

An estimation of the exposure of Queensland

# UNDERGROUND COAL LONGWALL WORKERS TO RESPIRABLE DUST

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## Abstract

This paper presents analysis of the personal respirable coal dust measurements recorded by each mine and the Department of Natural Resources and Mines up to mid 2001 for the 11 longwall mines in Queensland. A total of 813 results were analysed both for each mine and for the seven occupations characterised by Kizil and Donoghue previously. The mean respirable dust concentration for all occupations was  $2.06 \text{ mg/m}^3$  (SD  $2.04 \text{ mg/m}^3$ ). Measurements exceeded the eight hour equivalent exposure standard in 15.6 percent of cases. This compares to a mean of  $1.51 \text{ mg/m}^3$  and 6.9 percent exceedances in NSW. Using the formula of Kizil and Donoghue this would translate to a mean loss of FEV<sub>1</sub> of 100.5ml The increased risk of coal workers' pneumoconiosis was also estimated.

## Introduction

In 201, Kizil and Donoghue (Kizil and Donoghue 2001) reported the analysis of 11,829 respirable coal dust samples collected over 15 years from 33 longwall mines in NSW. This is equivalent to 24 samples per mine per year.

Following the results obtained it was decided to carry out a similar investigation of the Queensland underground coal mining industry.

The Queensland Coal Mining Safety and Health Regulations 2001 state:

Section 89 - the worker does not breathe an atmosphere at the mine containing respirable dust exceeding an average concentration calculated under AS 2985, equivalent to the following for an eight hour period

- i For coal dust –  $3 \text{ mg/m}^3$  air
- ii For free silica –  $0.1 \text{ mg/m}^3$  air

If the worker works a shift more than eight hours at the mine, the system must provide ways of ensuring the person's dosage of respirable dust is not more than the equivalent dosage for a person working an eight hour shift.

In this paper we present an analysis of data collected from the mines and also samples collected by the Department of Natural Resources and Mines. Most data lies within the period mid 1999 to mid 2001 though some data was collected prior to this.

## Method

As there is no equivalent of the Coal Services in Queensland the responsibility for undertaking respirable dust monitoring lies with each mine. Therefore each mine was contacted with a request to provide data.

The quantity of the data provided depended on what was readily available. In most cases the mine referred the researchers on to the agency that actually undertook the survey on their behalf. As these organisations could not be reimbursed for their time in collecting and providing the information, and they had other commercial pressures on their time, it was not possible to amass as comprehensive a dataset as was available for the NSW study.

The data were then converted to eight hour equivalent exposures based on the formulae of Tiernan and van Zanten (Tiernan and Van Zanten, 1998). This allows comparison with the regulatory exposure standard of  $3 \text{ mg/m}^3$  for an eight hour day and 40 hour week.

Given the finite size of the dataset, the analysis of the data was limited to the average for each mine over the time period for the data supplied and then the whole dataset was segregated into the operator classifications derived by Kizil and Donoghue.

As they demonstrated that there was no discernible change in the average respirable dust concentration in NSW over the past 10 years it was assumed that this would also be true in Queensland and no attempt was made to differentiate data by year.

In order to overcome the different sized datasets for each mine, the average value for each mine was compiled first and then the mean value from each mine was averaged to gain the industry-wide value.

The mean loss in lung function FEV<sub>1</sub> was then estimated using the formula cited in Kizil and Donoghue (2001).

A recent publication by the Health and Safety Laboratory (2000) has released formulae that relate the mean respirable dust exposure to increased incidence of coal worker(s) pneumoconiosis. These formulae make allowance for coal type, the hours worked per year and the number of years worked.

It is important to recognise that typically in Queensland respirable dust monitoring is undertaken from the time the worker leaves the surface until he returns to the surface.

This is different to the Coal Services approach, which monitors from the time the worker leaves the underground crib room at the start of a shift until he returns there at completion of shift. This will cause there to be a difference between the two datasets with an expectation that the NSW data will be approximately 10 percent higher than the Queensland equivalent.

## RESULTS

Table 1 below lists the results obtained from the

survey by mine and they are depicted graphically in figure 1. The percentage of each mines dataset that exceeds the standard 3mg/m<sup>3</sup> is also listed.

The mean value of the NSW data is lower than the Queensland data however they are not statistically significantly different at the 95 percent confidence level. The significance is only at a 75 percent confidence level.

The data are not normally distributed. For example in figure 2 below the data from one mine are plotted in a cumulative distribution. The mean of this distribution is 2.98 mg/m<sup>3</sup>, the median is 2.52 mg/m<sup>3</sup> and the distribution is skewed with a long tail to the high dust concentrations. For example removing the top 10 percent respirable dust measurements reduces the mean value to 2.45 mg/m<sup>3</sup>.

The seven operator categories analysed in the NSW study were:

- 1 deputy
  - 2 shearer operator – combines maingate and tailgate operators
  - 3 chock operator– includes shield operator, chock operator and support operator
  - 4 maingate operator
  - 5 face operator – this is a catch all for persons working a range of tasks on the face including job rotation
  - 6 boot end operator – most mines did not have a specified boot end operator.
  - 7 tradesman – includes fitters, electricians etc.
- Analysis of the data by operator category is listed

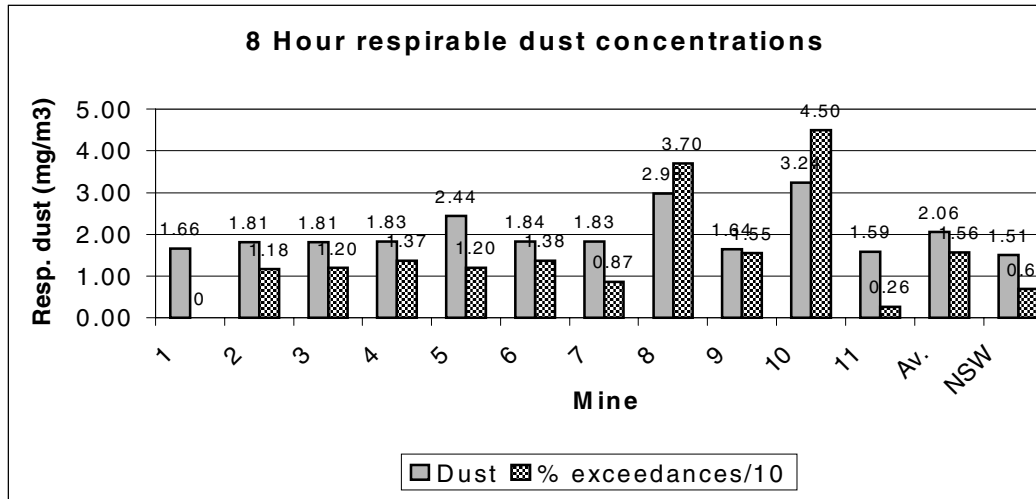


Figure 1

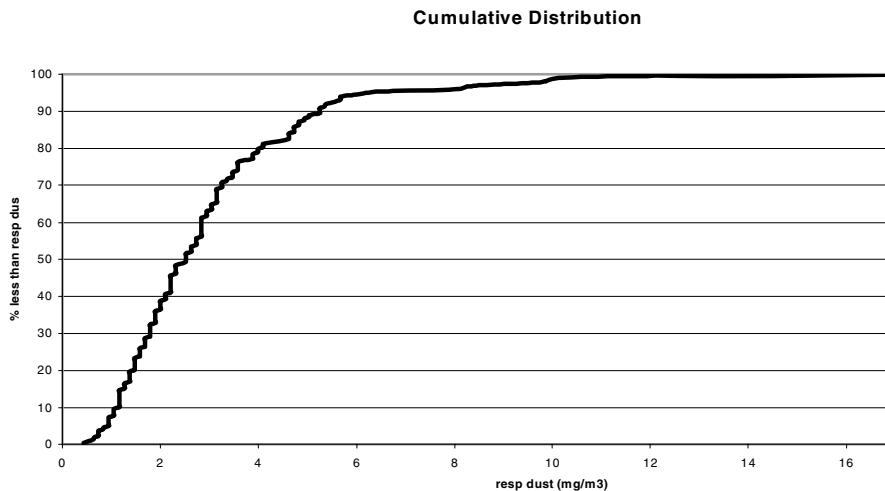


Figure 2 Cumulative respirable dust concentration for mine 8.

Mine	1	2	3	4	5	6	7	8	9	10	11	Av.	NSW**
Av 8 hr eq resp dust	1.66	1.81	1.81	1.83	2.44	1.84	1.83	2.98	1.64	3.24	1.59	2.06	1.51
SD	0.61	1.31	1.21	2.42	4.20	1.17	1.60	2.17	2.10	2.05	0.69	1.08	1.08
no. of samples	25	51	92	73	50	58	69	219	58	80	38	813	11829
% exceed	0.00	11.76	11.96	13.70	12.00	13.79	8.70	36.99	15.52	45.00	2.63	15.64	6.90

Table 1 Average eight hour equivalent respirable coal dust exposures for the Queensland longwall mines

\*\*Note that for comparison, it would be more appropriate to reduce the NSW values by approximately 10 percent to reflect the differences in sampling methodology.

in table 2 and figure 3.

Again these results are not statistically significantly different from their NSW corresponding values at the 95 percent confidence level due to the high standard deviation of the measurements.

In general face workers – shearer operators, chock operators and general face workers tend to have higher dust exposures than personnel who spend less time at the face.

**Discussion**

The last published comparison of respirable dust measurements for Queensland underground coal mines was undertaken in 1995. Bofinger et al (1995)

reported the results from respirable dust monitoring for the four operating mines over the period 1992 to 1994. The results are outlined below in tables 3, 4 and 5 with the comparable figures from the current project.

They reflect a total of 166 measurements.

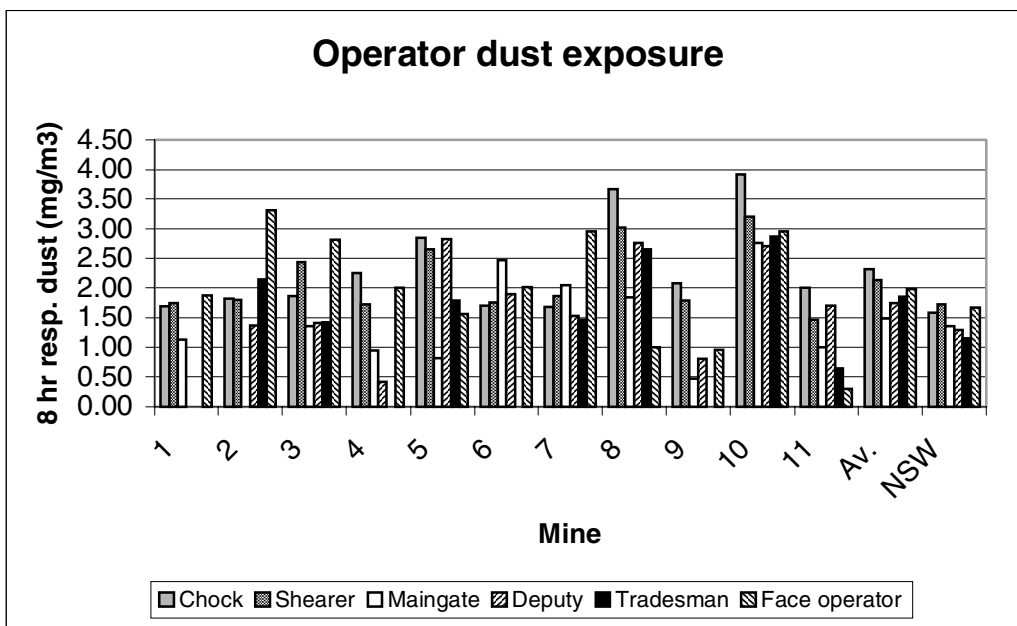
These data show a wide variation between the mines and between the individual years. The increase in exceedances at mine B from 1992 to 1994 was attributed to the coal seam thinning and the shearer cutting into the roof more.

Mine	1	2	3	4	5	6	7	8	9	10	11	Av.	NSW
Operator													
Chock operator	1.69	1.82	1.86	2.26	2.84	1.70	1.68	3.66	2.08	3.92	2.01	2.32	1.58
Shearer operator	1.74	1.80	2.44	1.72	2.65	1.75	1.87	3.03	1.79	3.20	1.46	2.13	1.72
Maingate operator	1.13		1.35	0.95	0.82	2.47	2.05	1.84	0.47	2.77	1.00	1.48	1.36
Deputy		1.37	1.41	0.42	2.82	1.90	1.53	2.76	0.80	2.71	1.70	1.74	1.29
Tradesman		2.14	1.43		1.78		1.46	2.65		2.87	0.65	1.85	1.15
Face operator	1.87	3.32	2.82	2.00	1.56	2.01	2.95	1.00	0.96	2.96	0.30	1.98	1.67
Bootend operator		1.05	0.80				0.93		0.90			0.92	0.93

**Table 2 Analysis by operator category – eight hour equivalent mean respirable dust exposure**

Mine	% dust exposures exceeding the regulation limit			
	Current survey	1992	1993	1994
A	13.8	30		33
B	15.5	0		55
C	11.8	12	0	0
D	2.6		13	20

**Table 3 Percentage of workers with respirable dust exposures exceeding the regulatory limit in Queensland 1992 – 1994**



**Figure 3 Operator category eight-hour equivalent mean respirable dust exposure**

Mine	Current survey	1992	1993	1994
A	1.64	2.6		2.4
B	1.84	1.1		3.5
C	1.81	1.8	1.5	1.3
D	1.59		1.6	2.2
Average	2.06	1.83	1.55	2.35

**Table 4 Average personal dust exposures – respirable dust 1992 - 1994**

Mine	Shearer operator	Chock operator
A	2.85	2.3
B	2.15	1.6
C	2.0	1.8
D	1.8	2.0
Average	2.2	1.93
Current survey	2.13	2.32

**Table 5 Average personal dust exposures – by operator category 1992 -1994**

Given the variability and wide scatter of the data it is not statistically valid to interpret these results in any detail. In general there appears to be a reduction in the number of exceedances from the 1992-1994 data to the current data set.

The increased risk posed by these dust concentrations in the absence of effective personal protective equipment was estimated by using the Health and Safety Laboratory model of Hurley and Maclaren (HSL, 2000).

This model allows for the rank of the coal to which the worker is exposed, by building in the carbon content of the coal as a factor. The model is based upon regression of the pneumoconiosis database maintained by the HSL since the 1950s. The equations for category 1 and 2 pneumoconiosis are:

$$P_{CAT1} = -\frac{104}{R} + \frac{0.0517 * C_{AV} * R * Y * H}{1631 * 40}$$

$$P_{CAT2} = -\frac{53}{R} + \frac{0.01667 * C_{AV} * R * Y * H}{1631 * 40}$$

Where  $C_{av}$  is the average dust concentration in mg/m<sup>3</sup>, R is the dry ash free carbon content, Y is the number of years worked and H is the number of hours worked per year. Using the eight hour equivalence basis, a 40 hour working week is used, 1840 hours are assumed to be worked per year and 40 years worked in the industry.

The values predicted for Queensland coals are:

$$P_{cat1} = 8.85\% \text{ after 40 years For NSW the value is } 6.26\%$$

$$P_{cat2} = 2.63\% \text{ after 40 years For NSW the value is } 0.98\%$$

These values are lower than the predictions made by the HSL for UK coals as the rank of UK coal tends to be significantly higher. These increased risks assume that the personal protective equipment is not worn effectively.

The expected loss in lung function (FEV<sub>1</sub>) can be predicted from the formula:

$$1.22 \times \text{mean dust exposure} \times 40 \text{ years} = 100.5 \text{ ml}$$

This compares to 73.7ml calculated for the NSW study. Neither of these values would indicate a significant loss in lung function.

**Conclusions**

The main conclusion of this study is that the respirable dust concentrations currently measured in Queensland underground coal mines at the longwall face regularly exceed the statutory limit. Of concern are the relatively few very high measurements (> 5 mg/m<sup>3</sup>). As such unless personal protective equipment is worn and is effective, the workers are exposed to an increased risk of respiratory disease.

Within the bounds of the accuracy of the analysis and the variability of the

measurements the respirable dust levels in NSW underground coal mines appear to be lower than their Queensland counterparts, both overall and by operator function. There have been no new reported cases of pneumoconiosis in Queensland or NSW in the past five years.

**Acknowledgements**

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