Investigation report

Fatality at Baralaba Coal Mine on 7 July 2019

Queensland Government

This publication has been compiled by Resources Safety and Health, Department of Natural Resources, Mines and Energy.

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Summary

At approximately 1.30 am on Sunday 7 July 2019, Mr Jack Daniel Gerdes, an excavator operator at Baralaba Mine was transported by a colleague to a large mining excavator to start loading a fleet of dump trucks with coal.

Shortly afterwards, at approximately 1.55 am, Mr Gerdes was found entangled between the movable part of the excavator's access ladder and the wall of the engine room. As a result of the entanglement he suffered serious injuries. An emergency was declared but despite the best efforts of colleagues and the Queensland Ambulance Service, his life could not be saved. He was transported by ambulance to the Baralaba Multipurpose Health Service facility where he was declared deceased at 3.00 am.

The Queensland Mines Inspectorate conducted an investigation which revealed that Mr Gerdes was most likely struck by the movable part of the access ladder as it was being lowered with an emergency release valve. Crush zones were generated by the movement of the rotating handrails as they moved past stationary handrails and the machine house. Although it was contrary to the requirements of the operations manual, it was physically possible to access this valve through the handrails of the access ladder.

After a comprehensive review of available information, including recorded machine data, no definitive conclusions could be made about how Mr Gerdes had approached or entered the area that lead to his death. Four scenarios were considered based on the evidence collected during the investigation. The most likely scenario is that Mr Gerdes tripped on the upper stairs or mid-platform and became entangled within cell A2 (see Image 7) of the handrails as the ladder was rotating down from the vertical position (refer to scenario 2 below).

While there were several potential scenarios for how Mr Gerdes became entangled, the evidence and analysis of data from the scene indicated that when Mr Gerdes tripped, he inadvertently activated the emergency valve (E-Valve) positioned behind the rails.

It was identified that the E-valve had been accessible to operators and could be operated manually in a way not consistent with the requirements of the original equipment manufacturer (OEM) operating manual. In addition, the valve could be rotated directly rather than by a pull cable installed for that purpose.

Four possible scenarios were identified during the investigation:

- Scenario 1—After shutting down the excavator with an emergency stop switch, Mr Gerdes did not maintain effective three point contact and slipped as he came down the upper stairway, falling head first into cell A2 of the ladder. As Mr Gerdes fell, he simultaneously released the emergency ladder release valve. This in turn initiated the lowering of the ladder. In addition to any injuries from the fall, Mr Gerdes was caught in the scissor action between the fixed and rotating handrails.
- Scenario 2—After shutting down the excavator with an emergency stop switch, Mr Gerdes did not maintain effective three point contact and tripped as he moved across the middle landing, falling head first into cell A2 of the ladder. As Mr Gerdes fell, he simultaneously released the emergency ladder release valve. This in turn initiated the lowering of the ladder. In addition to any injuries from the fall, Mr Gerdes was caught in the scissor action between the fixed and rotating handrails.

- Scenario 3—After shutting down the excavator with an emergency stop switch, Mr Gerdes reached out by hand to release the emergency ladder release valve through the handrails. He became caught in the scissor action between fixed and rotating handrails.
- Scenario 4—After shutting down the excavator with an emergency stop switch, Mr Gerdes did not maintain effective three point contact and tripped and was injured as he fell head first into cell A2. As Mr Gerdes fell, he simultaneously released the emergency ladder release valve. This in turn initiated the lowering of the ladder. In this scenario, Mr Gerdes's head did not protrude enough for it to be impacted by the stationary handrails, but he was carried along as the ladder rotated. As he tried to get up he moved deeper into cell A2 and received more injuries as he passed irregular surfaces on the engine room wall beyond the location of the fixed handrails and was subsequently trapped between the engine room wall and the rotating handrails.

During the review of two months of recorded machine data, multiple occasions were found where operators, contrary to procedure, may have used the emergency ladder release valve for lowering the ladder. Except for his final shift, no such occasion was found where Mr Gerdes was the sole operator during the particular shift.

The key contributing factor that caused the incident was the presence of a number of unguarded pinch points that were generated as the retractable ladder rotated past stationary handrails and/or irregular surfaces of the engine room wall.

The investigation team made eight recommendations. The three main recommendations were:

- hazards created by moving ladder parts should be considered during the design phase of the walkway and machine
- design and engineer access to the ladder release valve or similar device such that it physically can't be accessed directly from the stairs or platforms
- inform Standards Australia and/or the International Organisation for Standardization (ISO) about relevant findings of this investigation so that it can be considered for future versions of standards for heavy vehicle access systems.

The two PC4000-11 excavators at Baralaba Mine were modified soon after the incident. As a result, a similar incident will not be possible on these machines. Komatsu has advised that it will implement similar modifications on the remaining PC4000-11 in Australia. This excavator was still in Komatsu's possession at the time of this investigation.

There are similarities between this fatal incident and another on 26 April 2018 in Western Australia.[1]

[1] See WA Significant Incident report No. 261; https://www.dmp.wa.gov.au/Documents/Safety/MSH_SIR_261.pdf

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Purpose of the report

Providing information relating to safety incidents on mine sites is an important part of continuous improvement of mine safety. This report is based on the findings of an investigation by the Queensland Mines Inspectorate and has two key purposes:

1. To provide family, friends and co-workers with an understanding of the events leading to the death of Mr Jack Gerdes at the Baralaba Mine
2. To inform industry, government and the broader public of recommendations arising from the investigation with the goal of reducing the likelihood of such an event occurring again.

Mr Jack Gerdes

Mr Jack Gerdes was a 27 year old excavator operator employed by Golding.

Mine details

Baralaba Mine is an open cut coal mine operated by Baralaba Coal Company which produces a high quality ultra-low volatile pulverised coal injection coal using truck and excavator method. It is located five kilometres north of the town of Baralaba in Central Queensland and around 150 kilometres west of Gladstone.

Image 1 Location of Baralaba coal mine

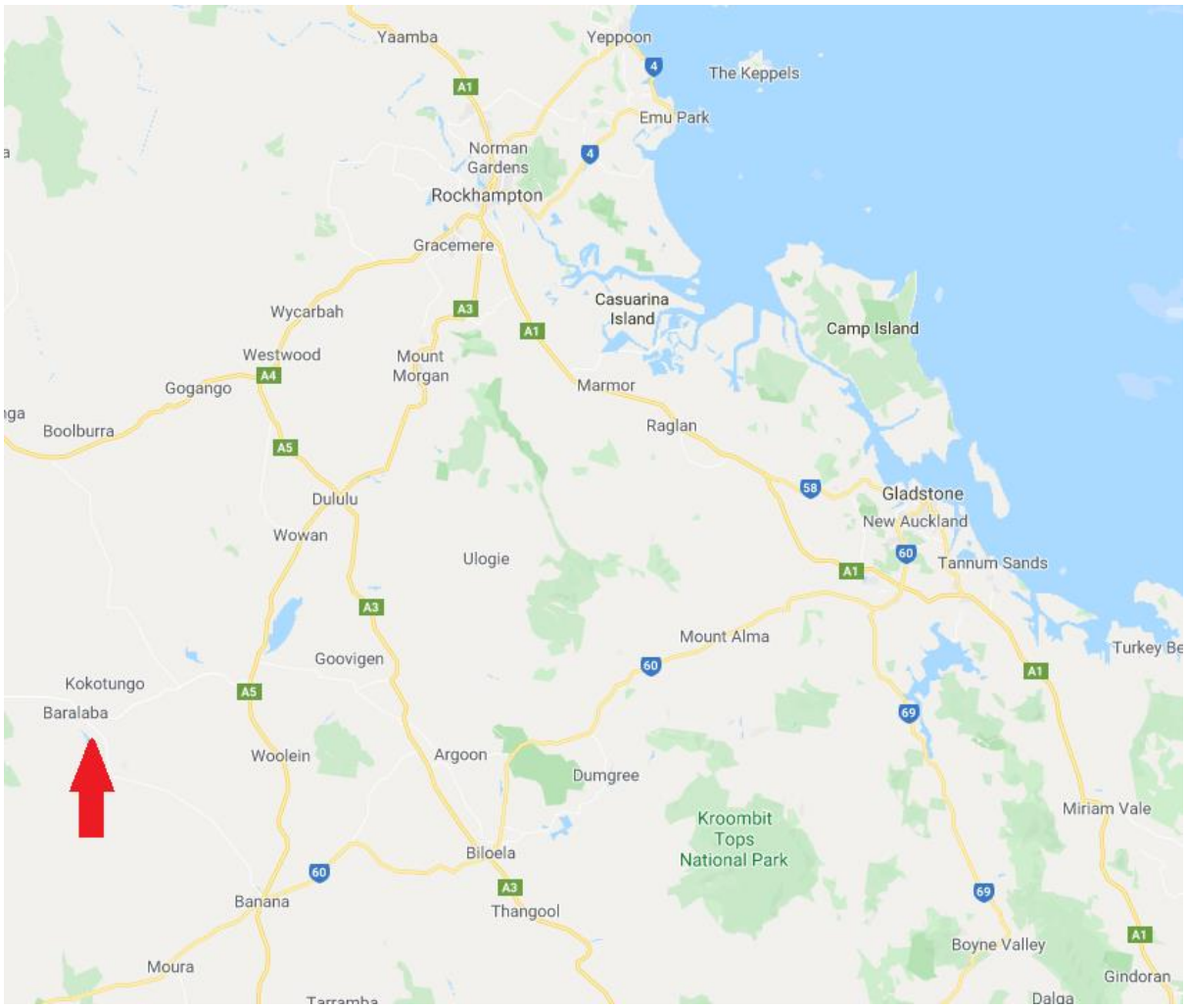


Image 2 Baralaba coal mine and incident location relative to Baralaba Township

The mine and the employer

Baralaba Coal Company is a metallurgical coal producer with a large tenement portfolio across the Bowen, Surat and Galilee Basins. Approximately 26 million bank cubic metres of waste and 1.8 million tonnes of coal are produced annually.

Golding delivers a full range of open cut mining services in the coal and metalliferous mining sectors, spanning the entire mine development and operations. Under contract, Golding undertakes all mining operations at Baralaba including overburden removal, coal mining, wash plant operation and maintenance, rehabilitation, maintenance, and site supervision and statutory responsibilities.

The incident

At approximately 1.30 am on Sunday 7 July 2019, Mr Gerdes was transported by a colleague to a large mining excavator to start loading a fleet of dump trucks with coal.

Shortly afterwards, at around 1.55 am, Mr Gerdes was found entangled between the movable part of the excavator's access ladder and the wall of the engine room. He suffered serious injuries as a result of the entanglement.

An emergency was declared and Mr Gerdes was transported by ambulance to the Baralaba Multipurpose Health Service facility. Despite the efforts of colleagues and medical professionals, Mr Gerdes was declared deceased at 3 am.

Location of incident

The incident occurred at the Fairway Pit North.

Image 3 A marked aerial photograph of the Fairway pit with incident location

Events leading up to the incident

At the start of nightshift (6 pm) on 6 July 2019, Mr Gerdes's crew convened for a pre-start meeting before work commenced in the Fairway Pit.

At the beginning of the shift, Mr Gerdes operated EX05, a 190 tonne Hitachi 1900 excavator at the south-western end of the pit. He was removing waste material to expose coal that had to be mined at a later time. This job was finished by around 8.30 pm.

From after the first crib break (around 10 pm), Mr Gerdes was operating a dozer in support of another excavator (EX03).

At around 1.15 am on Sunday 7 July 2019, the crew supervisor asked Mr Gerdes to leave the dozer and start EX04. The supervisor intended to re-direct the trucks in the EX03 circuit towards EX04.

An operator transported Mr Gerdes to EX04 in a light utility vehicle. It is estimated that they arrived at EX04 at 1.30 am. The excavator was parked on the bench in the Fairway Pit. After the operator had left, Mr Gerdes was the only person in the area.

Incident description

Information that was electronically recorded and collected from the excavator indicated that Mr Gerdes had accessed EX04, started the engine, and lifted the retractable access ladder.

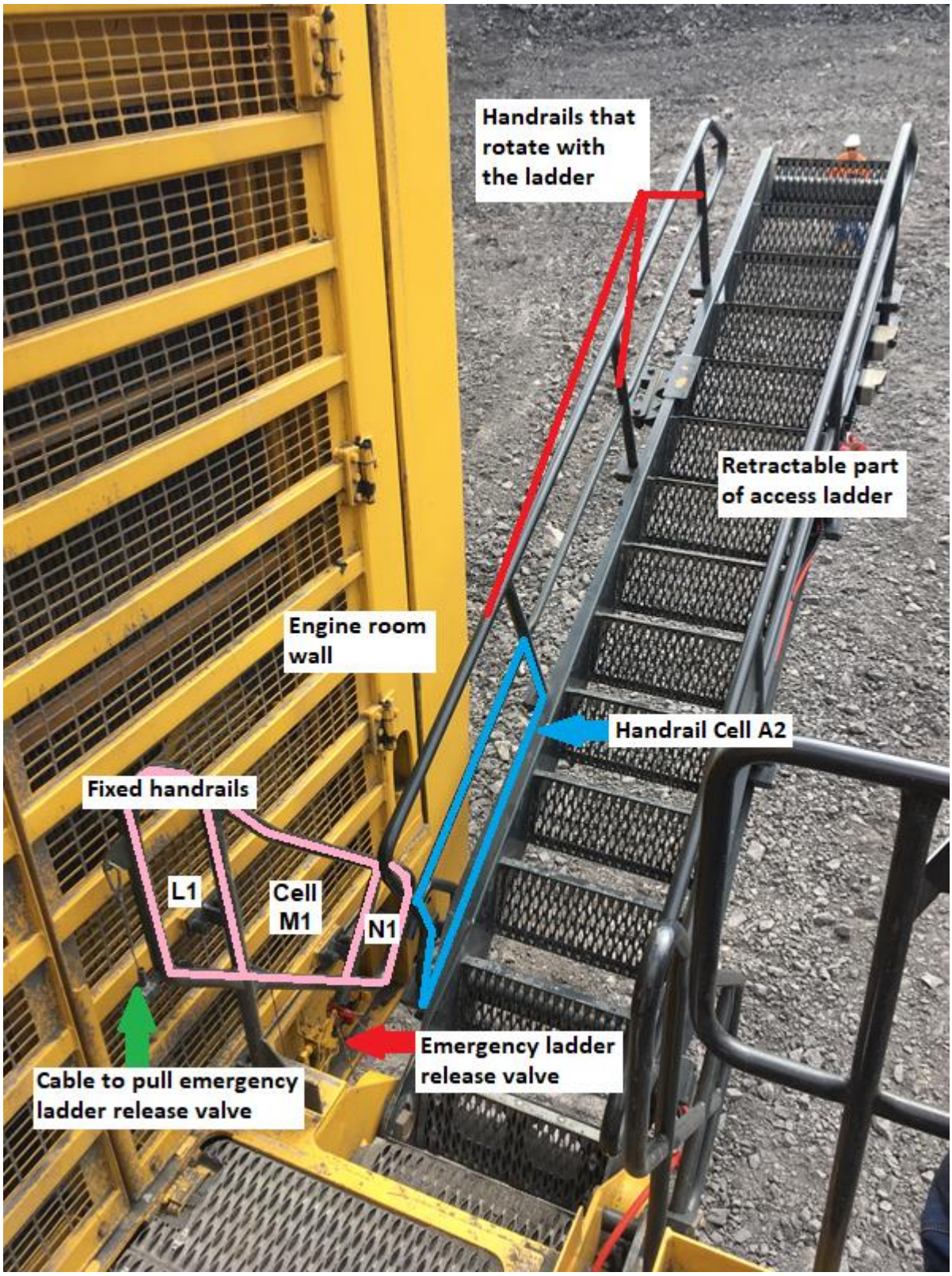
After Mr Gerdes had been transported to EX04 and accessed the machine, rear dump truck DT44 arrived ready to be loaded by EX04. In the headlights, the dump truck operator noticed that the ladder was in the lowered position and Mr Gerdes was trapped between the movable part of the access ladder and the wall of the engine room.

Image 4 Aerial photographs of incident scene with EX04 and DT44 (head on)

Image 5 General incident scene

Image 6 EX04 at the incident scene

Image 7 Retractable ladder parts defined for this report



Emergency response

An emergency was declared and others, including the site paramedic and the Queensland Ambulance Service, arrived to assist.

Handrails on the movable part of the access ladder had to be cut with an angle grinder to free Mr Gerdes.

Mr Gerdes was taken by ambulance to the emergency department of the Baralaba Multipurpose Health Service facility and declared deceased at 3 am.

Notification of Queensland Mines Inspectorate

The Queensland Mines Inspectorate was notified of the incident by the Queensland Police Service at 3.12 am on Sunday 7 July 2019.

Notification of industry safety and health representative

The industry safety and health representative was notified of the incident by the site senior executive at 1.22 pm on Sunday 7 July 2019.

The investigation

A principal investigation officer and an inspector of mines from the Queensland Mines Inspectorate travelled to the incident scene early on the morning of 7 July 2019. They were met by mine personnel and members of the Queensland Police Service—the acting officer in charge (Baralaba), a detective and a photographer. After an inspection, control of the scene was transferred from the Queensland Police Service to the Queensland Mines Inspectorate at 10.51 am.

The Queensland Mines Inspectorate formed an investigation team consisting of three inspectors and an investigator to investigate the incident.

The team returned to site on a daily basis until Friday 12 July 2019. Thereafter, further site visits were made as needed.

On Friday 12 July 2019, EX04 was moved out of the Fairway Pit because a previously loaded shot of explosives had to be fired and the excavator was within the exclusion zone. EX04 was set up at a maintenance pad to facilitate further investigation.

Investigation activities included:

- photography (video and still photos—from tripod, drone and handheld)
- interviews
- document seizure and review
- light readings of the site (under atmospheric conditions similar to those at the time of the incident)
- survey of site (including scanning with a laser enabled 3D scanner)
- download of electronic data (both from the excavator and from its engine)
- re-enactment of the ladder motion on EX03
- ladder functionality test on EX04 by Komatsu
- creep test on the service tail of EX04
- re-enactment of incident with a mannequin (with handrails on EX04 restored to same condition at the time of the incident)
- forensic examination by Queensland Police Service
- analysis of electronically recorded machine data
- PEEPO and ICAM analysis
- preparation of a safety alert to industry.

Safety alert and safety bulletin to industry

On 7 August 2019, the Queensland Mines Inspectorate published *Mines Safety Alert number 366—Retractable access ladders* and distributed it to industry.[2]

On 28 February 2020, the Queensland Mines Inspectorate published *Mines Safety Bulletin 185—Serious accidents involving retractable hydraulic access ladders on mobile mining equipment*.[3]

Observations

The investigation team made a number of safety observations in the course of the investigation.

This included observations about the equipment involved in the incident, the mine's safety and health management system and the training provided to workers. The investigators also conducted an incident cause analysis method (ICAM) process to identify local factors and failures within the broader organisation and productive system which may have contributed to the accident.

Equipment

The incident occurred on a Komatsu PC4000-11 hydraulic excavator. Its call sign, applied by the mine, was *EX04*. At the time there were three of these machines in Australia—two at Baralaba Mine and one that was still in Komatsu's possession. The second machine at Baralaba was designated EX03.

EX04 is mainly used for the loading of coal or overburden material onto rear dump trucks.

Access stairways

The excavator features two main personnel floors—level 1 (3020 mm from ground level) and level 2 (6105 mm from ground level). A fixed upper stairway (or ladder) provides access between level 1 and level 2 (see Image 8 Komatsu PC4000 access stairway—side view and Image 9).

A retractable lower stairway provides access between ground level and level 1. It retracts by pivoting around an axle close to the top. In the fully retracted position, it stands up vertically and rests against a stopper. The rotation is enabled by a hydraulic cylinder under the stairway.

The lower stairway is parallel to the left-hand engine room wall. It has handrails on the left and the right that rotate with the stairway during retraction. Near the top on the engine room wall is a set of handrails that are fixed to the engine wall. They do not rotate during retraction or lowering.

The lower and upper stairways are parallel to each other but not in line. To get to the operator's cabin from ground level, a person must walk up the lower stairway to level 1. A turn to the left is then required before proceeding to the upper stairway. The upper stairway terminates at level 2, just to the left of the cabin door.

With the excavator parked on level ground, the upper access ladder is at an angle of 45 degrees to the ground. In the lowered position, the bottom ladder is at a similar angle. However, it may deviate by a small angle, depending on the ground profile where it comes to rest.

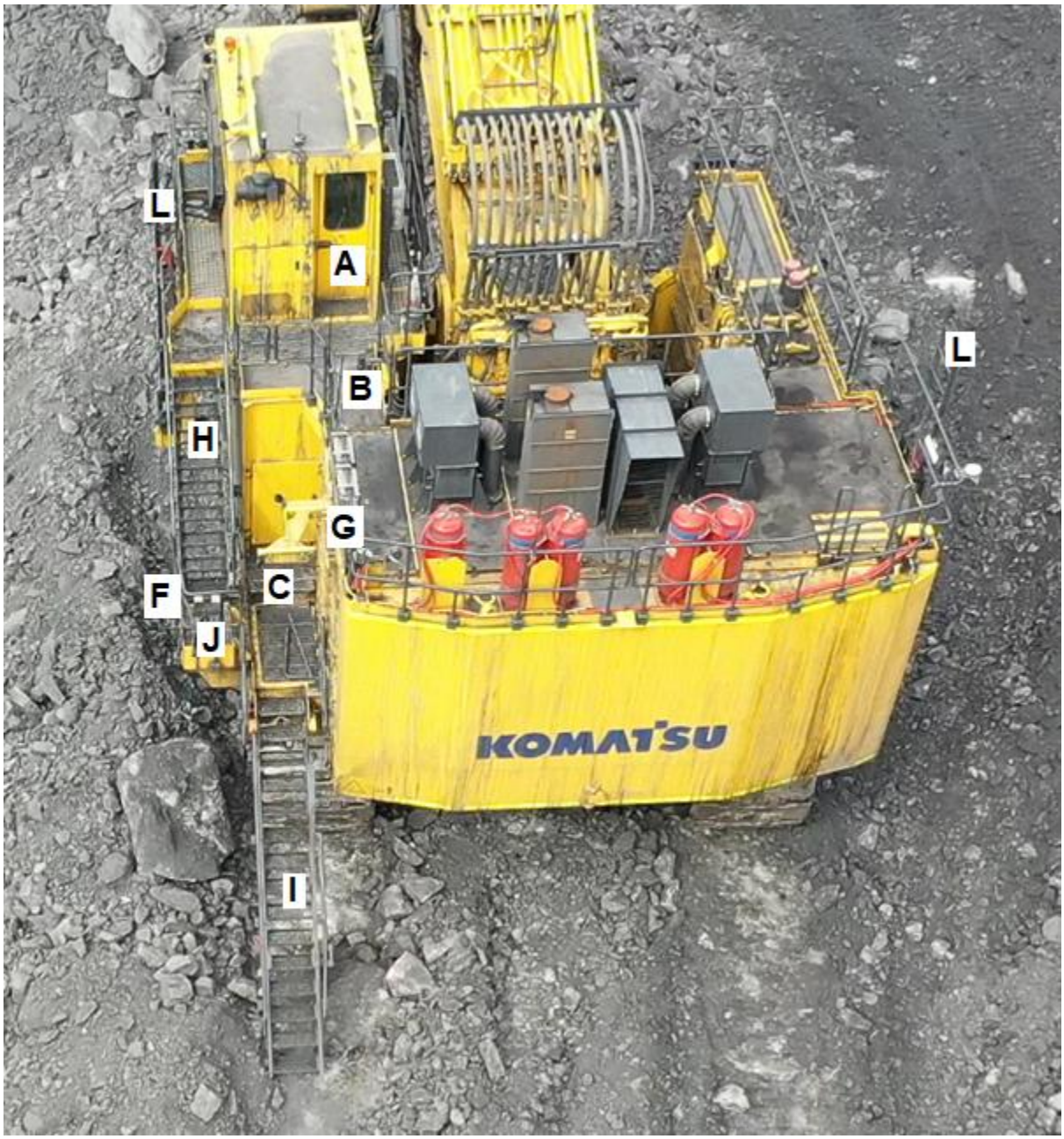
[2] Safety alert 366—Retractable access ladders available at https://www.dnrme.qld.gov.au/business/mining/safety-and-health/alerts-and-bulletins/mines-safety/retractable-access-ladders

[3] Safety bulletin 185—Serious accidents involving retractable hydraulic access ladders on mobile mining equipment https://www.dnrme.qld.gov.au/business/mining/safety-and-health/alerts-and-bulletins/mines-safety/serious-accidents-involving-retractable-hydraulic-access-ladders-on-mobile-mining-equipment

Image 8 Komatsu PC4000 access stairway—side view

Tag	Description	Tag	Description
A	Cabin door	G	Stopper
B	Level 2	H	Fixed upper stairway
C	Level 1	I	Retractable lower stairway
D	Ground Level	J	Small landing platform
E	Hydraulic lifting cylinder	K	Pivoting axle for lower stairway
F	Ladder control switches	L	Emergency escape ladder

Image 9 Komatsu PC4000 access stairway—aerial view



Tag	Description
A	Cabin door
B	Level 2
C	Level 1
F	Ladder control switches
G	Stopper

Tag	Description
H	Fixed upper stairway
I	Retractable lower stairway
J	Small landing platform
L	Emergency escape ladder

Controls for retractable stairway movement

For routine operation of the stairway, two ladder control switches are installed on the handrails above the small platform at the bottom of the upper stairway. At this location, the operator is in a safe location to rotate the stairway.

Image 10 Ladder control switches

The original equipment manufacturer (OEM) operations manual requires that, under routine circumstances, the ladder be lowered by holding the ladder control switches for their full lowering cycle.

To lower the ladder, both of the knobs shown in Image 10 need to be turned to the right. Similarly, to raise the ladder, both of the knobs need to be turned to the left. This action occupies both hands.

When raising and lowering the access stairs with the ladder control switches a continual alarm is activated.

Image 11 Lowering retractable stairway with ladder control switch

Image 12 Stairway in fully retracted position against stopper

Emergency controls for retractable stairway

In case of an emergency or electrical failure, the ladder can be lowered by opening a magnetic hydraulic valve near the pivot point. The emergency ladder release valve can be opened from level 1 by pulling a cable attached to it. Similarly, it can be opened by pulling an attached chain from ground level (see Image 13). The valve is not intended to be operated by accessing it through the handrails.

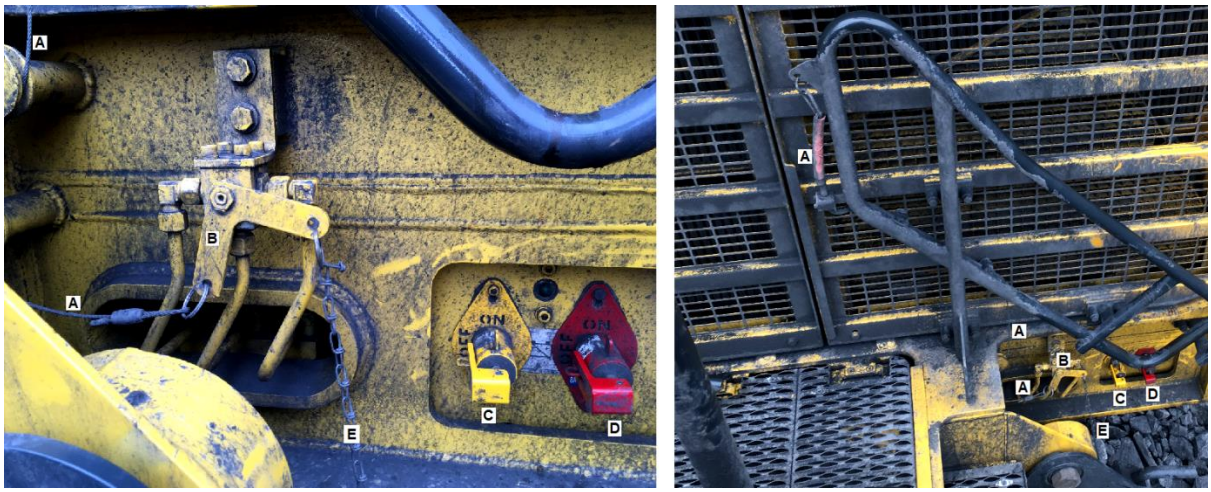
Before the ladder can be raised again, the valve needs to be rotated back to its closed position.

For lowering in either routine or emergency mode, the engine does not need to be running. The ladder is lowered by gravity in a controlled manner with the rate of descent controlled hydraulically.

The investigation team measured the time to lower the stairway on EX03 in both routine and emergency modes. In routine mode, it took 14 seconds to lower. In emergency mode it took 16 seconds.

It has been suggested that operators may be motivated to lower the ladder with the emergency ladder release valve because that would free up their hands while the ladder is lowering and, during this time, another activity would be possible (e.g. rolling a cigarette, cleaning glasses, tidying attire or checking a mobile phone).

Image 13 Emergency ladder release valve on EX04



Tag	Description
A	Pull cable for emergency ladder release valve from level 1 on-board
B	Emergency ladder release valve (In closed position)
C	Starter isolator
D	Battery isolator
E	Pull chain for emergency ladder release valve from ground Level

Data recording

On board EX04 is a vehicle health monitoring system, branded as *Komtrax Plus 2*. When operating, the system records parameters from each of 155 monitoring points around the machine. Every second, a new recording is made for each point.

A wide scope of parameters is monitored including time, temperatures, pressures, location, engine revolutions, and position of the retractable access ladder. The recorded data is stored on board and can be downloaded when required.

The investigation team downloaded monitoring data for review. The data spanned a period from about eight weeks prior to the incident up to a few days after the incident and included more than a billion data points.

Data was reviewed and scanned for evidence relating to what could have contributed to this incident. Non-conformance with the operations manual was found in the data related to engine stop and lowering of the access ladder.

Engine stop

According to the operations manual, at the conclusion of regular operations, the engine must be switched off with the ignition key. Directly before turning it off, the engine needs to have been idled for 3–5 minutes or alternatively idled for the duration determined by the idling stop timer. The idling period is intended to protect the engine against damage from thermal stress, especially in the turbochargers.

In an emergency, the engine may be shut down with any of four emergency stop switches.

Emergency stop switches are located at:

- the outside of the engine room wall near the stairway
- ground level near the stairway (pull chain)
- on the house roof at the right hand rear corner
- inside the operator's cabin.

By using an emergency stop switch, the potential consequences from the emergency are assumed to be outweighing the impact of potential engine damage.

The Komtrax system records if an emergency switch has been activated. However, it does not record which switch was activated. The system only continues to record for another 2–3 seconds after activation. This is because the emergency stop switch also cuts power to the Komtrax system.

From the downloaded data, the investigation team observed that on 68 occasions EX04 was switched off with an emergency stop button (see Table 1). In eight of those instances, the key was also turned off. On two occasions (post-incident), the excavator was switched off with the key only. No evidence was found of any emergencies during the times that the emergency stop button was activated.

Table 1 Machine data for activation of emergency stop switch

Time	Engine Speed[rpm]	Emergency Line Monitor
26/06/2019 6:18:17	800.125	0
26/06/2019 6:18:18	800.875	0
26/06/2019 6:18:19	800.625	0
26/06/2019 6:18:20	800	0
26/06/2019 6:18:21	800.75	0
26/06/2019 6:18:22	800.25	0
26/06/2019 6:18:23	800	0
26/06/2019 6:18:24	801.625	0
26/06/2019 6:18:25	582.625	1
26/06/2019 6:18:26	390.625	1

Lowering of the ladder in accordance with the operations manual

For routine egress from the excavator, the operations manual prescribes:

> *Lower the ladder by turning switch (70S084b) to the right (arrow down) and hold until the ladder is completely lowered.*

The downloaded data showed that the ladder was usually lowered with the ladder control switch in accordance with the operations manual. On some occasions the ladder was lowered in ways that was not in accordance with the operations manual.

Lowering the ladder with the emergency ladder release valve only

The investigation team observed data which showed that the stairway had sometimes been lowered with the emergency ladder release valve instead of with the ladder control switches.

An example of this can be seen in Table 2. In the data it can be seen that the ladder up proximity switch was on (i.e. 1) until 6:11:24, indicating that the ladder was in the fully raised position. From 6:11:25 to 6:11:30, both the ladder up proximity switch and ladder down proximity switch were off (i.e. 0). This indicates that the ladder was in the process of lowering. The ladder down proximity switch was activated at 6:11:31 indicating that the ladder was in the fully lowered position. During this time, the ladder down switch was not being used. (i.e. 0). Therefore, it can be concluded that the emergency ladder release valve was being used to lower the stairs, as it is the only other way to lower the ladder.

Table 2 Machine data for retractable ladder showing lowering of the ladder with emergency ladder release valve

Time	Ladder Up Switch	Ladder Down Switch	Ladder Up Proximity Switch	Ladder Down Proximity Switch
28/06/2019 6:11:22	0	0	1	0
28/06/2019 6:11:23	0	0	1	0
28/06/2019 6:11:24	0	0	1	0
28/06/2019 6:11:25	0	0	0	0
28/06/2019 6:11:26	0	0	0	0
28/06/2019 6:11:27	0	0	0	0
28/06/2019 6:11:28	0	0	0	0
28/06/2019 6:11:29	0	0	0	0
28/06/2019 6:11:30	0	0	0	0
28/06/2019 6:11:31	0	0	0	1

Other supporting evidence that this practice existed at the mine was found during an interview with an operator. The operator indicated that in the past, when he had arrived at an excavator to commence work, the ladder could not be raised because the emergency ladder release valve had previously been used but not reset, presumably by the previous person that had lowered the ladder.

Lowering the ladder using a combination of the ladder down switch and the emergency ladder release valve

The investigations team found 10 occasions where the ladder was partially lowered with the ladder down switch and then completed by opening the emergency ladder release valve (see Table 3).

Testing showed that both in *routine* and *emergency* modes, the ladder takes more than 10 seconds to complete the full lowering cycle. If the routine lowering procedure is followed, the ladder down switch needs to be held for a similar time.

In the sample below, the ladder down switch was held for three seconds and then released (18:23:06 to 18:23:08). After two seconds, the ladder up proximity switch lost contact (i.e. the ladder started to move downwards).

It should be noted that a characteristic of the ladder down switch is that when it is not held anymore, the ladder stops lowering. If at this point it is in close proximity to the upper stop position, it will automatically return to that upper stop position.

In the sample below, 10 seconds after the ladder down switch was released (18:23:18), the ladder down proximity switch activated, indicating that the ladder was fully lowered.

Therefore, it can be concluded that the lowering of the ladder was completed with the emergency ladder release valve, as it is the only other way the ladder could be lowered.

Table 3 Machine data for retractable ladder showing lowering of the ladder with a combination of the ladder down switch and emergency ladder release valve

Time	Ladder Up Switch	Ladder Down Switch	Ladder Up Proximity Switch	Ladder Down Proximity Switch
28/06/2019 18:23:03	0	0	1	0
28/06/2019 18:23:04	0	0	1	0
28/06/2019 18:23:05	0	0	1	0
28/06/2019 18:23:06	0	1	1	0
28/06/2019 18:23:07	0	1	1	0
28/06/2019 18:23:08	0	1	0	0
28/06/2019 18:23:09	0	0	0	0
28/06/2019 18:23:10	0	0	0	0
28/06/2019 18:23:11	0	0	0	0
28/06/2019 18:23:12	0	0	0	0
28/06/2019 18:23:13	0	0	0	0
28/06/2019 18:23:14	0	0	0	0
28/06/2019 18:23:15	0	0	0	0
28/06/2019 18:23:16	0	0	0	0
28/06/2019 18:23:17	0	0	0	0
28/06/2019 18:23:18	0	0	0	1

Safety and health management system

Under Section 42(c) of the *Coal Mining Safety and Health Act 1999*, the site senior executive is obligated to “develop and implement a safety and health management system for all persons at the mine, including contractors and service providers”.

The investigation team observed that the site senior executive at Baralaba Mine complied with this requirement and an effective safety and health management system was in place at the time of the incident.

Elements of the safety and health management system relevant to this investigation included a standard operating procedure for using mobile plant, an operation and maintenance manual for the Komatsu PC4000-11 hydraulic excavator and a training scheme.

Standard operating procedure—using mobile plant

During the investigation, no evidence was found of non-compliance with the elements of the standard operating procedure for using mobile plant.

One of the requirements of this procedure is for operators of heavy vehicles to “maintain three point contact when accessing and egressing machines”.

At the time of the incident, it is possible that scenarios 1, 2 and 4 could have been prevented if effective three point contact had been maintained as required.

Operation and maintenance manual

The operation and maintenance manual for the Komatsu PC4000-11 hydraulic excavator requires that the ladder be lowered and raised with the ladder down switch and ladder up switch respectively. The manual requires that the emergency ladder release valve can only be used for emergencies or electrical faults.

The machine data analysis showed that the ladder was lowered with the emergency ladder release valve on multiple occasions. No evidence has been found of any emergencies or relevant electrical faults that existed during any of these occasions.

Training scheme

Under section 42(h) of the *Coal Mining Safety and Health Act 1999*, the site senior executive is obligated to ensure that no work is undertaken by a coal mine worker until the worker has received training about hazards and risks related to the work to be undertaken. In addition, the site senior executive is required to ensure that the coal mine worker has received training and is competent to perform the work to be undertaken.

The investigation team found that the safety and health management system at Baralaba Mine complied with this requirement and contained an appropriate training scheme.

As part of the site training plan, a skills matrix identifies the training requirements for each coal mine worker relevant to the activities being undertaken.

The investigation team found that Mr Gerdes received training in *load, haul and dump operations* on 12 December 2018. On 19 December 2018, he was authorised for five years to operate a Komatsu PC4000-11 hydraulic excavator.

Incident cause analysis method

The investigation team conducted their investigation using a systematic safety investigation analysis method called *incident cause analysis method* (ICAM). An ICAM is used to identify local factors and failures within the broader organisation and productive system (e.g. communication, training, operating procedures, incompatible goals, organisational culture, equipment, etc.) which may contribute to the incident.

The ICAM identified a number of factors and failures which contributed to the incident, including absent/failed defences, individual/team actions, task/environmental conditions and organisational failures.

Absent/failed defences

The ICAM identified a number of absent or failed defences that could have detected and protected the system against technical and human failures related to the incident:

- The mine did not conduct its own pre-operational risk assessment on the machine before it was used on site—the pre-operational risk assessment by the OEM was used instead.
- The mine did not conduct documented task observations of workers that could have potentially identified incorrect behaviours.
- The mine's introduction to site process did not identify the nip points associated with the raising and lowering of the machine access stairs.
- Neither the machine manufacturer nor the organisation identified the nip points associated with the raising and lowering of the stairs.
- Neither the machine manufacturer nor the organisation identified the potential trip hazard associated with the kick plate on the access walkway.
- Neither the machine manufacturer nor the organisation identified that the emergency stairs lowering valve was easily accessible.

Individual/team actions

The ICAM identified a number of individual/team actions that may have contributed to the incident:

- Neither the machine manufacturer nor the organisation identified the nip points associated with the raising and lowering of the stairs.
- Neither the machine manufacturer nor the organisation identified the potential trip hazard associated with the kick plate on the access walkway.
- neither the machine manufacturer nor the organisation identified that the emergency stairs lowering value was easily accessible.
- The excavator was parked on a 9 degree pitch which may have made it easier for someone to slip or lose their footing.
- Mr Gerdes had conducted the task of raising and lowering the access stairs on many occasions.
- The method of lowering the access stairs was frequently conducted in a manner not recommended in the operations manual during normal operation.
- The method of stopping the machine was frequently conducted in a manner not recommended in the operations manual during normal operation.
- The lowering of the access stairs by activating the emergency switch was seen as an easier method.

Task/environmental conditions

The ICAM identified a number of task/environmental conditions that may have directly influenced human and equipment performance in relation to the incident:

- The incident occurred on nightshift in the early hours of the morning.
- The lighting in the area where the incident occurred was adequate
- The excavator was parked on a 9 degree pitch which may have made it easier for someone to slip or lose their footing.
- Mr Gerdes had conducted the task of raising and lowering the access stairs on many occasions.
- The method of lowering the access stairs was frequently conducted in a manner not recommended in the operations manual during normal operations. However, there was no evidence that Mr Gerdes had operated the access stairs in an incorrect manner

- The method of stopping the machine was frequently conducted in a manner not recommended in the operations manual during normal operation.
- Production on the circuit was about to commence.
- There had recently been rain in the area, but the location of the incident was not excessively wet.
- The lowering of the access stairs by activating the emergency switch was seen as an easier method.
- The raising and lowering of the access stairs with the ladder down switch activated a continual alarm which was relatively loud.

Organisational factors

The ICAM identified a number of organisational factors that may have contributed to the incident:

- The mine did not conduct its own pre-operational risk assessment on the machine before it was being used on site—the pre-operational risk assessment by the OEM was used instead.
- The mine did not conduct documented task observation of workers that would identify incorrect behaviours.
- The mine's introduction to site process did not identify the nip points associated with the raising and lowering of the access stairs.

Potential causes of the incident

Mr Gerdes was alone when he was fatally injured and there were no witnesses to the event.

The investigation team could not find an unequivocal explanation as to how the incident occurred and found there to be more than one plausible scenario. The four scenarios inferred by the investigation team are presented below. The most likely scenario based on the evidence collected during the investigation is that Mr Gerdes tripped on the upper stairs or mid-platform and became entangled within cell A2 of the handrails as the ladder was rotating down from the vertical position (scenario 2).

While there were several potential scenarios for how he became entangled, the evidence and analysis of data from the scene indicated that when Mr Gerdes became entangled he advertently or inadvertently activated the E-Valve positioned behind the rails.

It was identified that the E-valve had been accessible to operators and could be operated manually in a way not consistent with the requirements of the OEM operating manual. In addition, the valve could be rotated directly rather than by a pull cable installed for that purpose.

Scenario 1

This scenario proposes that after shutting down the excavator with an emergency stop switch, Mr Gerdes did not maintain effective three point contact and slipped as he came down the upper stairway, falling head first into cell A2 of the ladder. As Mr Gerdes fell, he simultaneously released the emergency ladder release valve. This in turn initiated the lowering of the ladder. In addition to any injuries from the fall, Mr Gerdes was caught in the scissor action between the fixed and rotating handrails.

Evidence that supports this scenario

There had been light rain earlier in the day and a film of moisture was present on the surface of the metal stair treads and walkways which may have made it more slippery. In addition, the excavator was parked at a slope of 9 degrees which may have made the surface more slippery than if it was parked on a level surface.

Evidence that discredits this scenario

Because of the slope at which the excavator was parked, a person would tend to slip feet first rather than head first. In addition, an operator that was interviewed as part of the investigation stated that the stairs and walkways were not slippery.

Scenario 2

This scenario proposes that after shutting down the excavator with an emergency stop switch, Mr Gerdes did not maintain effective three point contact and tripped as he moved across the middle landing, falling head first into cell A2 of the ladder. As Mr Gerdes fell, he simultaneously released the emergency ladder release valve. This in turn initiated the lowering of the ladder. In addition to any injuries from the fall, Mr Gerdes was caught in the scissor action between the fixed and rotating handrails.

Evidence that supports this scenario

There is a section of kick plate on the platform under the ladder control switches at the small platform at the bottom of the upper fixed stairway that could have acted as a trip hazard when transferring from the upper to lower stairs (see Image 10).

The distance from the kick plate to the emergency ladder release valve is approximately 2 metres, which is similar to Mr Gerdes's height of 1.86 metres.

Scenario 3

This scenario proposes that after shutting down the excavator with an emergency stop switch, Mr Gerdes reached out by hand to release the emergency ladder release valve through the handrails. He became caught in the scissor action between fixed and rotating handrails.

Evidence that supports this scenario

Multiple sets of machine data were found of operators releasing the ladder with the emergency ladder release valve over the preceding two months.

Evidence that discredits this scenario

Of the machine data samples reviewed, no examples were found of the ladder being lowered with the emergency ladder release valve on a shift where Mr Gerdes was the only operator. One example was found during a shift that he shared with another operator.

During an interview with the investigation team, another excavator operator stated that Mr Gerdes always used the ladder control switches.

Scenario 4

This scenario proposes that after shutting down the excavator with an emergency stop switch, Mr Gerdes did not maintain effective three point contact and tripped and was injured as he fell head first into cell A2. As Mr Gerdes fell, he simultaneously released the emergency ladder release valve. This in turn initiated the lowering of the ladder. In this scenario, Mr Gerdes's head did not protrude enough for it to be impacted by the stationary handrails, but he was carried along as the ladder rotated. As he tried to get up he moved deeper into cell A2 and received more injuries as he passed irregular surfaces on the engine room wall beyond the location of the fixed handrails and was subsequently trapped between the engine room wall and the rotating handrails.

Evidence that discredits this scenario

If Mr Gerdes's head did not protrude enough into cell A2 for it to be impacted by the stationary handrails, there was a lower probability of him being carried along by the rotating cell A2.

Physical evidence was found within the stationary handrail at cell N1.

Findings

The investigation team made a number of findings in relation to the incident.

1. Mr Gerdes died as a result of a head injury. The injury was possibly the result of
    a. The scissor action between rotating and stationary handrails of the retractable stairs on EX04.
    b. Mr Gerdes falling.
    c. Mr Gerdes impacting other protrusions on the engine room wall.
2. It is unknown how or why Mr Gerdes approached or entered the area that lead to his death. The recommendations in this report are based on four possible scenarios. The recommendations in this report may be more comprehensive than if the actual scenario had been known.
3. In the months leading up to the incident, and contrary to the instructions in the operations manual, some operators lowered the stairs partially or fully with the emergency ladder release valve.

    The operations manual requires the stairs to be raised and lowered with a set of switches in a safe location. In case of an emergency or electrical fault, the emergency ladder release valve can be operated either through a pull chain (from below) or pull cable (from above).
4. From the machine data over the preceding eight weeks, no firm evidence was found of Mr Gerdes lowering the stairs with the emergency ladder release valve.
5. The emergency ladder release valve pull cable was hard to operate.
6. The emergency ladder release valve was physically accessible, allowing operators, contrary to procedure, to turn it directly, without using the pull cable.
7. Access to the area covered by the sweeping radius of cell A2 was possible due to the open design of the handrails.
8. The author of the operations manual relied on an administrative control (procedure) for safe operation of the stairs. Additional engineering controls would have been more effective (e.g. covering the emergency ladder release valve or installing mesh inserts into the handrails).

Recommendations

The Queensland Mines Inspectorate made the following recommendations as a result of the investigation.

Recommendation 1

OEMs and mine operators must consider the hazards created by moving ladder parts during the design phase.

The designs of access ladders where crush zones are created when the rotating handrails pass stationary handrails in a scissor action need to be reviewed.

At Baralaba Mine, after the incident and as an isolation control, mesh inserts were installed on the rotating handrails of the PC4000-11 hydraulic excavators to prevent people from reaching through them (see Image 14).

Recommendation 2

Apply the hierarchy of controls to the design of the emergency ladder release valve.

The procedure (an administrative control) required the ladder to be lowered from a safe location. However, it was physically possible to access the emergency ladder release valve directly.

Engineering controls should be applied to isolate the valve and prevent it from being accessed inadvertently. This should include covers for the valve and inserts for the handrails (see Image 14).

Image 14 E-valve covers and handrail inserts that were installed after the incident

Recommendation 3

Review Australian and/or International Standards.

It is recommended that the Queensland Mines Inspectorate inform Standards Australia and the International Organisation for Standardization about relevant findings of this investigation so that it can be considered for future versions of standards for heavy vehicle access systems.

Recommendation 4

Identify and rectify trip hazards.

The excavator design should be reviewed to identify possible trip hazards and implement engineering controls.

Recommendation 5

Power supply to the vehicle health monitoring system.

Following a risk assessment, modifications should be made to excavators similar to EX04 so that power continues to be supplied to the vehicle health monitoring system after the application of an emergency stop switch.

This will reduce the likelihood of improper operation and assist with data analysis.

Recommendation 6

Communicate and reinforce the need to maintain three points of contact.

The findings of the investigation should be communicated to industry, including the importance of maintaining three points of contact while using ladders or stairs on any building, plant or equipment.

Recommendation 7

Training and information.

Communicate the recommendations of this investigation to OEMs, operators and maintainers, including the hazards associated with retractable ladders. Communication through safety alerts, industry forums and inclusion of recommendations in OEM manuals.

Recommendation 8

Review the process for releasing the emergency ladder from ground level in all modes of operation.

Upon inspection of another model of excavator on site, it was found that the ladder can only be released if the engine is running (i.e. when the release mechanism is pulled without the engine running, the ladder doesn't lower). In case of an emergency (e.g. if the operator had become incapacitated), a rescuer would not be able to access the machine unless the engine was running.

An engineering control should be implemented to enable remote operation of the release mechanism when the machine is powered off.

Actions taken by Queensland Mines Inspectorate after the incident

The Queensland Mines Inspectorate took the following actions after the incident.

Directives and substandard conditions or practice notices issued

The Queensland Mines Inspectorate issued two directives and one substandard conditions or practice notice as a result of this investigation.

Excavator stairs—directive issued on 8 July 2019

For each excavator on site with a hydraulically operated access ladder, do not use unless it has been determined that the ladder can be used safely.

As a result of this directive, functionality tests involving the OEM were conducted.

Excavator access way to be made safe—directive issued on 8 August 2019

Through a process of risk assessment by competent people, implement measures on EX04, EX03 and other similar equipment on site in order to reduce the likelihood of a similar incident being repeated.

As a result of this directive, emergency ladder release valve covers were installed and inserts installed within the rotating handrails.

Emergency release for access ladder—substandard conditions or practice issued on 29 August 2019

The release mechanism for the access ladder on EX02 was tested from ground level. It was observed that the ladder could only be released if the engine was running (i.e. when the release mechanism is pulled without the engine running, the ladder doesn't lower).

In case of emergency (e.g. if the operator had become incapacitated), a rescuer would not be able to access the machine unless the engine was running.

The system for accessing the excavator from ground level if the ladder is lifted and the engine is not running should be reviewed for all excavators on site and rectified as appropriate.

As a result of this substandard conditions or practice notice, the hydraulic system was modified so that the stairs could also be released when the engine was not running.

Safety alert to industry

On 7 August 2019, the Queensland Mines Inspectorate published *Mines Safety Alert number 366—Retractable access ladders* and distributed it to industry.[4]

Safety bulletin to industry

On 28 February 2020, the Queensland Mines Inspectorate published *Mines Safety Bulletin 185—Serious accidents involving retractable hydraulic access ladders on mobile mining equipment.*[5]

[4] Safety alert 366—Retractable access ladders available at https://www.dnrme.qld.gov.au/business/mining/safety-and-health/alerts-and-bulletins/mines-safety/retractable-access-ladders

[5] Safety bulletin 185— Serious accidents involving retractable hydraulic access ladders on mobile mining equipment https://www.dnrme.qld.gov.au/business/mining/safety-and-health/alerts-and-bulletins/mines-safety/serious-accidents-involving-retractable-hydraulic-access-ladders-on-mobile-mining-equipment

Inspection—other excavators

The retractable stairs on other models of excavators at Baralaba Mine and other operations were inspected for related issues.

Liaison with other inspectors

Preliminary findings as appropriate were communicated to:

- The New South Wales Resources Regulator during a meeting in Sydney on 13 August 2019.
- The Queensland Mines Inspectorate during a meeting in Emerald on 10 October 2019.