Safety Bulletin

Date: April 2024

LHD crowd cylinder failures - potential worker injuries

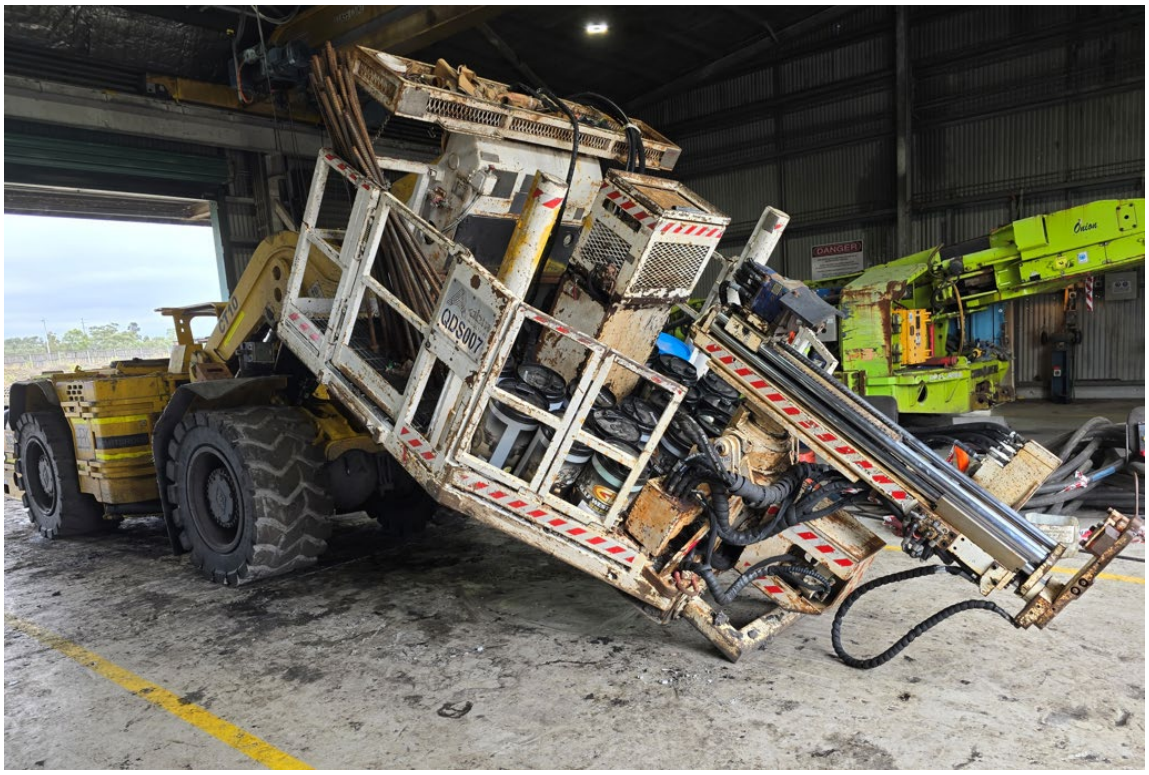
This safety bulletin provides safety advice for the NSW mining industry.

Issue

In the past 9 months, there have been 5 significant incidents involving the hydraulic crowd cylinders on load haul dump (LHD) machines in underground coal mines. Four of these incidents have occurred in the past 4 months.

The crowd cylinder forms the top mount supporting the attachment plate. LHDs in the underground coal industry are widely used as utility vehicles, coupling to a variety of implements including some where people are elevated (such as work baskets and drill rigs). Overloading or failure of the crowd cylinder can cause the implement to drop and rotate about the lower load arm pivot joint. Any people in the machine, or in close proximity on the ground, are placed at immediate risk of serious injury or worse.

Figure 1: LHD with drill rig attachment during simulation testing after crowd cylinder failure



Circumstances

Incident 1 – 31 July 2023 (IncNot0045155)

A Coaltram CT08 LHD had a Roberts jib attachment to raise a bolting supplies cassette. As the operator raised the bolting cassette from the ground, there was a loud bang, and the cassette, jib, and LHD attachment plate dropped about 300 mm to the ground. No one was in the immediate vicinity of the pod at the time of incident. On closer inspection, it was found that the front crowd cylinder clevis had separated from the cylinder rod end.

Figure 2: Coaltram CT08 crowd cylinder clevis failure

The LHD was removed from service and the crowd cylinder sent to the original equipment manufacturer (OEM) to be stripped, measured and investigated. The OEM determined the clevis:

- threaded bore was out of round (oval) by 0.58 mm.
- was damaged, causing the clamp gap to spread
- had worked its way off the rod over time until it separated suddenly under load.

Actions taken:

- The attachment design was reviewed to prevent reoccurrence:
  - The clamp procedure was developed to reduce potential for the clamp joint fasteners from becoming loose.
  - The clamp bolt length is to be checked on assembly to ensure that the bolts do not bottom out on the bolt shank.
  - Consideration was given to shimming clevis clamp so bolts can pull up tight on closed joints.
- A routine inspection service sheet was developed.
  - Workers should inspect that clamp bolts are in place and secure.
  - Workers should inspect for any gaps between the rod and clevis.

Incident 2 – 6 January 2024 (IncNot0046121)

A worker was hanging mesh from a hydraulic strata support bolting rig basket attachment for the majority of the shift. The worker asked the LHD operator to tilt the basket up to gain better access for meshing. The LHD operator activated the tilt up lever, but the bolter basket tilted forward towards the ground from a height of about 1.5 m.

Figure 3: The bolter basket rotated forward with a worker onboard when controls were activated

Actions taken:

- The hire CT10LP LHD was brought to the surface and hydraulic pressures tested with the OEM.
- The crowd cylinder was removed, stripped and inspected. It was determined the piston had been machined for an alternative seal. On disassembly, the seal back-up rings were found to have markings of damage that may have affected the seal.
- The crowd cylinder was replaced, retested and the LHD was returned to service.
- A maintenance program work order was created to replace crowd cylinders annually.

Incident 3 – 22 February 2024 (IncNot0046389)

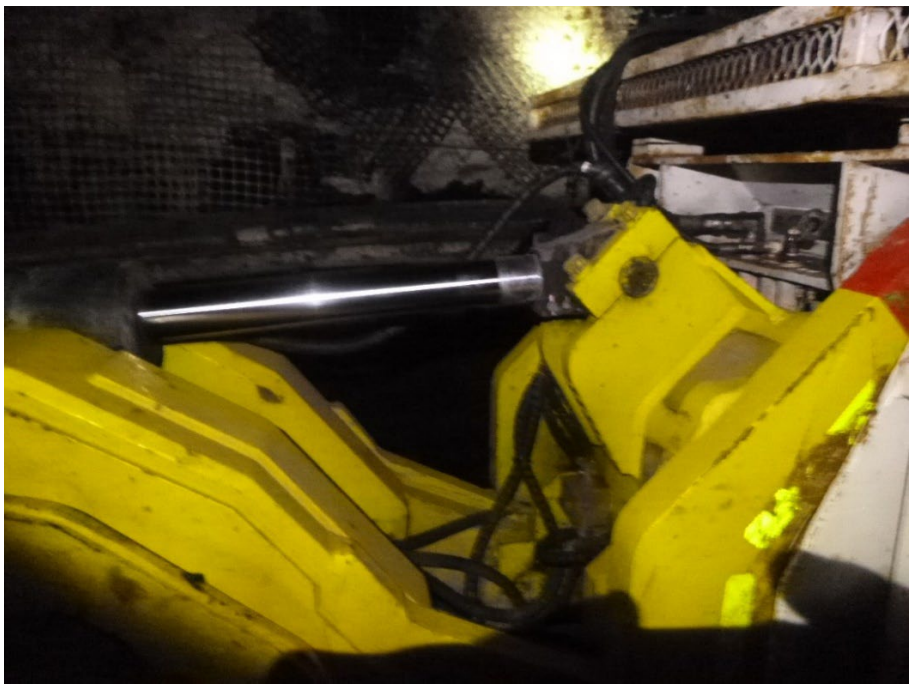
This incident reoccurred after the same equipment was returned to service.

A worker was in the bolting rig basket fitted to the same Coaltram CT10LP LHD in incident 2, installing poly pipe over structure bolts. The basket was fully raised when the basket rolled forward unexpectedly. The worker was thrown against the basket control panel but was not injured. The operator lowered the basket to the floor to check on the worker, and the scene was preserved. A prohibition notice was placed on use of the CT10LP for lifting workers.

The mine and OEM investigated the incident and determined the following:

- The bolting rig basket was about 400 kg heavier than the nameplate requirement and the centre of the mass was unknown.
- The hydraulic pressure relief (rapid yield valve) setting was unable to hold the basket level across the full range of movement of the implement.

Figure 4: The bolter basket fitted to the CT10 rotated forward unexpectedly. The worker in the basket was not injured



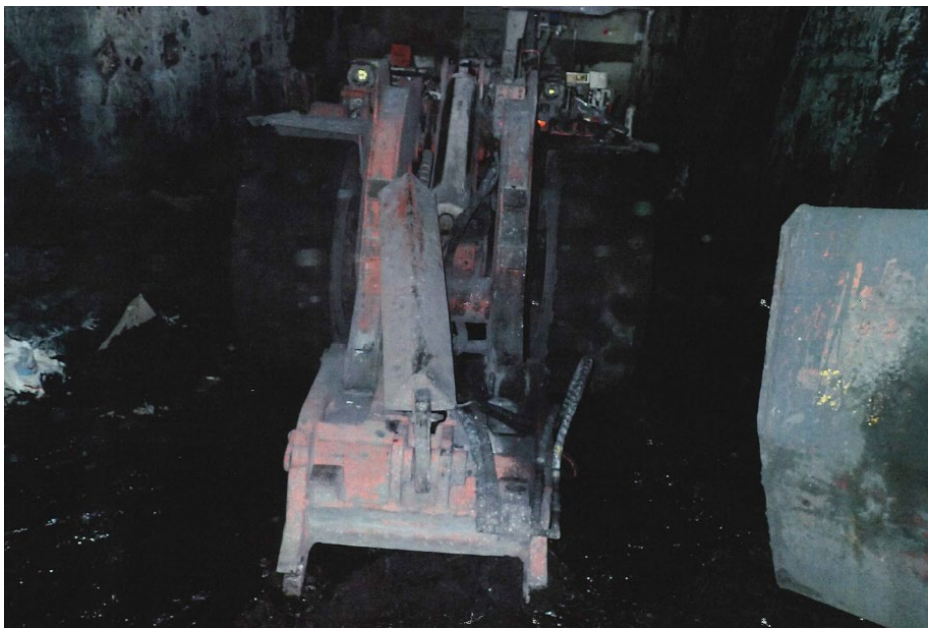
Even if the rapid yield valve was set correctly, the additional mass of the bolting rig basket along with its unknown centre of gravity were outside the operating capabilities of the Coaltram CT10LP and it would not have held the basket level over the full range of movement.

Note: The CT10 (not CT10LP) had a low flow hydraulic function that should be used to provide fine control of the crowd function when using work platforms.

Incident 4 – 5 March 2024 (IncNot0046476)

A Sandvik ED10 LHD fitted with a bucket attachment had unloaded stowage material in a cut through when the crowd cylinder failed at the connection between the clevis and cylinder rod. The bucket fell to the ground as the operator was lowering the bucket.

Figure 5: The ED10 with bucket attachment suffered failed welds on rod end clevis



The welds between the crowd cylinder clevis at the attachment plate and the rod end of the crowd cylinder failed. The mine prohibited the use of work baskets and jibs and conducted NDT inspections on the remaining LHD fleet crowd cylinders.

The OEM was notified of the incident and requested to participate in a root cause analysis (RCA), and the crowd cylinder was replaced.

Figures 6 and 7: The ED10 attachment plate crowd cylinder clevis and crowd cylinder rod failed welds

The welds between the clevis and the rod end appeared to lack fusion. Fatigue and corrosion contributed to the failure.

Incident 5 – 26 March 2024 (IncNot0046606)

An ED7 LHD with a duck-bill attachment was carrying 2 bundles of link n lock timber and stopping material. The crowd cylinder piston rod broke at the piston-end inside cylinder. All crowd cylinders on these LHDs were overhauled or replaced within the previous 3 years. A leaking crowd cylinder was reported at the mine on an ED7 in recent reports.

The mine operator contacted the equipment owner and advised its workforce that neither work baskets nor bolting rig baskets were to be used on the ED7 fleet until crowd cylinders were verified as replaced.

Cyclic fatigue initiated from the rod-end machining transition to the threaded section used to secure the piston to the rod.

Figure 8: ED7 with duck-bill attachment suffered piston rod end fatigue failure

Analysis of incidents

Different LHD OEMs were represented in the failure of crowd cylinders.

Investigation of each incident identified a variety of failure modes, including:

- detachment or failure of the rod end clevis
- failure of the cylinder rod piston end
- hydraulic overload of cylinder

All the incidents involved the attachment falling to the ground or rotating of the attached load to the lowest extent. This included 2 instances where workers were in the attached drill rig basket.

Contributing factors included:

- LHDs were used to carry and position work baskets and drill rig baskets for workers.
- The crowd cylinder held the suspended load and was a single line failure component with no redundancy.
- The inadequate capacity of the LHD to hold a suspended load across the full range of implement motion was not known by the OEM.
- Information of limitations of the LHDs were not determined or provided to the user.
- The selected components in the crowd cylinder system were inadequate.
- The rod attachment to rod clevis design for machined, welded, bolted or clamped connections provided failure mechanisms for the crowd cylinder carrying a suspended load.

- Heavy duty ground loading and fines build-up adjacent to the crowd jack subjected rods, barrels, pins and joints to fatigue, corrosion and overload.

Recommendations

OEMs and suppliers of LHDs should:

- identify and assess all failure modes related to crowd cylinders. Provide rated operating capacity of the LHD for stability at pay load capacity (for example AS 14397.1) including static tipping loads
- provide dimensional and mass information to allow mine operators to apply the information when assessing an LHD/implement combination is fit-for-purpose
- clearly identify the centre of gravity of the maximum lift capacity nominated for their LHD, and identify the load capacity derating when the centre of gravity is moved higher or further forward of the attachment face
- identify any design or operational limits to the lift capacity or lift envelope due to LHD functionality, including hydraulic capacity, or machine stability
- identify any specific hydraulic control requirements for the safe operation of the LHD when fitted with attachments that can be occupied by workers
- identify any component that limits machine capacity rating over the full operational movement envelope of the LHD, such as fatigue factor of safety of clevis pins
- identify all conditions required for safe use of the LHD over the full operating envelope
- consider forged clevis construction for loader crowd cylinder applications
- consider redundancy for the crowd cylinder.

OEMs and suppliers of implements to be attached to LHDs must provide any information necessary to ensure that the LHD can be used without risks to safety when implements are attached as designed, including accurate mass and centre of mass.

Mine operators should:

- identify the actual mass and centre of gravity of attachments for LHDs, especially attachments that can be occupied by workers
- ensure the implement parameters match the LHD capabilities provided by the OEM across the full range of movement
- identify suitable controls and verifications required to mitigate risks to as low as reasonably practical and ensure all personnel are trained and competent in the work to be performed.

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