NSW DEPARTMENT OF
PRIMARY INDUSTRIES

SAFETY ALERT

Braking standards for trucks may not be fit for purpose

INCIDENT

A truck driver was fatally injured at a quarry when the truck he was driving failed to negotiate a corner and rolled down an embankment.

CIRCUMSTANCES

The truck was loaded and descending the haul road when the incident occurred. The haul road was an average slope of 21% (1:4.7) with peaks at almost 25% (1:4).

This Safety Alert is a follow-up to SA05-10 Fatal Truck Accident at Quarry.

INVESTIGATION

The investigation found that compliance with recognised braking standards does **not** automatically mean the truck is safe to operate on all grades of a mining operation.

The following recognised standards appear to be fit for purpose on grades of up to 10% (1:10) only.

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Mine Safety Report No: SA06-13
File No: 06/3598
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Date Created:14 June 2006

- *AS 2958.1:1995 Earth-moving machinery – Safety, Part 1: Wheeled machines – Brakes*
- *ISO 3450:1996 Earth-moving machinery – Braking systems of rubber-tyred machines – Systems and performance requirements and test procedures*
- *SAEJ1473 Brake performance – Rubber-tyred earthmoving machines*

Note: Compliance with these standards does not automatically mean compliance with the NSW Occupational Health and Safety Act 2000 or Duty of Care

Section 8(1) (b) of the *NSW Occupational Health and Safety Act 2000* states:

(1) Employees

An employer must ensure the health, safety and welfare at work of all the employees of the employer

That duty extends (without limitation) to the following:

(b) Ensuring that any plant or substance provided for use by the employees at work is safe and without risks to health when properly used.

Some problems which the investigation identified with the above standards include:

1. The formulae for stopping distances for *rigid-framed and articulated steer dumpers with gross mass over 32,000kg* is not clearly defined in the standards. The calculations for stopping distances only allow for testing on slopes from 8% (1:12) to 10% (1:10) (which is common industry practice for mining industry haul roads). The standards do not adequately address the use of machines on inclines greater than this. A rollaway condition could occur at grades in the order of 13.5% (1:7.4) for secondary (emergency) brake performance, if the truck's braking system was designed to the minimum requirements of the standards.
2. The formula for stopping distances for lighter trucks does not adequately address the issue of travelling on grades. A rollaway condition could occur at grades in the order of 11.5% (1:8.7) for secondary brake performance, if the truck's braking system was designed to the minimum requirements of the standards.
3. Criteria for stored energy (pressurised) braking systems may allow reservoirs of insufficient capacity to be utilised upon failure of a single component in the braking system.
4. Independence of service and secondary braking systems, particularly pressurised brakes, may not be adequately achieved.
5. Issues with alarm levels and automatic application of brakes for pressurised systems.

RECOMMENDATIONS

To meet occupational health and safety obligations it is expected that all mobile equipment can ascend, descend, stop and hold stationary on all grades on which they traverse with consideration to:

- The gross vehicle mass (GVM).
- The operating environment.
- The failure modes of the truck.

As a minimum, brakes should be designed and tested in accordance with the recognised standards. Where equipment is required to operate on grades steeper than 10% the following additional criteria should be considered:

1. The '*service braking system'* is able to stop and hold the mobile equipment stationary, on the grade being traversed, in the shortest practicable time upon failure of the retarder. This should be achieved with:
    - A net deceleration of not less than 0.6 m/s^2 (6%g) for stopping on the decline. For example, to traverse a 20% (1:5) grade the service brakes need to be capable of sustaining an average deceleration of approximately 2.6 m/s^2 (26%g) over the stopping period (2.0 m/s^2 to overcome grade gravitational energy and 0.6 m/s^2 for net deceleration).
    - An average deceleration of no less than 1.85 m/s^2 (18.5%g) for overall service brake performance.
2. The '*secondary braking system*' is able to stop and hold the mobile equipment stationary, on the grade being traversed, in the shortest practicable time upon failure of the retarder or failure of any component of the service braking system. This should be achieved with:
    - A net deceleration of not less than 0.3 m/s^2 (3%g) for stopping, on the decline being traversed.

      For example, to traverse a 20% grade means the secondary brakes need to be capable of sustaining an average deceleration of approximately 2.3 m/s^2 over the stopping period. (2.0 m/s^2 to overcome grade gravitational energy and 0.3 m/s^2 for net deceleration).
    - An average deceleration of no less than 1.3 m/s^2 (13%g) for overall secondary brake performance.
3. Brake testing and analysis should simultaneously consider maximum loads, speed and grades; energy absorption requirements; heat fade for the grades being traversed; simulated component failure and low system pressures.
4. For pressurised systems, the secondary brake performance should also be able to be achieved after the following event occurs simultaneously:
    - A failure of a single common component of the braking system, and
    - Following five applications of the operator's treadle (foot) valve, and
    - The system pressure reaches the operator's alarm level.
5. At the point of or following automatic application of the brakes the mobile equipment is still able to stop and hold on the grade being traversed.
6. The integrity of the braking systems be assessed against AS 4024 or AS/ISO 62061 or AS/ISO 61508 or other equivalent standards and failure modes and effects analysis (FMEA) or other similar risk assessment techniques.

   Note: Guidance is provided in MDG 1010 or Minerals Industry Safety and Health risk Assessment Guideline for FMEA analysis.

Typical mobile equipment



All mobile equipment designers, manufacturers and suppliers should review designs and documentation to ensure:

1. Equipment is safe to operate and is capable of ascending, descending, stopping and holding on all specified operating grades, loads and environments.
2. The above criteria are met for the specified operating conditions and appropriate testing carried out to confirm compliance.
3. Appropriate information is provided to mines stating the safe operating loads and grades for their equipment (refer MDG 15 Clause 2.7).

All mines should immediately:

1. Review their site haulage routes and identify all trucks travelling on grades in excess of 10%.
2. Where mobile equipment is operating on grades steeper than 10%, they should contact the equipment manufacturer and have them confirm in writing that the above criteria is met and the mobile equipment is safe to use on the specified grade under the specified conditions.
3. Educate operators:
    - That these grades are maximums, and in no way take into account variations in ground or haul road conditions that can affect travel speeds. Other factors such as visibility, traffic and weather may need to be considered.
    - Of the correct gear, speed and use of retard to descend a grade.
4. Where information is not forthcoming by the equipment manufacturer then the mine should carry out their own examinations and tests to ensure the above criteria is met and the mobile equipment is safe to use on the specified grade.
5. Design haulage roads to grades of 10% or less wherever practicable.
6. Carry out periodic testing to confirm the in-service brake performance.

    Note: Any testing by mines should be under the direct supervision of a competent and qualified mechanical engineer and/or the equipment manufacturer's representative.

This Safety Alert should be read in conjunction with the following Safety Alerts:

- *SA05-10 Fatal Truck Accident at Quarry*
- *SA06-12 Maintenance of Safety Critical Systems*

NOTE: Please ensure all relevant people in your organisation receive a copy of this Safety Alert, and are informed of its content and recommendations.

Signed

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