Spinal Damage - A Study of Permanent and Temporary Injuries

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Summary

A taxonomy of spinal injuries to mobile plant operators at a large open pit coal mine has been performed to understand the damaging energies at work. This has identified a common set of damaging energies and identified some strategic areas for risk reduction. Some work processes were identified that resulted in permanent and temporary damage. These results are now being confirmed with incident debriefs with plant operators. This will lead to a major intervention program aimed at eliminating or minimising the conditions which result in permanent spinal injury

Introduction

Coal & Allied Operations Hunter Valley No 1 has commenced a project to identify the causes of, and develop strategies to prevent spinal damage to mobile plant operators. The study has a focus on the events leading to permanent back damage.

The study is being assisted with funding from the ACARP program. The project is still in its early stages. This paper outlines the background to the program and the initial studies conducted.

Background to Hunter Valley No 1 Operations

Hunter Valley No 1, operating in the Hunter Valley coalfields, is a large open cut black coal mine, incorporating 2 open pit operations, mine maintenance, coal preparation and stockpiling facilities. A total of 580 employees are employed on site. The site produced 5.5MT of saleable coal in 1994.

The open pit mines are worked by shovels and loaders with rear tip truck haulage. The fleet is characterised by large equipment, with 3 rope shovels ($27m^3$ to $44m^3$), 6 front end loaders (leTourneau L1400 and L1100) and 45 rear tip trucks (ranging from 85 to 218 mt). A large fleet of ancillary equipment maintains the roads and prepares broken rock and coal.

Three hundred and thirty employees work in the two open pit mines, with 24 hour mining operations. The employment profile is characterised by low employee turnover, so that the operators are generally experienced and the average age is now 41 (see Figures 1 and 2)

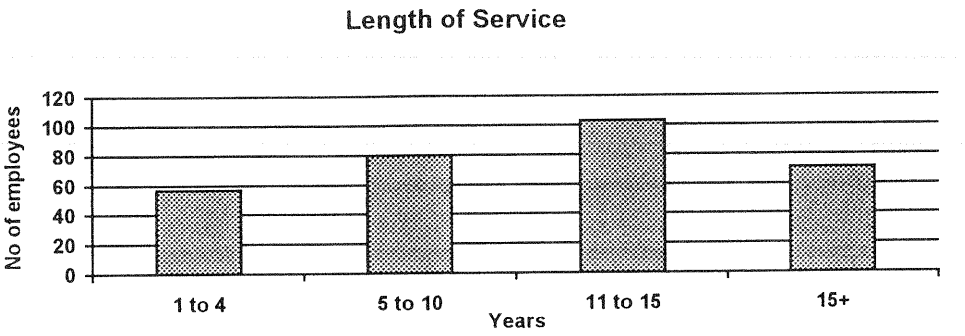

Figure 1 Length of service for Hunter Valley No 1 mining employees

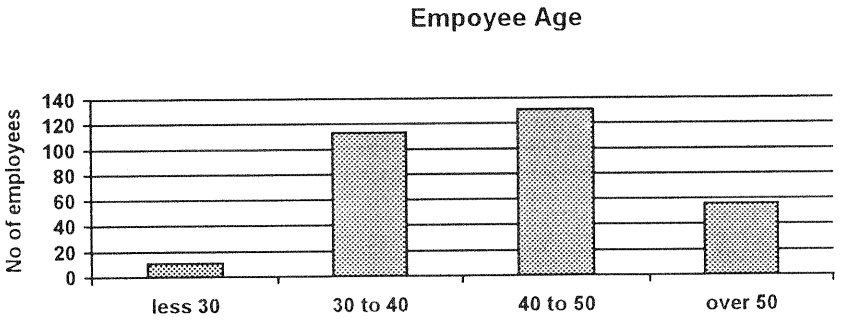

Figure 2 Hunter Valley No 1 mining employee age

Spinal Damage

Spinal Damage to mobile plant operators has been recognised for some time as a major source of injury in open cut coal mining. The injuries range from temporary and minor, to permanent and debilitating. A study by VIOSH on OH&S performance in the Australian Coal Industry (Mitchell and Larsson, 1994) identified that back injuries constitute 35% of compensation claims for surface excavation workers. The study reported six mechanisms which had greater than average relative severity for surface excavation workers. These were vehicle jarring, vehicle vibration, bumped stationary object, fall from height, vehicle accident and overexertion - push/pull.

This pattern is the rule at Hunter Valley No 1, where spinal injuries account for 40% of the total injuries in the mining operations. They also account for 44% of the lost time injuries. It is recognised that at Hunter Valley No 1, spinal injuries represent a major barrier to improving safety performance.

Previous Intervention Strategies

Previous intervention strategies have focused on improving one component of the equation. Typically roads, seating, cab mounts and blast fragmentation have been addressed..

The effects of whole body vibration on operators was studied in 1994. Whole body vibration in the critical 3 to 8 Hz range has been linked to driver fatigue and spinal injury. A snap shot of the whole body vibration characteristics of the haulage fleet was achieved through a vibration study. A typical test result for a large haulage truck (Dresser 830E) is shown in Table 1.

FDP Limits in hours AS2670.1-1990	Heavy Operator Smooth terrain	Heavy Operator Rough terrain	Light Operator Smooth terrain	Light Operator Rough terrain
Cab Floor Vertical	12	10	3	6
Drivers Seat Vertical	18	16	15	13
Drivers Seat Side to Side	18	8	5	24
Drivers Seat Fore Aft	>24	>24	16	22

Table 1 Fatigue decreased proficiency limits, Dresser 830e haul truck

This demonstrated that the truck suspension and seating was positively damping the whole body vibration. The FDP limits were acceptable in our shift arrangements. However the testing to AS2670 did not account for the shock loading events. Further study is necessary to understand the critical relationships between whole body vibration and the jarring occurring at loading, spotting and dumping.

A Multifactorial Approach

The previous intervention strategies based on improving one factor have not yielded sustainable results. The thrust of this project is to adopt a multifactorial approach. A simple mental model of the injury causation factors is shown in Figure 3.

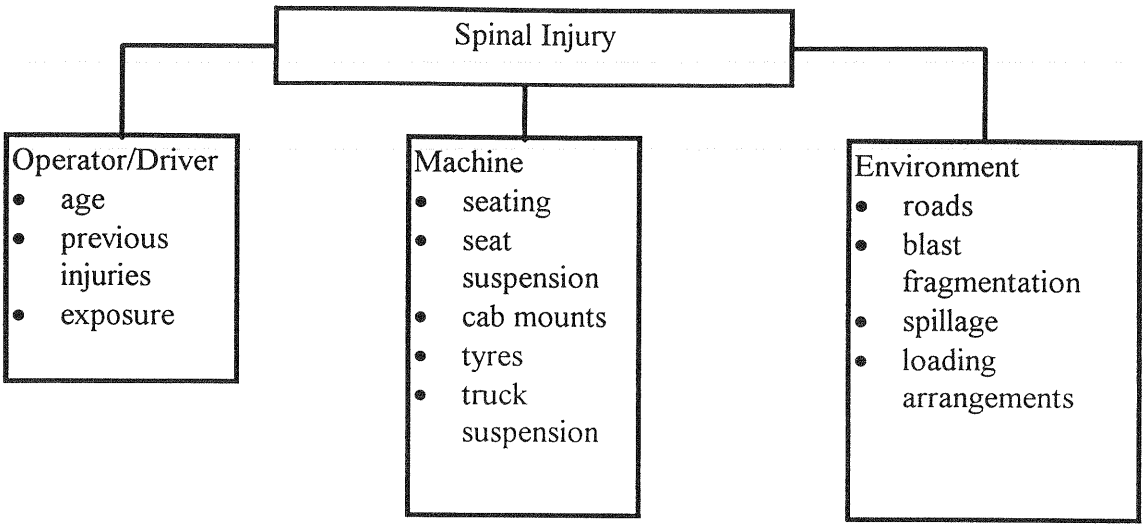

Figure 3 The ergonomic model applied to the loading/hauling process

Taxonomy of Hunter Valley No1 Injuries

To understand some suitable starting strategies, a taxonomy was conducted of the spinal injuries recorded at Hunter Valley No 1. Good records of the injury history, together with the detailed knowledge of a safety specialist were available.

This study was different from other studies, insofar as the damage severity was defined on the basis of whether the spinal damage was of a permanent or temporary nature. A particular research issue in the study was the question of whether there were differences with regard to the damaging energy distribution, and the nature of the activities in the categories of permanent and temporary spinal damage.

The study defined permanent damage as injury which had not fully recovered 12 months after the injury occurred.

The starting point for this study has been to gain an understanding of the damaging energies involved in the loading and hauling process, and the impact these may have on the human spine. A feature of modern mining is that the damaging energies are so large, that any uncontrolled energy release has real potential to cause personal damage.

The damaging energies identified include:

Machine energy

operator/machine interaction, when say

- truck drives over spillage on the road
- truck drives over a pot hole in the road
- loading unit hits truck while loading
- large rock is dropped into the truck tray while loading

Gravitational Energy

- typically people falling
- getting on and off equipment
- objects falling onto people walking around equipment

Personal Energy

- lifting, pushing, pulling

Permanent Spinal Damage

Twenty three cases of permanent spinal damage were identified. Classification of these 23 cases into the damaging energy types (Figure 4) revealed 11 cases of machine energy, 6 cases of gravitational energy, 3 cases of people energy and 3 cases which did not allow classification because of insufficient information.

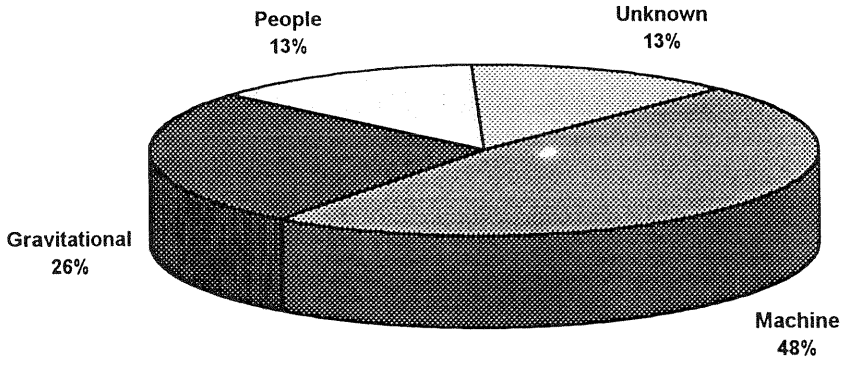

Figure 4 Permanent spinal injuries by damaging energy

A second level analysis of mobile machine energy cases (Figure 5) showed that road conditions, vehicle collisions, lift of vehicle cabin with sudden drop and driving were the processes that led to the damaging energy exchange. The vehicle collisions were the result of shovel bucket hitting truck body.

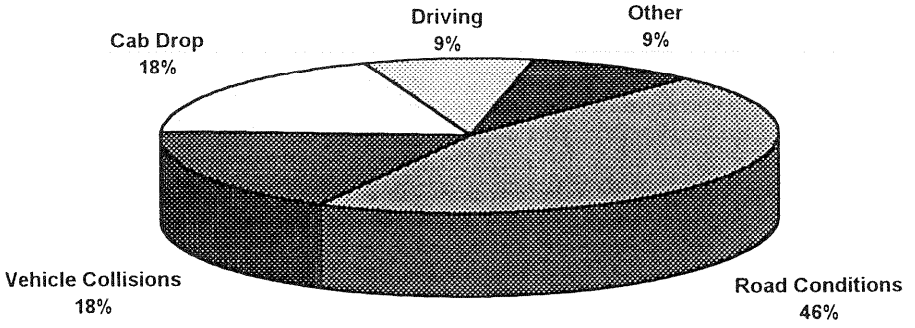

Figure 5 Work processes leading to permanent injury from mobile machine energy

The gravitational energy exchanges were the result of operator falls. Falls to the same level contributed to 2 cases and falls to a lower level 4 cases.

Temporary Spinal Damage

A detailed study of temporary spinal damage identified for the period 1987 to 1994 identified the following damaging energies (Figure 6).

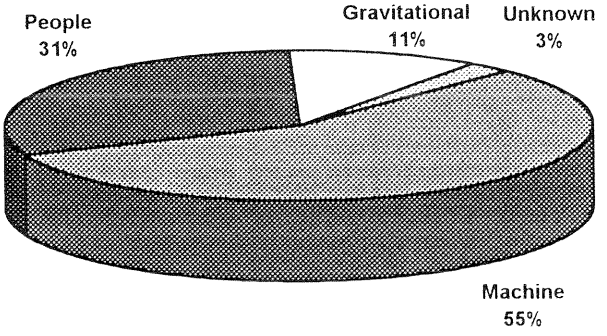

Figure 6 Temporary spinal injuries by damaging energy

A detailed study of the mobile machine energy cases (Figure 7) was performed with the following results: road conditions (165 cases), heavy load drops (25 cases), vehicle collisions (27 cases), driving (15 cases), seating (5 cases) and other (14 cases).

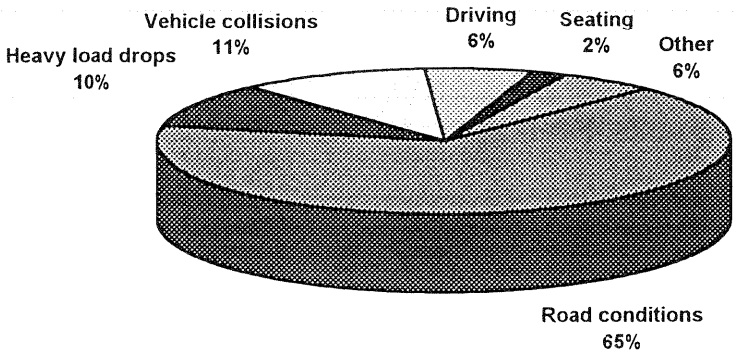

Figure 7 Work processes leading to temporary spinal damage from mobile machine energy.

A third level analysis revealed that heavy load drops were predominately caused by dropping a single large piece into a truck tray.

Vehicle collisions were a result of the loading process, both shovel hitting truck and truck hitting shovel.

The majority of spinal damage from gravitational energy (Figure 8) was due to people falling (41 cases), and the remainder due to objects falling onto people (5 cases). Falls to a lower level were predominantly operators accessing equipment (18 cases)

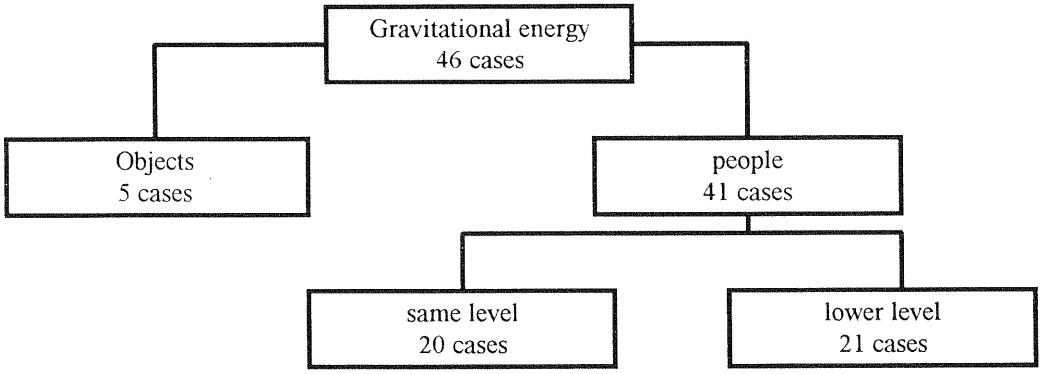

Figure 8 Analysis of the gravitational energy leading to temporary spinal damage

Discussion

This study has shown that spinal damage to plant operators is essentially due to three types of damaging energy: mobile machine energy, gravitational energy and people energy. This is not surprising given the scope and duties a plant operator performs.

It is interesting to note that while the damaging energies are similar, the work processes that led to the damage are slightly different for permanent and temporary injuries. This is consistent with the quantum of energy released when the work process

fails. In this study falls from height and the shovel dipper striking the truck body while loading were two examples.

It also appears that the percentage distribution of each of the three types of damaging energy is different in the permanent damage group from the temporary group (Table 2). This is consistent with the magnitude of the energies involved in the range of activities that a plant operator performs.

Energy	mobile machine	gravitational	people
permanent damage	48%	26%	13%
temporary damage	55%	11%	31%

Table 2 comparison of damaging energies

A quantitative assessment of the improvement strategies is now possible. This will lead to the operation targeting particular process activities for risk reduction.

The next steps

This taxonomy paints one view of the spinal damage at the operating mine. It focuses on the high energy exchange events. It is also important to develop our understanding of the medium and low level energy exchanges that take place.

The next step is to conduct incident debriefs with plant operators to get an operator perspective on the problem. It will be particularly important to understand the lower energy interactions that are present, which may not have been captured by the taxonomy. A structured interview has been constructed to facilitate the information gathering.

This is being run concurrently with studies, and research to understand the present knowledge of spinal injury and injury management.

Finally. a major focus is to better understand the state of the industry, and tie together the work being conducted on different sites. This will run concurrent with other research programs into employee health and whole body vibration.

References

Mitchell, T. and Larsson T. (1994), Commissioned Study of Occupational Health and Safety in the Australian Coal Industry, VIOSH.