

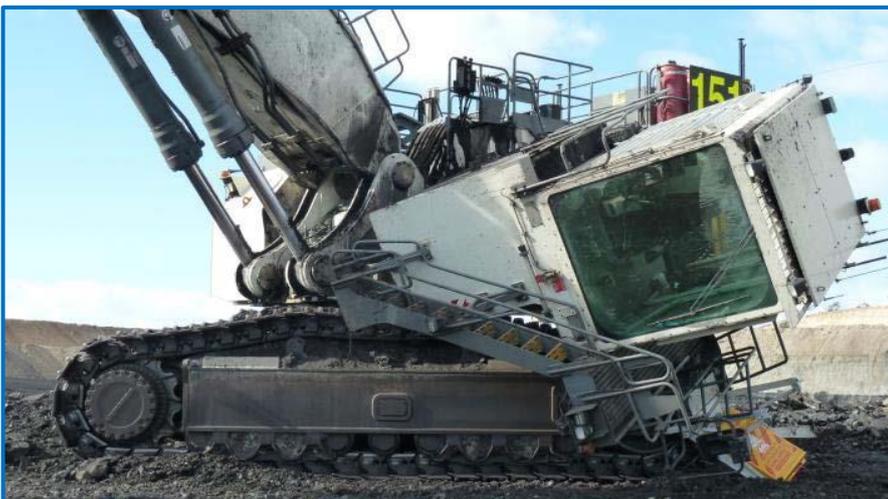
Excavator cabin detaches and falls

- **Incident date:** 10 October 2016
- **Event:** dangerous incident
- **Location:** Mangoola Mine, Wybong, Hunter Valley NSW

Overview

- While the operator of a 250 tonne Liebherr R9250 excavator (excavator) was inside, the cabin of the excavator dislodged and fell off the side of the machine. The incident occurred at 8.45 pm on 10 October 2016 during normal coaling operations.
- The mine's emergency rescue team was required to provide a safe means of egress for the operator out of the excavator cabin. The operator has since not been able to return to work.
- Before the incident, four of the six structural bolts securing the cabin had broken. The mine had carried out temporary repairs.
- The NSW Resources Regulator is undertaking further investigation. The integrity of structural components on plant and machinery (including structures) is paramount for the safety of people on the plant or in the vicinity of the plant.

Figure 1: Cab and riser of the excavator separated from the chassis. Photo supplied by the mine.



The mine

Mangoola open cut mine is owned and operated by Mangoola Coal Operations. It is near Wybong, NSW, about 20 km west of Muswellbrook in the Hunter Valley.

Mining is carried out using truck and shovel methods to handle overburden and coal, with a run of mine (ROM) coal extraction rate of 13.5 Mt annually. The mine operates 24 hours a day, seven days a week. It has about 450 employees, according to the [mine's website](#).

The incident site

The incident occurred in the south pit coaling area of Mangoola open cut coal mine on 10 October 2016 at 8.45 pm. The incident occurred while the excavator was mining coal.

Figure 2: The incident site.

Figure 3: Operator's cabin on the excavator tracks, indicating failed horizontal bolts and interim weld repair.



The injured worker

The excavator operator involved in the incident was an experienced machine operator. He had been employed at Mangoola open cut mine for over six years.

As a result of the incident, the operator has still not returned to work.

The incident

The operator was carrying out regular coal mining activities on the evening of 10 October 2016. It was a clear night with no rain or fog. The working area was well lit by mobile lighting towers.

The operator mined one pass of the bench and finished loading the last truck. He then walked the excavator back to the start of the dig, swung the excavator around to put the bucket on the ground, then pushed the bucket into the ground and picked up the tracks to turn the tracks in the direction he wanted to go (to turn the excavator around). As the tracks came around and down, the excavator's cabin kept turning. The operator thought he was on a small lip or a lean. However, the operator's cabin dislodged and fell down onto the excavator's tracks, stopping at an angle. This damaged the hydraulic hoses and electrical harnesses and caused structural damage to the cab riser mounting. Refer to figure 3. Had the cabin not come to rest on the tracks, the cabin and operator may have fallen further, potentially to the coal seam floor.

The operator heard what he thought was fluid running (possibly hydraulic oil) out of the excavator so he grabbed the two-way radio and made an emergency call for help. The dozer operator needed to push a track

towards the excavator so the water cart and light vehicles could access the excavator. During this time, the operator sat in the excavator's dickie seat, believing this was the safest place to be seated.

After a track was made, a ute with a platform fitted to it was backed up to the excavator and the operator was able to egress from the cabin safely. The operator indicated he was in the cabin for approximately 15 minutes.

The investigation

A mine safety inspector responded to the incident and undertook a range of enquiries.

The mine prepared an incident investigation report on the 'cab and riser of Liebherr R9250 separated from chassis'. This report identified several attempts to repair broken bolts on the excavator cabin between 13 May 2016 and 1 August 2016. Ultimately, the bolts failed on 10 October 2016.

The NSW Resources Regulator is undertaking further investigation.

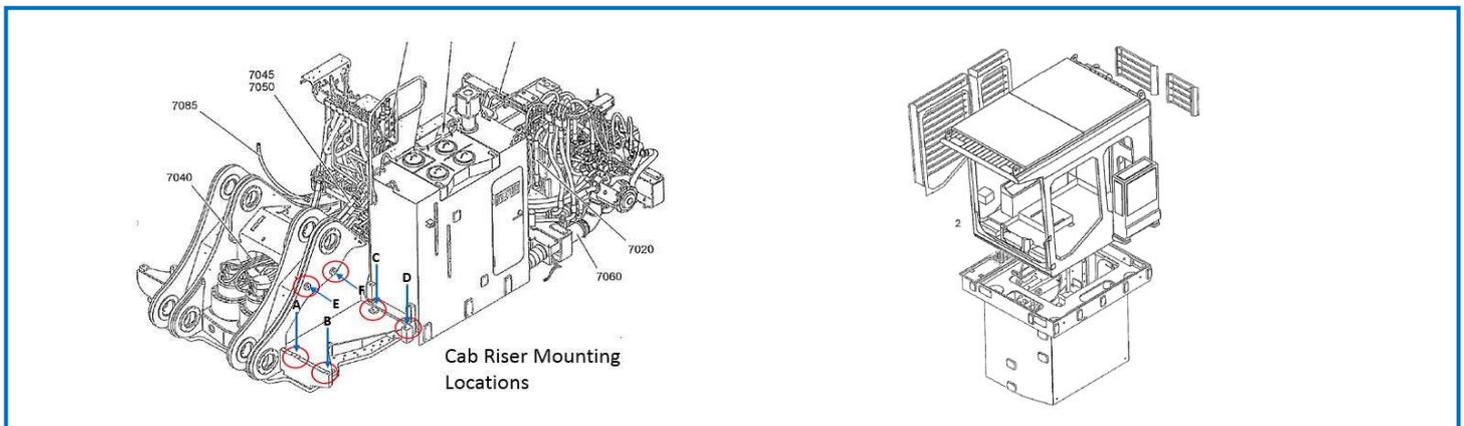
Cabin mounting

The operator's cabin is on the front left-hand side of the excavator and sits on top of a riser that is joined to the chassis (see figure 4). An escape chute had been fitted to the outside of the driver cabin and towards the rear.

The cabin was supported by four rubber mounts that were secured to a cab 'riser'. The combined cab and riser weigh approximately nine tonnes and is held in place by six bolts.

Of those six bolts, four were installed vertically through the floor of the riser (A, B, C and D) and two were installed in a horizontal orientation through the side wall of the riser (E and F). The bolts were installed from the inside of the riser to a threaded bore in the chassis. The bolts were specified as 30 mm in diameter, 300 mm in length and property class 10.9.

Figure 4: Cabin riser mounting locations



Circumstances leading up to the incident

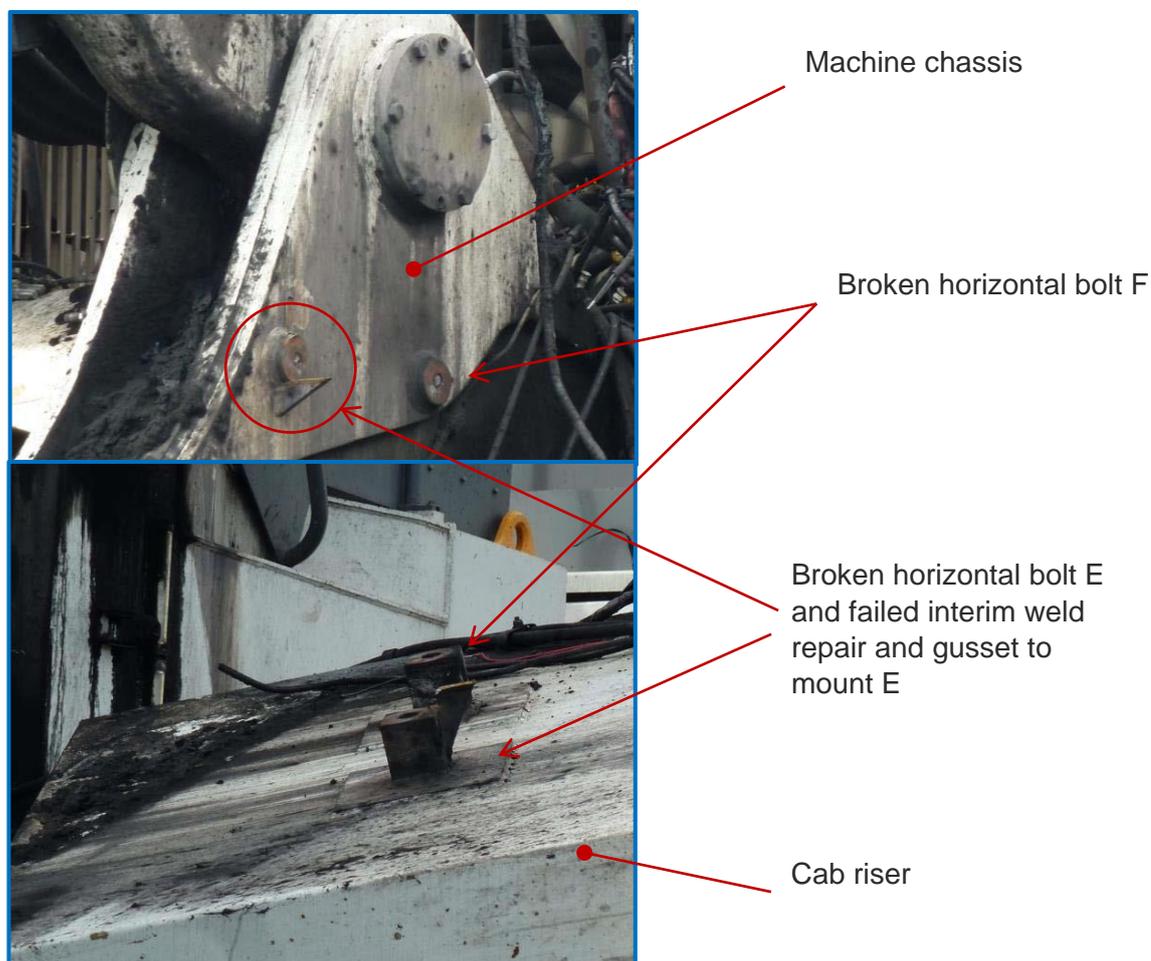
The following sequence of events took place between the 13 May 2016 and 10 October 2016. It resulted in the continued operation of the excavator with four broken bolts, an interim weld repair to replace those broken bolts, two intact bolts and visual inspections of the weld for cracks each shift.

- 13 May 2016: two broken bolts were found by a mechanical tradesperson (bolts A and E on figure 4). A maintenance order was raised and the excavator returned to operation.

- 21 June 2016: an attempt was made to replace those two bolts. The bolts could not be extracted and remained in the bore. The attempt was unsuccessful and the excavator was returned to operation.
- 7 July 2016: a second attempt was made to replace the two broken bolts. This was unsuccessful and the excavator was returned to operation.
- 10 August 2016: a third broken bolt was found (bolt B on figure 4). Interim weld repairs were carried out following an informal assessment. The weld repairs welding the cab riser to the machine chassis at mounts A, B and E. Visual inspections were implemented and the excavator was returned to operation on 11 August 2016.
- 12 August 2016: a fourth broken bolt was found (bolt C on figure 4).
- 13 August 2016: further reinforcement (which included an additional gusset plate to mount E) was carried out to the interim weld repairs, along with more visual inspections. The excavator was returned to operation with the cabin being secured by vertical bolt D and horizontal bolt F (refer to figure 4) as well as an interim weld repair.
- 10 October 2016: the cabin dislodged and fell off, meaning the remaining bolts and interim weld repair had failed.

The excavator had over 30,000 hours of operation. The excavator had a scheduled shutdown planned in November 2016. The mine operator believed that the shutdown was an appropriate time for maintenance and repairs to be made on it. The necessary repairs were estimated to take three to five days.

Figure 5: Failed horizontal bolts and weld repairs between machine chassis and cab riser.



Analysis of broken bolts and welds

Following the incident, a consultant metallurgist was engaged by the mine. The metallurgist was required to carry out an investigation to determine the mode and cause of failure of the remaining two bolts.

Non-destructive testing was conducted on the cab riser that indicated the presence of cracking at a number of locations. These included:

- inboard rear side
- inboard rear bolt mount – within welds
- outboard rear horizontal bolt mount – within welds around the bolt mount to plate and plate to riser on the top and rear sides
- outboard front horizontal bolt mount – within welds around the bolt mount to plate and plate to riser on the top and front sides
- inboard front horizontal bolt mount – within welds around the bolt mount on the top and front sides
- inboard rear horizontal bolt mount – within welds around the bolt mount on the top and rear sides.

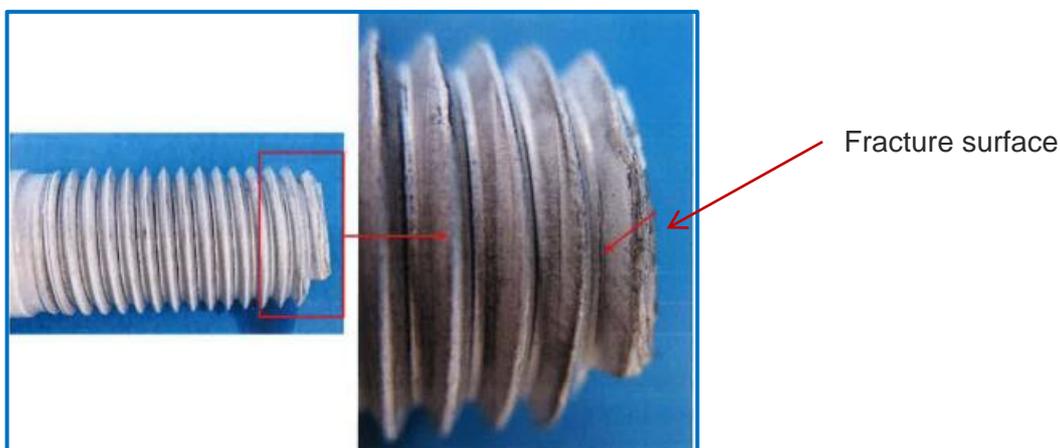
The two remaining bolts were found to have failed at the first engaged thread. This thread would have experienced the highest load.

The overall finding of the metallurgical analysis was that failure of the bolts used to join the cab and riser to the excavator chassis was attributable to a fatigue-related fracture of the front vertically installed bolt, resulting in loss of pre-load.

Figure 6: Two broken bolts found at incident scene.



Figure 7: Floor bolt showing cracking within thread root.



Initial findings of investigation

Initial findings of the investigation include:

- Management of the two defective bolts identified on 10 May was seen as routine maintenance decision. As such the original equipment manufacturer (OEM) was not involved, there was no qualified professional engineer to assess the situation and the statutory mechanical engineer was not involved. Replacement of the two broken bolts was tagged as P3 'medium' priority, allowing the excavator to return to operation with two out of six bolts which secured the operator's cabin to the excavator broken.
- The OEM was not involved with the two unsuccessful attempts to replace the broken bolts as it was considered as a routine task by the mine.
- The excavator had a scheduled shutdown planned in November and the shutdown was seen as an appropriate and opportune maintenance window for the repairs to be carried out, following the second failed attempt to replace the two broken bolts.
- The assessment of the third broken bolt was carried out by a team consisting of qualified tradespeople. The team carried out an informal assessment that was not documented. A visual inspection was carried out to determine the cause of third broken bolt. The team identified an interim repair, however, no documented calculations or engineering analysis was carried out on the interim repair. Neither the OEM nor the statutory mechanical engineer was involved with the assessment and interim repair and the excavator was put back to operation with three out of six bolts broken.
- The assessment of the fourth broken bolt was carried out by a team consisting of qualified tradespeople. Neither the OEM, the statutory mechanical engineer, or a qualified professional engineer were involved with the assessment. The team determined additional gussets to the front horizontal mount would provide additional weld length and strength across the joint to provide reinforcement before a full repair to the cab riser mounts during the scheduled November shutdown. The group formed the view that addition crib break inspections would detect any compromise to the interim repair. No documentation, calculation or engineering analysis was carried out. The excavator was put back into operation with four out of six bolts broken and with a temporary repair that had not undergone any engineering analysis as to its adequacy.
- There is little documentation between the mine and the OEM.
- Following the incident, the mine conducted an incident cause analysis method (ICAM) investigation, however, the ICAM
 - did not involve the OEM
 - did not involve a qualified professional engineer who was competent with structural components
 - did not include the metallurgical report on the failures or metallurgist who wrote the report. There are differences in events between both reports.
 - indicates people were interviewed, however, interviews were actual witness statements and not all of those statements were available to all ICAM team members. Some pertinent maintenance people weren't interviewed.
 - some ICAM team members did not agree with the risk rating findings of the report. They felt **the potential consequence was higher than 'moderate'**.
 - scores potential consequence as a 'moderate risk that requires improvement'. However, there was potential for fatal injuries as the operator was without safe egress for a period of time, with leaking fluids, and the cabin may have fallen further to the coal seam floor or impacted in a different manner.

Safety observations

The integrity of structural components on plant and machinery (including structures) is paramount for the safety of people on the plant or in the vicinity of the plant.

Mine operators must ensure, so far as is reasonably practicable, the provision and maintenance of safe plant and structures.

Where OEMs have designed connections that use bolts of grade 8.8 or above, they should be considered as a structural connection. This is unless the OEM or a qualified professional engineer has stated otherwise.

The statutory mechanical engineer has a statutory function to supervise the installation, commissioning, maintenance and repair of mechanical plant at the mine. As such the statutory mechanical engineer must be involved with any repair to the plant's structural components.

Mine operators must develop a mechanical engineering control plan that must set out control measures for risks to health and safety associated with mechanical aspects of plant and structures at the mine. Among other things, this includes provisions for the catastrophic failure of plant or structures.

Catastrophic failures of plant or structures have typically been associated with factors such as:

- inadequate understanding or analysis of the loads
- manufacturing or installation faults
- inadequate periodic inspection systems
- overload
- using plant or structures for something other than its intended purpose
- physical damage
- degradation from corrosion or fatigue.

When developing control measures, the mechanical engineering control plan must take into account the identification, assessment, management and rectification of defects that affect the safety of plant or structures. Mine operators must consider how safety defects will be identified, assessed, managed and rectified on plant and structures. This system should be documented and should incorporate:

- a means to document how the defect was found and the details of the defect
- a means to prevent the use of mechanical plant or structures until a defect has been assessed by a person with appropriate mechanical competence, for example, the use of 'danger' or 'out of service' tags
- recording action taken to remedy or control the defect, for example, a logbook or defect system
- a competent person reviewing the plant or structure and verifying it is safe to use
- if possible, eliminate the defect from occurring again.

The in-service failure of any structural connection must be identified as a defect and must be assessed by people with appropriate professional engineering competence, or the OEM.

Plant with structural defects should be stopped and not used until such time as the plant has been assessed and signed off as being safe to use by either:

- a professional structural or mechanical engineer, or
- the OEM, or
- in the absence of one of the above, a person with appropriate engineering competence.

In assessing structural failures consideration should be given to:

- appropriate inspection, tests, engineering analysis and assessment of the failed component
- the cause of the structural failure
- the potential for further degradation of the components
- calculations on expected failure propagation rates
- the effectiveness of any interim repairs
- the effectiveness of ongoing monitoring
- the use of non-destructive test methods
- not using the plant and carrying out a permanent fix on the defect.

Mine operators must be mindful of any warning of regressive structural failures, such as what occurred in this incident. The progressive failure of two, three and four structural bolts indicated there was a significant defect that needed to be fixed. In this instance, the plant needed to be taken out of operation.

Where interim structural repairs are carried out, then those repairs should be designed, detailed and checked by a professional engineer or the OEM. Those designs, including calculations and analysis, should be documented. The interim repairs must have sufficient strength to hold the loads imposed upon them for the expected duty.

The monitoring for degradation of defects should also be documented.

Structural connections should be preloaded. Ongoing maintenance may need to periodically check preloads in order to prevent mechanical looseness.

Incident investigations on structural failures should include the people with appropriate professional engineering competence and the OEM.

Further guidance

For further guidance, refer to the [NSW code of practice for mechanical engineering control plans](#).

About this information release

The Resources Regulator has issued this information to draw attention to the occurrence of a dangerous incident in the mining industry. Investigations are ongoing and further information may be published as it becomes available.

The information contained in this publication is based on knowledge and understanding at the time of writing. However, because of advances in knowledge, users are reminded of the need to ensure that the information upon which they rely is up to date and to check the currency of the information with the appropriate officer of the Department of Planning and Environment or the user's independent adviser. All photographs were taken by the Resources Regulator, unless otherwise attributed.

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