 20 years ago and was reviewed and updated for every machine build and after every industry incident involving continuous miners.
- The risk assessment had identified the risk of crush injury caused by unplanned movements during tramming however, it had not identified or considered the risk of the machine slipping due to operating grade for either of its 12CM12 and 12CM30 continuous miner models.
- The design risk assessment had reviewed and considered safety alerts and publications issued by the NSW mining regulator, QLD mining regulator and its own internal safety bulletins and had not identified the risk of the machine slipping due to operating grade.

- No occurrence of a continuous miner slipping in a similar manner had ever been reported to the OEM during the lifespan of its 12CM12 and 12CM30 products worldwide.

5.5. Implemented risk controls

To manage the health and safety risk associated with a continuous miner experiencing an unplanned movement caused by loss of traction during tramming, the mine primarily relied on the following key controls:

- 12CM12 incorporated safety systems
- safe standing zones
- maximum grade limits for underground roadways
- trained and competent workers.

5.5.1. 12CM12 incorporated safety systems

Figure 5 below outlines a summary of 12CM12's key safety systems designed to control the risk of unplanned movements caused by a loss of traction during tramming (with or without the cutter head operating).

Figure 5 12CM12 Safety systems

SAFETY SYSTEM	DESCRIPTION
Fail to safe braking system	The continuous miner is fitted with a fail to safe automatic braking system where the brakes remained applied as a default setting and are only released when engaged by the remote under hydraulic power. Brakes immediately reapply when either the dead man or other function switches on the remote are disengaged or in the event of a detected mechanical, electrical or hydraulic fault.
Radio remote dual deadman switch	For a continuous miner to tram, both radio remote deadman switches must be engaged and acknowledged by the continuous miners control system. If at any stage either switch position is disengaged or remote signal lost, the tram function is stopped, and the brakes immediately apply. This prevents unintended operation of the continuous miner as a result inadvertently pressing the remote buttons.

SAFETY SYSTEM	DESCRIPTION
Radio remote teach and learn function	The continuous miner is paired uniquely with a single remote control so that it only accepts commands from one source preventing a second remote from inadvertently controlling the miner's functions.
Operational mode lighting	The miner was fitted with mode lighting which indicates to workers the current operational mode of the continuous miner allowing workers to position themselves in protected locations in accordance with safe standing zones.
Tramming audible indicator	When the continuous miner operator presses and selects the traction button on the remote an audible indicator sounds alerting workers in the vicinity that the machine is about to commence tramming.

Mechanical inspection and functionality testing conducted as part of the investigation did not identify any faults or operability issues with any of the above safety systems. Data log information retrieved from the CM04 did not identify any braking system faults or any other operability issues.

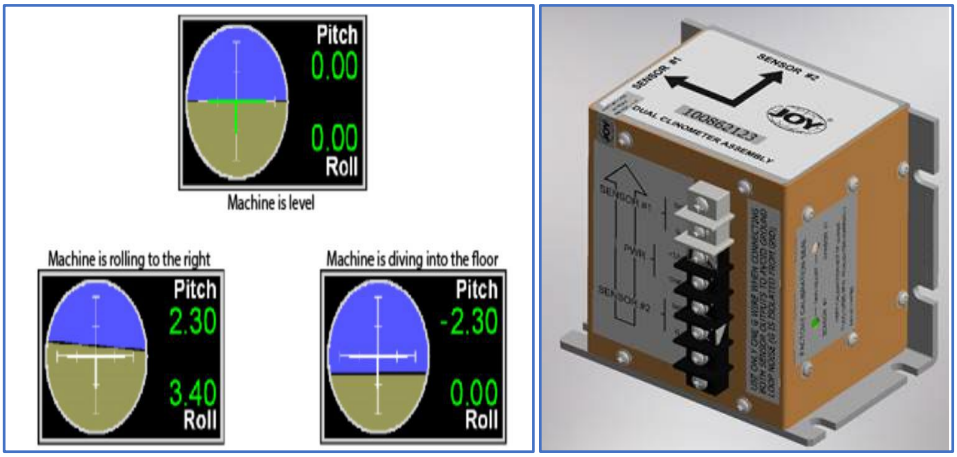
When interviewed, workers stated that the CM04's safety systems appeared to function as designed. The CM driver indicated that he had noticed a slight split-second delay in the time taken for the CM04's brakes to apply, however during testing, the CM04's brakes were observed to apply instantaneously upon command with no visible delays.

At the time of the incident the CM04 was not fitted with any kind of sensor, alarms or similar kind of grade calculation or positioning device that alerted operators of its pitch and roll positioning. This meant that operators had no real time information available to them to determine if the machine was approaching or had exceeded its safe operating limits.

Inquiries conducted with the OEM identified that since the early 2000's its 12CM12 models were able to be fitted with a tilt sensor unit that calculated the relative pitch and roll positioning of the machine. (see figure 6). The OEM stated that the sensor's information was available as a diagnostic only feature providing operators with general information to allow them to follow the coal seam/cutting plan.

The sensor display was not configured to be utilised during normal operation to identify and control the positioning of the machine. At the time of the incident the CM04 was not fitted with the pitch and roll sensor unit but it was available to be retrofitted.

Figure 6 OEM tilt sensor unit and visual diagnostic display of pitch and roll readings on 12CM12 models



5.5.2. Safe standing zones

To prevent workers from being positioned in unsafe locations during tramming (with or without the cutting head operating), the mine operator relied primarily on the implementation of safe standing zones. The zones were incorporated into the mine's safe operating procedures and prescribed the conditions that had to be met before any person was permitted to access designated areas.

In accordance with the mine's operating procedures these zones were defined as follows:

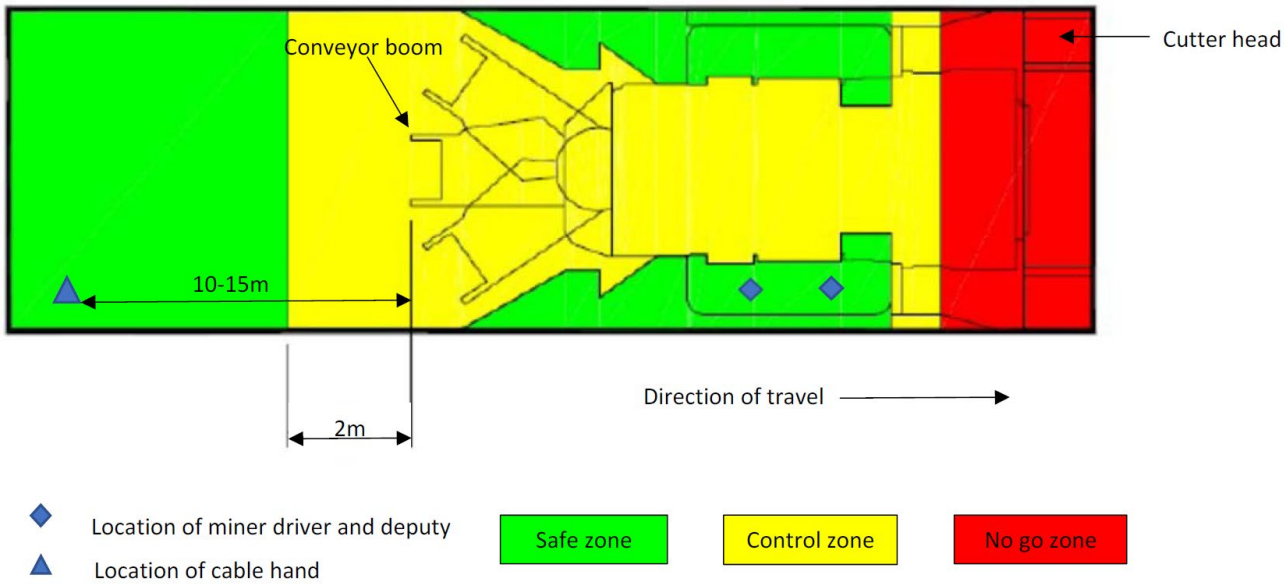
- *Safe zone (Green) - Area which can be occupied with no danger of being hit by any part of the continuous miner if operated or moved to its limit either deliberately or unexpectedly.*
- *Control zone (Yellow) – To stand or work in this area the continuous miner must be:*
  - *shut down (pump stopped) or;*
  - *isolated at the traction breaker or;*
  - *in bolting mode (diversion valve operated) or;*
  - *fully isolated at the main isolator.*
- *No go zone (Red) – To enter this area the continuous miner must be isolated, additionally:*
  - *to enter the area past the cutter head it must be retracted and the mined slewed to one side to provide a clear walkway*

- *to physically contact the cutter head the continuous miner must be isolated with a personal danger lock fitted in accordance with the Ashton 12CM12 isolation procedure*.

The safe standing zones had been implemented at the mine since 2005 and were periodically reviewed, most recently in February 2019.

Figure 7 below depicts the safe standing zones implemented for straight cutting operations (including floor trimming) and the approximate locations of the workers when the incident occurred.

Figure 7 Safe standing zones and position of workers at the time of the incident



The zones prescribed that during straight cutting operations (including floor trimming) workers were required to be outside the yellow control zone perimeter which extended two metres from the end of the miner's conveyor boom.

The distance provided adequate clearance for workers to remain clear of the miner's swinging conveyor boom but had not accounted for the possibility of an unplanned movement causing the miner to move backwards in excess of two metres.

At the time of the incident, the cable hand was positioned between 10 to 15 metres from the back of the miner's boom well outside the designated two metre control zone area (see figure 7).

When establishing/reviewing the suitability of the control zone perimeter, the mine operator reviewed prior incidents at the mine, the OEM technical manual and OEM issued safety alerts and publications.

Investigation inquiries did not identify any prior instances at the mine where a continuous miner had lost traction causing it to slide in excess of two metres in any direction. Review of OEM safety alerts and

publications issued prior to the incident did not identify and instances of a continuous miner experiencing an unplanned movement with similar circumstances to that of the incident.

5.5.3. Maximum grade limits for underground roadways

The mine operator's ROVOA management plan had been implemented since January 2015. The plan specified the criteria for the design of roadways such that road conditions did not present a risk to the health and safety of workers. In accordance with the ROVOA management plan the maximum grade limit for underground roadways was 1:5 (longitudinal grade) and 1:8 (cross grade).

During the investigation a survey of the LW203A roadway was undertaken. Of the surveyed area a span of 5.3 metres was recorded as 1:3.8 exceeding the mine's design rules (see figure 3). This section of roadway was developed during night shift approximately 38 hours prior to the incident.

5.5.3.1. Development of roadways

To ensure that underground roadways were developed in accordance with the road design maximum grade limits, survey sites were established prior to the mining of the relevant sequence of roadway.

Continuous miner operators were required to utilise the survey sites to set a grade position with the continuous miner's cutter head maintaining the set cutting horizon as the road was developed. Additional surveys were also completed on an "as required" basis depending on seam variability or at the request of mine deputies to ensure compliance with the grade limits.

The investigation identified that in the days leading up to the incident, the mine's surveyors and development supervisors had inspected the LW203A road and informed mine deputies that the roadway was being developed as planned and had an overall 1:8 uphill longitudinal grade.

5.5.3.2. Road condition inspections

To ensure roadway grades were compliant with the mine's design rules, the ROVOA management plan required deputies to conduct regular inspections of the road conditions as part of their statutory mine inspections. Deputies were not provided with any kind of grade calculation equipment or devices to assist in this process, but rather were expected to arrange surveys of any areas that they suspected may not comply with the mine operator's road design rules.

During interviews, deputies who had worked within the LW203A road during the week prior to the incident stated they were unaware of the mine's road design rules for the maximum longitudinal grade.

5.5.4. Trained and competent workers

5.5.4.1. Continuous miner and radio remote operation

At the time of the incident, the mine operator had implemented a requirement that only trained, assessed and deemed competent workers were permitted to operate 12CM12 continuous miners including the CM04. The investigation identified that all involved CM operators had been trained and deemed competent in the mine's continuous miner safe operation procedures including remote operation.

5.5.4.2. Safe standing zones

At the time of the incident all workers involved had been trained and deemed competent in the mine operators safe standing zone procedures. When interviewed, workers generally understood the safe standing zone requirements and how they applied to working in proximity to continuous miners.

5.5.4.3. Road design maximum grade limits and OEM safe operating limits

The investigation identified that at the time of the incident:

- involved workers who had received training and been deemed competent in continuous miner operating procedures were unaware of the 12CM12 OEM's stated safe operating grade limits
- deputies and continuous miner operators who had received prior training in ROVOA management plan and had worked within the LW203A road during the week prior to the incident were not unaware of the mine's road design rules for the maximum grade limits.

5.6. Foreseeability of the risk and incident

Although the mine operator's ROVOA and 12CM12 operational risk assessments had identified and considered the general risk of unplanned movements during tramming, it had not foreseen and considered the risk of a continuous miner losing traction and sliding down a roadway with an uphill/downhill grade. Notable factors that contributed to this include the following:

- Workers and supervisors were unaware of any prior instances of a continuous miner losing traction and slipping down roadways at the mine, within industry, or at any other mines they had previously worked at.

- It was not identified as a potential risk within the OEM design risk assessment or the mine's ROVOA and 12CM12 operational risk assessments
- The OEM had not been notified of any such incidents occurring during the entire lifespan of its 12CM12 and 12CM30 products worldwide, and as such, had not published any safety alerts, bulletins or similar publications addressing the risk
- Reviewed mining regulator issued safety alerts and bulletins had not identified any previous incidents of similar circumstances.

5.7. Actions taken post incident

5.7.1. Mine operator

As a result of the incident the mine operator implemented the following corrective actions:

- Conducted a formal risk assessment that specifically focused on identifying and assessing the risks associated with operating development face machinery on grades and operating other mobile plant on roadways under development. The risk assessment was conducted with a cross section of the workforce and reviewed:
  - continuous miners and other development machinery safe operating limits
  - testing of equipment undertaken by the OEM
  - stability of a continuous miner on varying floor material
  - design requirements for underground roads
  - risks to personnel and assets from developing roadways on grades.
- Developed and implemented the use of a trigger action response plan (TARP) for developing roads on grades and operating plant on grades. In accordance with the TARP, the mine introduced more stringent requirements including:
  - safe standing zones for roads with steeper than 1:6 grades, which prohibited pedestrian access within 30 metres of mobile plant traversing the area and continuous miners in cutting mode
  - instructing workers to where possible stop production and reduce roads with grades steeper than 1:5 back to 1:6.

- provided workers with instruction and training in the newly developed TARP, including the OEM safe operating limits for continuous miners and other mobile plant
- installed inclinometers onto the body frame of its continuous miners, providing workers with a method of identifying in real time the pitch and roll positioning of the miner chassis.

5.7.2. OEM

Since the incident, the OEM has commenced work on reconfiguring 12CM12 pitch and roll sensor display information so that it can be utilised by the mine and potentially other mine operators to assist in controlling the positioning of the machine. The OEM has indicated that the software and controls are under development.

6. Recommendations

It is recommended that mine operators:

- review operational risk assessments to ensure appropriate consideration is given to the risk of mobile plant slippage due to underground roadway conditions including:
  - steep roadway grades
  - slippery floor conditions
  - hard stone floor substrates.
- review and risk assess the design and configuration of continuous miners operated on site, and where reasonably practicable, ensure they are fitted with appropriate equipment that allows workers to readily identify the pitch and roll positioning of the miner chassis
- review and update operating procedures to ensure safe standing and pedestrian access zone perimeters account for the possibility of a continuous miner losing traction and sliding down steep underground roadway grades
- ensure that underground roadways with steep grades (including those under development) are appropriately sign posted to alert workers of hazardous conditions and the potential for machine slippage
- ensure that all workers involved in the operation of continuous miners are provided:
  - appropriate information, instruction and training in identifying hazardous roadway conditions that could increase the likelihood of machine slippage

- appropriate equipment, information and/or suitable means to readily identify the pitch and roll positioning of the miner chassis.

- ensure that all workers required to inspect underground roadway conditions are provided:
  - appropriate information, instruction and training in the mine's maximum road grade design rules
  - appropriate equipment, information and/or suitable means to readily identify roadway grade compliance during inspections.