NOISE AND AIRBORNE DUST IN QUEENSLAND LONGWALL MINES

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BHP AUSTRALIA COAL
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Introduction

This paper is naturally divisible into two parts, covering the aspects of noise and airborne dust, and is therefore presented in its constituent sections.

The section on airborne dust is highly specific to longwall mining whilst that on the noise hazard is applicable to all areas of a typical Australian longwall mine.

Background

Both sections of this paper are based on operational investigations and assessment of modifications as applicable to longwall mining in the Bowen Basin mine. The results quoted are from actual performance achieved, and whilst not as rigorous as laboratory processes, do display trends and indications that increase in validity with the statistical base. The vast majority of the results were obtained by external sources and are considered unbiased.

The airborne dust section of the paper attempts to highlight areas of ongoing investigation and possible outcomes, based on the overall workings of the industry Task Force. This section represents a summary point in the process by which dust control has been evaluated in Queensland, in that broad CMRA compliance has been achieved but further understanding and enhancements are warranted.

The section of this paper on noise presents results applicable to a range of equipment in use in most Australian longwall mines and is representative of an ongoing programme to improve noise suppression on such machines. The data presented relates to some four years of activity at Oaky Creek Coal's NO. 1 Colliery that stemmed from involvement with a NERDCC project undertaken in 1990. It is notable that much of the work undertaken in noise suppression has been paralleled in the USA in the late 1970's, but does not even yet form part of the basic design specification of common underground coal mining equipment.

A Review of Airborne Dust Control Methodologies Applied in the Bowen Basin Longwall Mines

Since its inception in 1992, the Industry Task Force that was formed under the guidance of the Chief Inspector of Coal Mines has been active in developing and enhancing dust suppression techniques as applied to longwall mining. The measure used to assess effectiveness has been the concentration of respirable dust as sampled by personal monitors worn by operators in the longwall crews. In addition, static samples, taken at fixed locations in a longwall district, have also been analysed to gain better understanding of dust sources.

A review of results from dust surveys undertaken in 1992 and 1993 showed that compliance with the Regulations was being consistently achieved and that the Task Force had been successful in achieving its aim of reversing a trend to higher dust concentrations.

In analysing the gains made, it is apparent that success has stemmed primarily from encapsulation of the Breaker Stage Loader (BSL). Furthermore, the tendency for longwall outputs to increase towards a more regular 10,000 tonnes per shift indicates that this one area of effective suppression will be unable to contain the overall dust problem. It is therefore appropriate to consider the basic factors once again, whilst rejoining the debate on the effectiveness of venturi entrapment and filtration systems.

Sources of Dust

a. Intake air has consistently been sampled as containing some 0.5 to 1 mg m^{-3} of dust in the size range measured. Reference to the wide and opposing range of results at different output levels indicates that dust make in the incoming ventilation is <u>not</u> primarily related to production.

   Intuitively, I propose that intake dust levels have most to do with the condition of the gateroad conveyor and ventilating air velocities. It would seem appropriate that condition and type of belt joint, condition of idlers, effectiveness of sprays and scrapers,, and air velocity will determine intake dust concentrations.

   The representation of the range of intake dust concentrations encountered forms a diverging cone, such that improved belt condition management will tend to narrow the cone divergence and increase the overall slope (indicating a tolerance towards high outputs without breaching statutory limits). Figure 3 shows the results assessed.

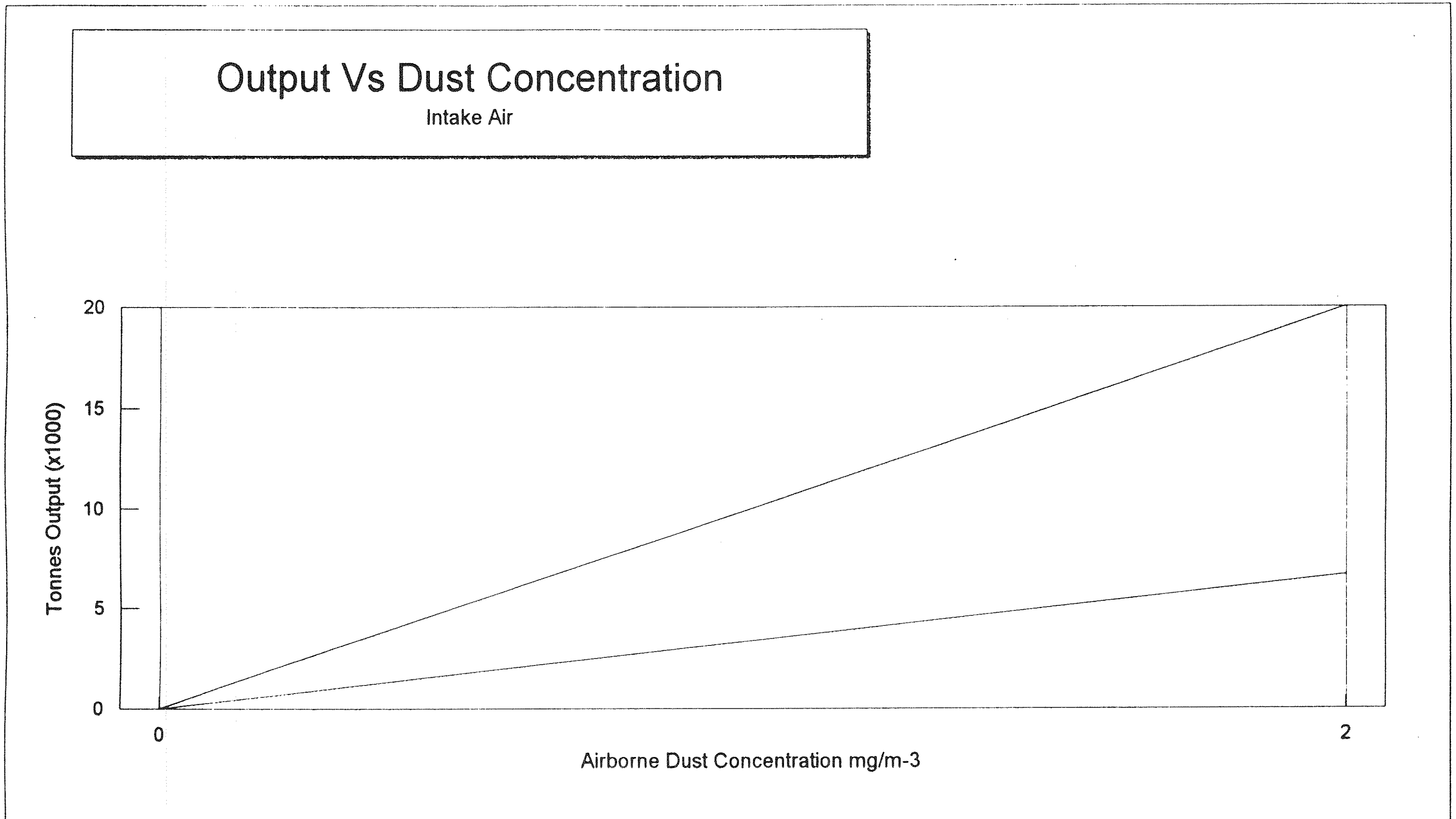

Output Vs Dust Concentration
Intake Air
Tonnes Output (x1000)
20
15
10
5
0
0
2
Airborne Dust Concentration mg/m-3

Figure 3

b. Recent samples taken at the crusher on the BSL show a similar range and form to the intake air results. The overall graph tends to an origin zero, which conceptually seems correct. In this instance, results can be differentiated between those for which the venturi dust extraction system was operating, as against those when the system was not in place. As is shown by Figure 4, the overlapping divergent cones indicate that the venturi system gave an enhanced level of dust control with greater tolerance to bulk throughput.

c. The sample trend from results at 10 chock on the longwall face again show the same form as the results from the crusher location. Similar improvement due to the venturis can be seen by reference to Figure 5. Results from this area of the longwall represent the overall dust make emanating from the intake air, BSL and Side Discharge Unit (SDU), and by subtraction can indicate dust make at the SDU. To date most work has utilised data taken from this and upwind sampling points.

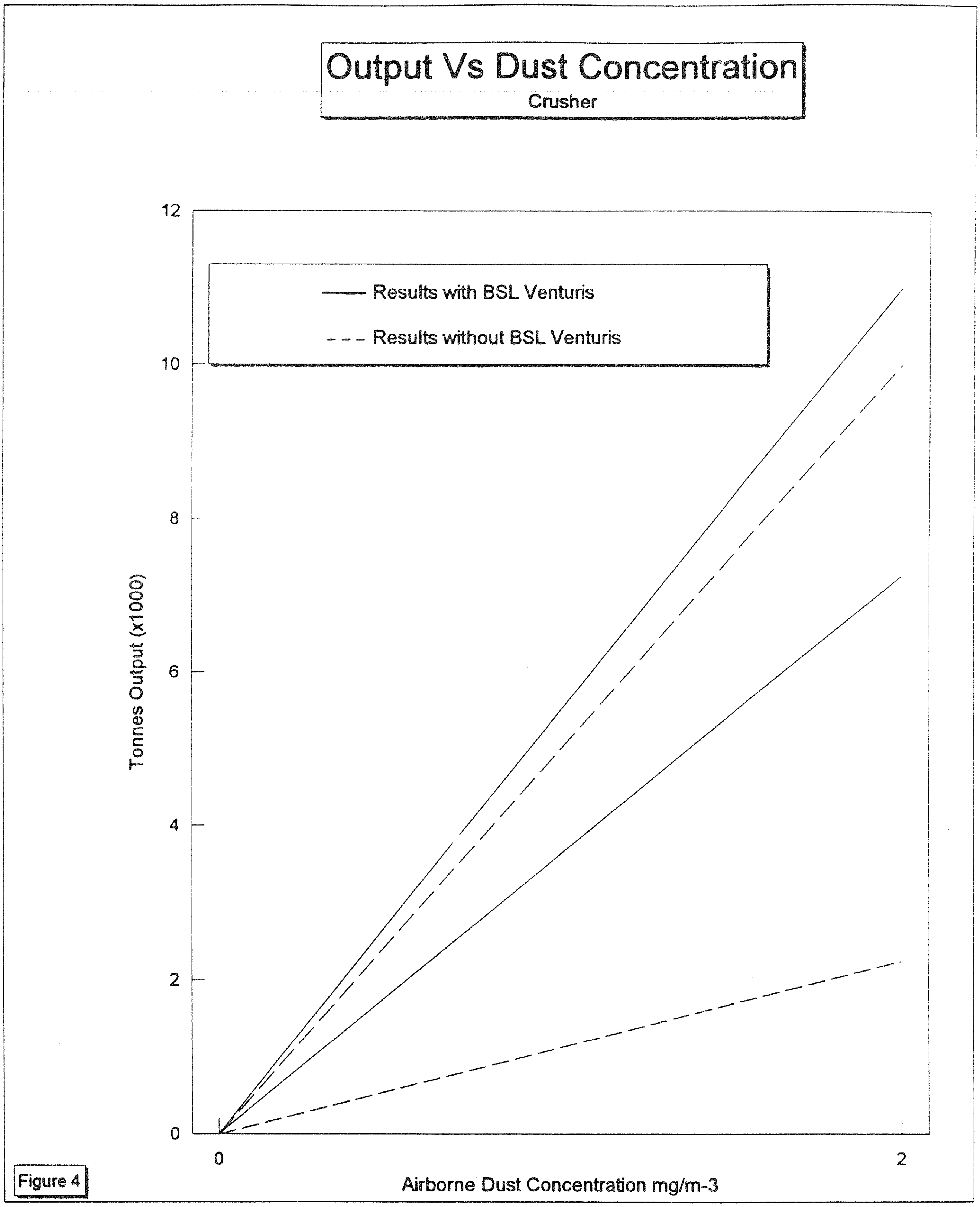
d. The shearer is responsible for producing a major portion of the dust in a longwall system and as yet has not been significantly addressed at the operating mines. Initial work has been undertaken to quantify the levels of dust make, but there is not yet a significant data bank available. Until a reasonable data base of static samples is available for the shearer, the impact of shearer clearer systems, ventilated drums, drum lacing and pick configuration, and even cowls, will not be objectively quantifiable. Early and sparse results indicate dust concentrations at the shearer drum area of up to 5 $mg.m^3$.

e. Dust production by the action of chock contact advance is only now being addressed in Australia, with installations being trialed at South Bulga, Metropolitan and North Goonyella collieries. No results are generally available as yet.

Impact of Air Velocity

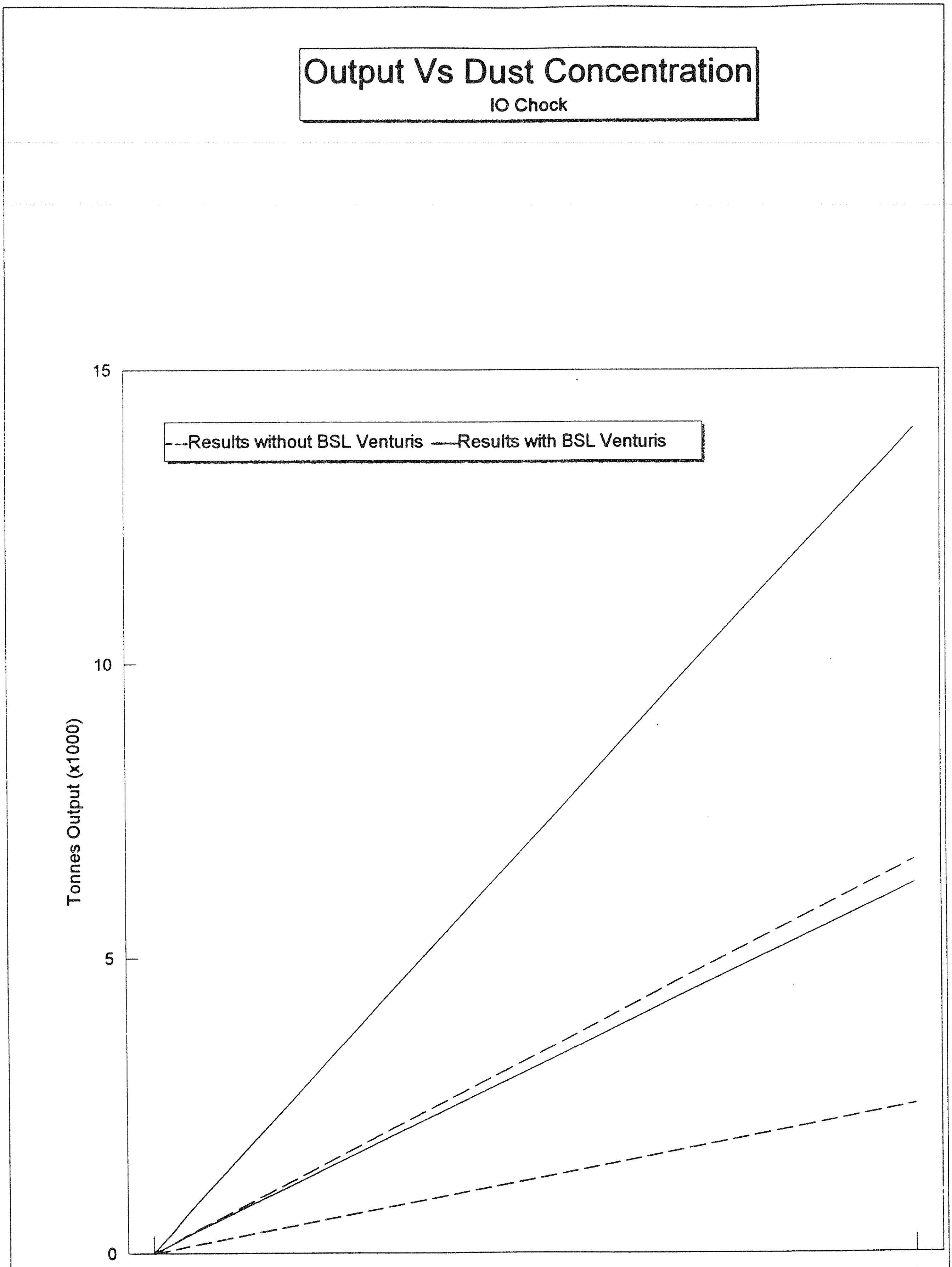
A literature review indicates that dust is whipped up into the airstream when air velocities exceed 650 to 800 ft per minute (variable according to water content), i.e. 3.3 to 4 metres per second. The effect of air velocity on the dust concentration surveys done to date has not been assessed, and only recent surveys have included a velocity profile for the face. The profile that results from coursing 40 m^3s^{-1} through a reasonably standard 4 leg chock face at 3.2m of seam height, is shown by Figure 6.

Of major note is the air splitting that occurs around and over the stage loader (including the



Output Vs Dust Concentration
Crusher
Results with BSL Venturis
Results without BSL Venturis
12
10
8
6
4
2
0
Tonnes Output (x1000)
0
2
Airborne Dust Concentration mg/m-3

Figure 4



Output Vs Dust Concentration
IO Chock
---Results without BSL Venturis —Results with BSL Venturis
15
10
5
0
Tonnes Output (x1000)
0
2
Airborne Dust Concentration mg/m-3

Figure 5

VELOCITY PROFILE FOR OAKY CREEK LW4:SHOWING BOTH AIR OVER AND ALONG THE SIDE OF SOME ITEMS

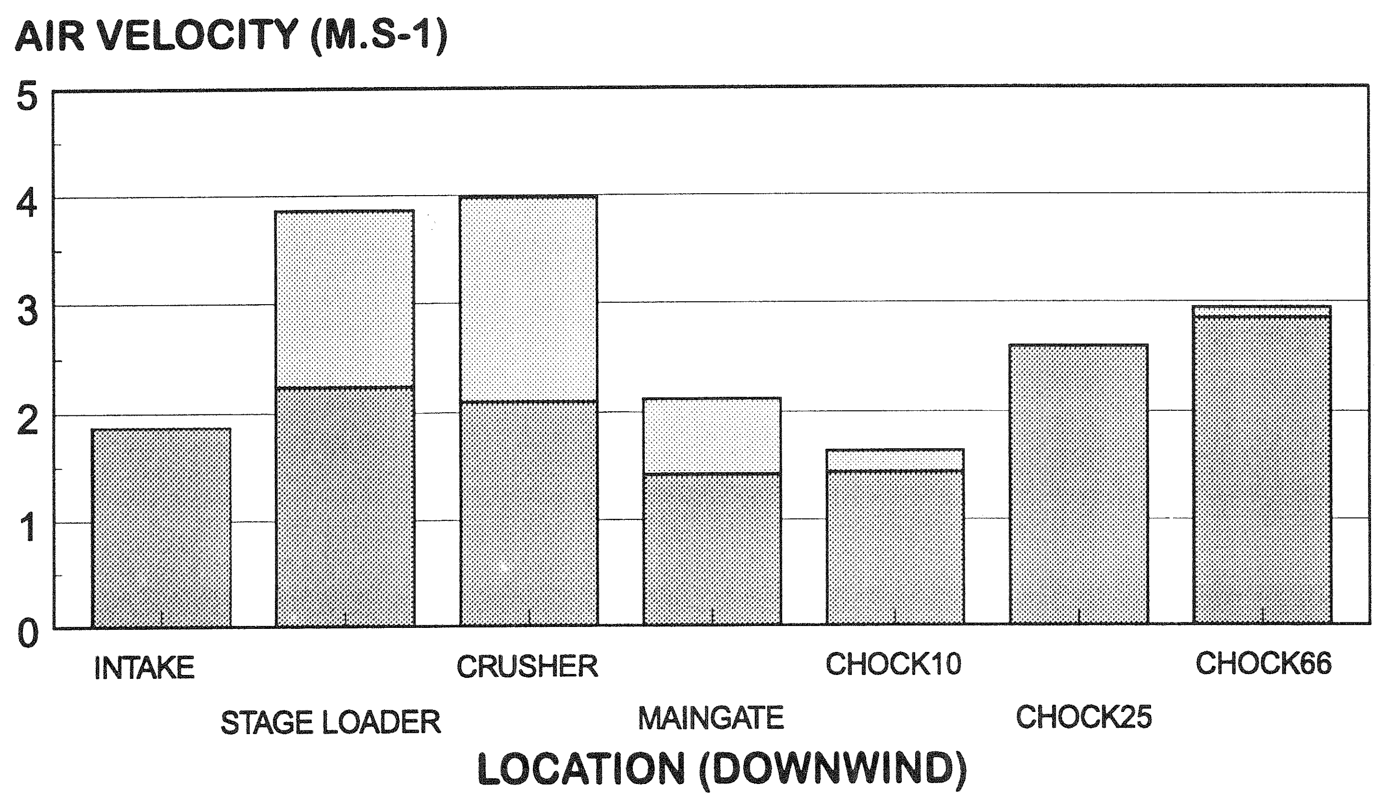


FIGURE 6

crusher), and the "piston effect" of the shearer causing localised variations towards the tail end of the face. The localised air velocity around the BSL/crusher of 4 metres per second is certainly capable of entraining respirable dust.

The effect of the BSL on intake air velocities would be mimicked by the placement of a pantechnicon in the belt road, and this cross sectional limitation will obviously exacerbate the negative effect of greater section air flow.

The issue of increasing volumes of air to match increasing output levels requiring greater gas dilution causes a basic impasse to the objective of reducing airborne dust, due to the creation of high air velocities. This situation will not pertain to thick seams, although other aspects of dust suppression (eg the effectiveness of the shearer clearer system above 2.4m) may be impacted by height.

Future Developments

A review of the latest information from the USA indicates that further benefits will result from the adoption of BSL scrubber systems and chock sprays. Some trials are apparently progressing on a transparent dust screen in the line of the spill plates.

Other methods such as ventilated drums, water additives, shearer mounted scrubber and cowls have not proven successful in the USA.

The successful BSL scrubber systems were of the "flooded bed" type operating with an airflow of 2000 to 3000 cfm. The chock spray systems utilised up to 8 sprays per chock (including sprays on the lemniscate linkage and rear goaf shield), operating for 6 to 10 seconds at 10 gallons per minute as the chock is activated.

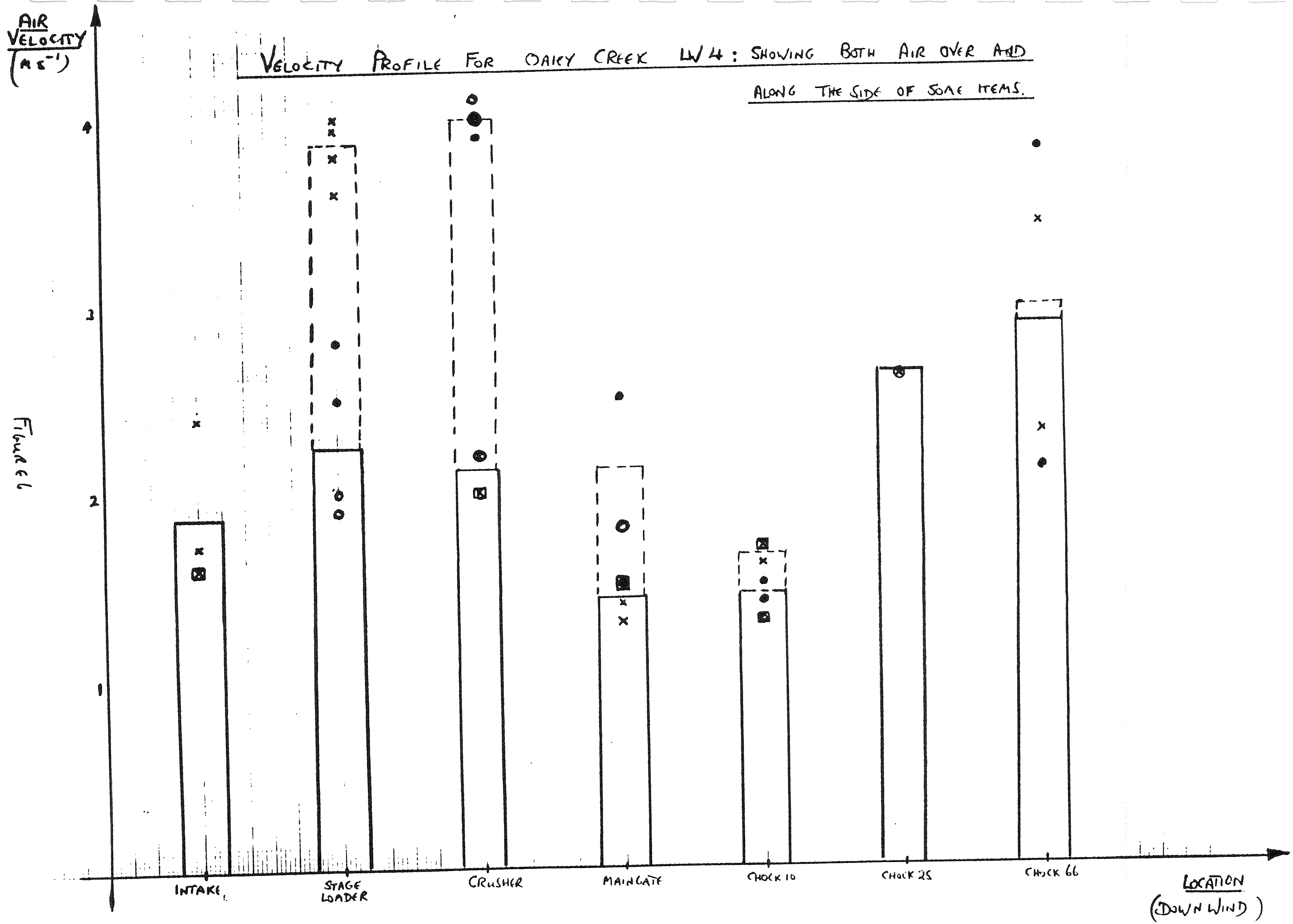
Conclusions

The trend for increasing outputs is promoting requirements that conflict with inherent dust suppression doctrines, e.g. greater ventilating quantities versus more suppression equipment and complexity, and more exacting standards of build.

The imposts of rebuild standards, maintenance requirement and initial cost all militate against higher financial returns, especially when compounded by breakdown and complexity of operation issues.

The exposure of the workforce to significant dust concentrations is not acceptable, but the controls adopted must have a "balanced" approach.

Given the high noise levels inherent to the longwall face, the removal of dust alone is still not an acceptable outcome. The industry should continue to develop cost effective dust suppression techniques, and, concurrently, develop and prove the automated face controls that are currently available to enable personnel to be withdrawn to a less hazardous environment.



VELOCITY PROFILE FOR OAKY CREEK LW4 : SHOWING BOTH AIR OVER AND
ALONG THE SIDE OF SOME ITEMS.
AIR VELOCITY (m s^-1)
4
3
2
1
INTAKE
STAGE LOADER
CRUSHER
MAINGATE
CHOCK 10
CHOCK 25
CHOCK 66
LOCATION (DOWN WIND)

FIGURE 6

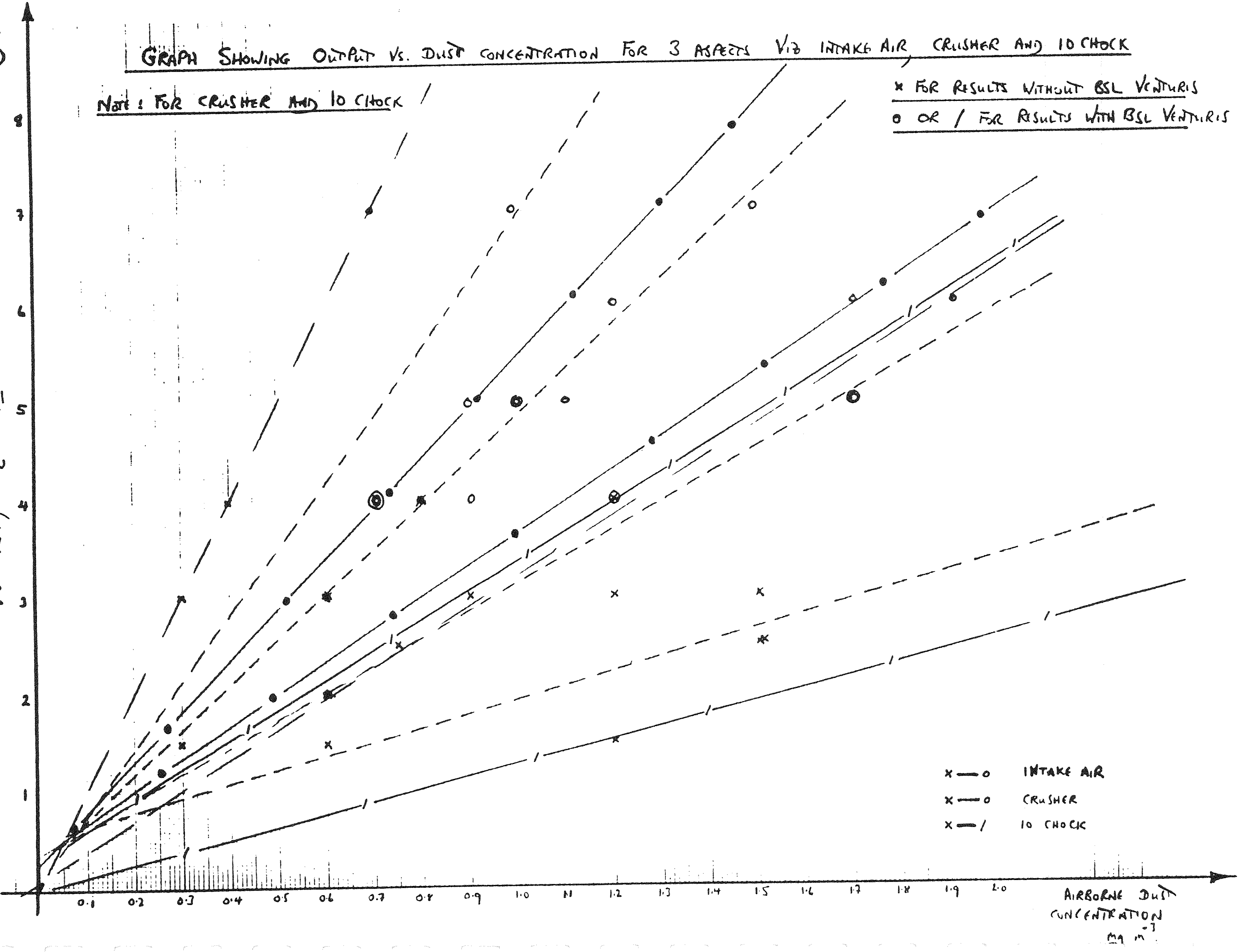


FIGURE 3 (INTAKE AIR
4 = BSL
5 = CHOCK 10

NOISE ATTENUATION MODIFICATIONS APPLIED TO UNDERGROUND COAL MINING MACHINERY AT OAKY CREEK No. 1 COLLIERY, QUEENSLAND

Investigation into the statistics pertaining to the work related health problems at underground coal mines in both New South Wales and Queensland, shows clearly that the most significant of the environmental issues to be addressed is noise.

Most underground coal mines in Australia that employ longwall extraction methods utilise diesel powered, rubber tyred, free-steered vehicles for the transport of men, materials and equipment. As is the case with Oaky Creek, the diesel vehicles utilised in the transport of longwall equipment are becoming more powerful and consequently noisier. The longwall and development equipment in use and being developed is also becoming noisier due to modern day increased output levels.

Management recognition of the problems with noise emissions and an awareness of impending Occupational Health & Safety regulations that specified a lower equivalent continuous noise standard (Leq) of 85 dB(A), encouraged participation in an industry research project - "Managing Noise Emissions and Exposures in Underground Coal Mines". Total funds expended on this project were $305,000, of which NERDDC contributed $200,000, Oaky Creek $50,000 and Work Safe Australia $55,000.

The project had three aims:

(a) To demonstrate that noise control can be effectively achieved with current underground mining equipment.

(b) To investigate the use of a new method of detecting hearing loss in the coal industry - namely "Oto-Acoustic Emission Testing".

(c) To identify the current usage and effectiveness of hearing protection in the underground coal industry.

The purpose of this paper is to illustrate the methods, results and costs of work that has been done in noise suppression on a range of equipment utilised at Oaky Creek.

The NERDDC project focused on two pieces of underground equipment for sound suppression trials, namely an auxiliary fan and a PJB man transporter. The results achieved were noise reductions of 6 Db(A) at the control panel of the fan, 10 Db(A) at the fan exit, and 3 Db(A) at the ear of a PJB transport driver. Oaky Creek officials parallelled work with the PJB man transporter, later extending this to a purpose built underground ambulance, and also expanded the scope to include noise suppression work on Eimco 913 and 936 LHD's, Noyes MPV's, Domino Myne grader and lately, continuous miners.

The initial stages of the NERDDC project involved the establishment of a data bank of what were the noise levels of each piece of machinery in use at the Colliery, the equipment being as supplied for underground use by the manufacturer. Details of the noise levels measured are given in Appendix 1. Details of the equipment in use are given in Appendix 2.

The data on initial noise levels has been used throughout as the base control in evaluating improvements, with further cross referencing by surface measurements immediately before and after modifications. Obviously these readings relate to the same machine under similar conditions and test processors, but as yet limited comparative data is available for modified equipment in use underground.

PJB Man Transporter/PJB Ambulance

As is the basis with all the Oaky Creek machines, under bonnet and under cover (engine) surfaces of the PJB were lined with Rockwool, a glass fibre matting material of good soundproofing, flame resistance, oil and dirt resistant characteristics. Due to the arduous operating environment this matting is retained and protected by perforated stainless steel sheets. (An attempt to use an automotive style of soundproofing matting earlier proved unsuccessful due to the material peeling off, being torn off and generally disintegrating). This matting or insulating material is usually some 25mm thick with 0.9m stainless steel sheeting with 3mm diameter perforations.

Inner panel surfaces of the passenger compartments - such as headlining on the roof have been lined with a proprietary, sound mat type of material - Nylex Sound mat. The rear passenger compartment and front drivers compartment were divided, this being a sheet metal division in the lower portion with the upper area having an open central area. On both sides of the cental open area of the division, a shatterproof transparent plastic sheeting was installed. The central area was not fitted with a plastic window due to driver visibility problems with reflections from the cap lamp when reversing. Similarly the rear window apertures on both sides of the entry were also left open.

The transparent plastic material was also used to fill the window apertures on both sides of the machine in all fixed areas. A laminated glass windscreen was fitted to the vehicle, complete with pneumatic wiper assembly and washer, a glass windscreen being necessary as the plastic material is not totally scratch resistant and does not allow similar clarity of vision as glass. It should be noted that the plastic windows are sealed into position using a rubberised compound, with a pop riveted retaining strip.

Close attention was given to panel fit in the areas of the machine dashboard, firewall and transmission tunnel. The transmission cover was lined with the glass fibre matting and perforated stainless steel, with rubber seals utilised along closure planes.

No changes to the engine, transmission or ancillaries were made, save for fitment of an exhaust muffler to the scrubber tank outlet. This muffler merely directed the exhaust under the machine rather than any sound attenuation effect.

The effect of the changes made can be judged by reference to Figure 1.

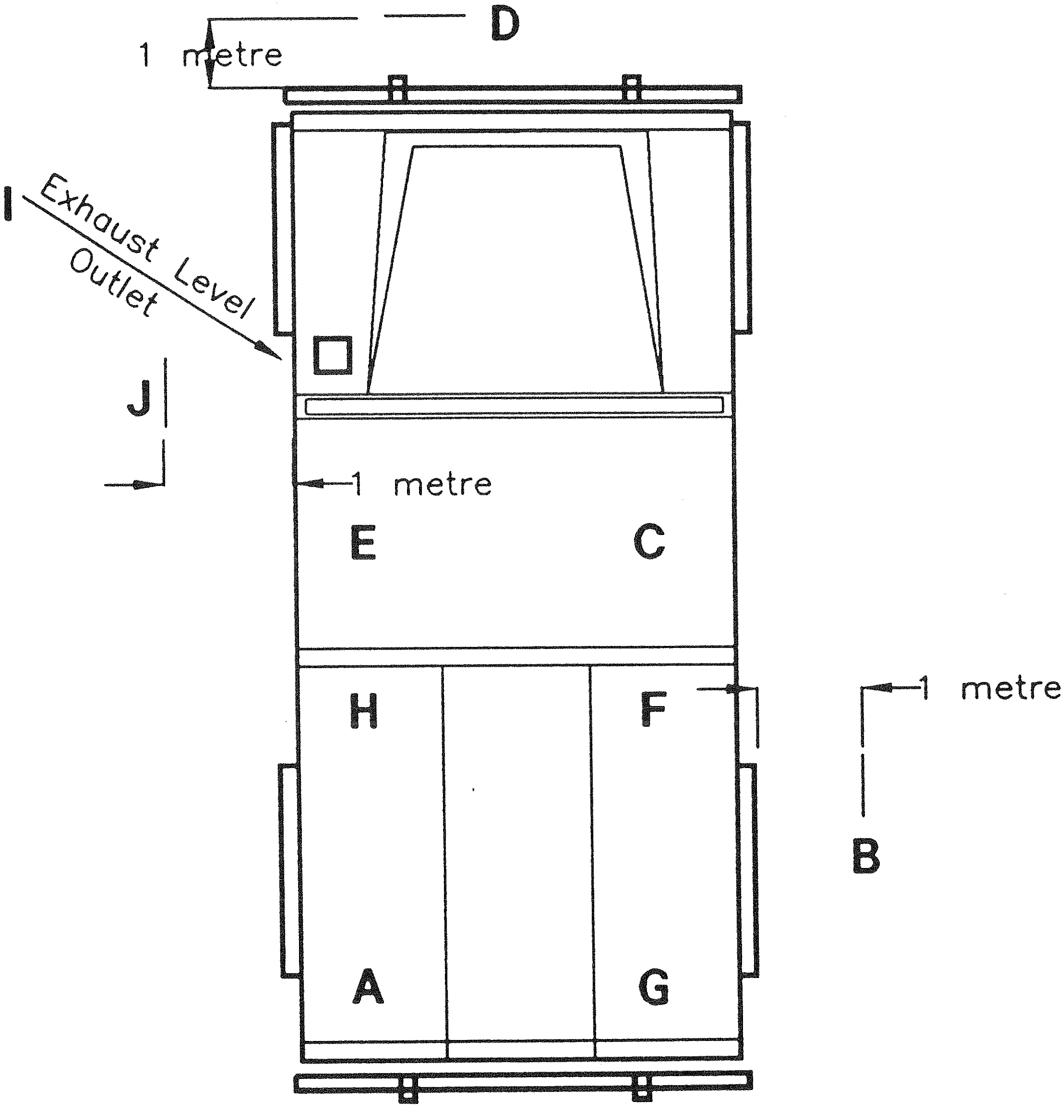
The rationale used for the man transporter was again utilised for the ambulance, and several ongoing improvements included. These were as follows:

(a) The air intake pre cleaner assembly for the engine induction system was moved from a mounting in the front compartment (immediately in front of the passenger), and accommodated under the bonnet in the engine bay.

(b) The rear compartment was fully enclosed with the plastic window material with the objective of optimising the patient environment in an infrequently utilised vehicle. Communication and ventilation flaps, plus rear view wing mirrors were introduced to accommodate the emphasis on the patient's environment.

(c) Floor matting was utilised in both compartments to reduce vibration and noise reflection. This matting is a product made from recycled tyres treated with flame retardant and available in various thicknesses and densities.

P.J.B. MINECRUISER MK 4.5 & 5
NOISE LEVEL TEST



POSITION	A	B	C	D	E	F	G	H	I	J
NOISE LEVEL dB(A)										
PRE MODIFICATIONS	90	90	93	103					108	
POST MODIFICATIONS	84	89	88	101					100	
AMBULANCE	85		89		89	85	86	85	99	85
LATEST OVERHAUL	82		68*			82	83	89		80

* Leq at Max speed on open road on surface.

FIGURE 1

The success of the measures taken can also be seen from Figure 1.

Indicative costs for the labour and materials for soundproofing this type of underground man transporter range from approximately A$7,000 for a man transporter to some A$13,000 to equip an ambulance to a similar standard (inclusive of stretcher costs, etc).

It is anticipated that such costs would diminish if the provisions noted were part of original building specifications.

The latest overhaul of a PJB included even greater attention to the detailed aspects of sealing the dashboard area of the vehicle, improved engine bay and transmission lining and the adoption of multiple compound polyurethane engine mounts.

The aim of the last overhaul was to improve current techniques and to adopt a sound absorption strategy as opposed to sound deflection.

The target areas of improvement were greater elimination of vibration and reasonance, and sound paths. The results shown by Figure 1 illustrate slight improvements but the reducing trend is indicative of diminishing returns on expenditure. Furthermore, the effort that was made to fashion these improvements reinforces the conclusions that the sound reductions possible on this machine type without major redesign, is reaching a plateau.

An area of specific interest from the last overhaul was the siting of the starter motor exhaust (air start) in the transmission tunnel with a proprietary silencer fitted. These modifications, together with the extensive sound proofing, significantly improved the high intensity short burst of noise associated with starting such machines.

Eimco 913/936 LHD

The second machine at Oaky Creek that was targeted for noise attenuation work was one of the 913 LHD machines. This machine was fitted with engine bay covers - "gull wing doors" - that were internally lined with the glass fibrematting and stainless steel inner skin, and latterly with gas filled struts to assist in opening and to double as stays. This being the first machine to be modified, close attention was paid to opening the rear of the machine for airflow, whilst at the same time reducing the fan speed as a means of reducing noise levels.

In addition, the machine was fitted with rubber transmission mounts and a transmission sock. The sock comprised of a glass fibre matting insulation with a glass fibre cloth cold facing and a stainless steel mesh hot face.

The work in enclosing the engine bay area of the machine on both sides and the top also necessitated relocating the air cleaner assembly, and the cooling implications required the movement of the radiator and the careful evaluation of airflow characteristics through the radiator when operating in an underground air stream.

The noise reduction achieved at the operator's ear was significant and a spin off benefit of the enclosed engine bay that became apparent in operation was that the engine and ancillaries were kept in a cleaner condition. Cleanliness in the engine bay obviously has safety and maintenance advantages.

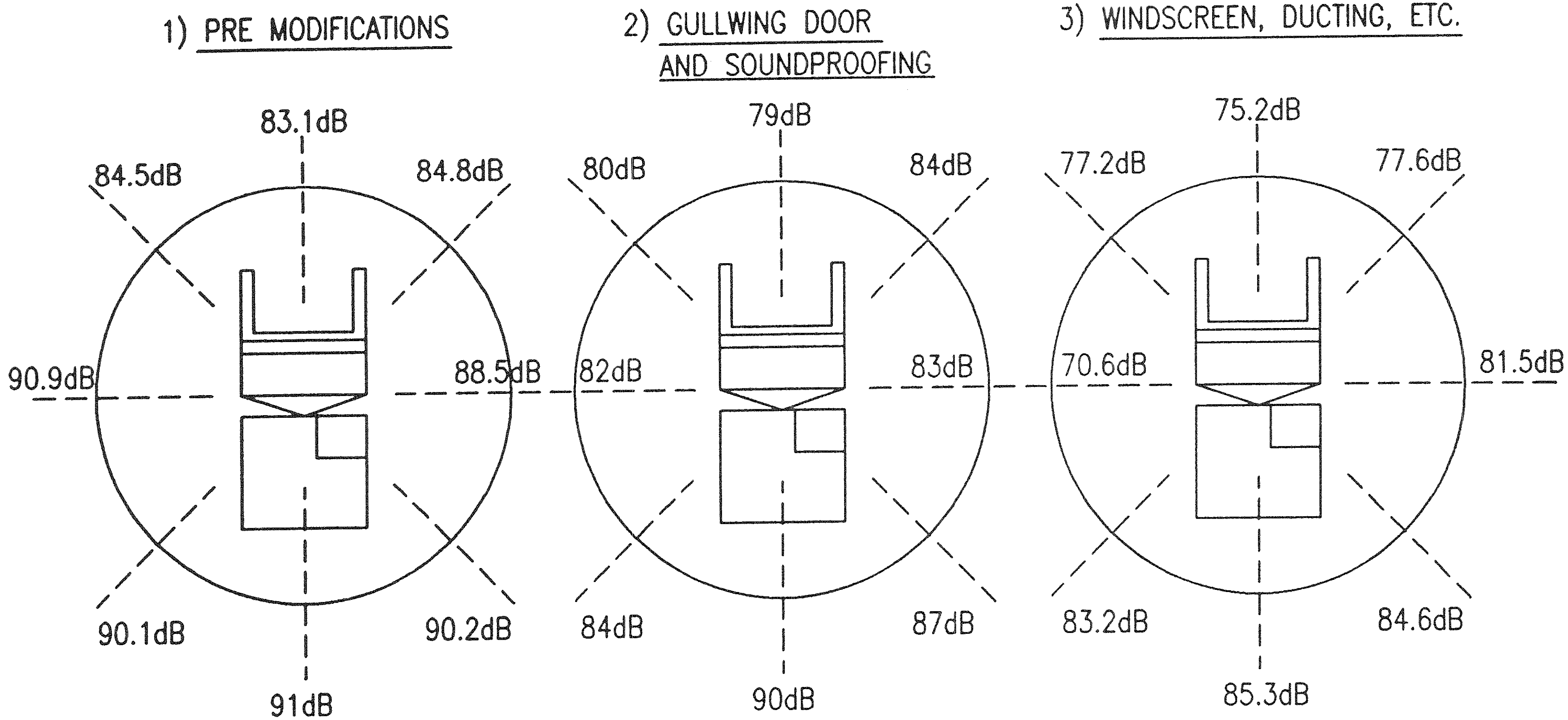
The cost incurred in modifying the 913 was of the order of A$12,000, and the noise reduction results achieved are shown by Table 1.

The Eimco 936 LHD was modified in much the same fashion as the 913, but initially did not result in a similar reduction in noise at the operator's ear. This may have been due to the difference in engines, the 913 having a 100 h.p. Caterpillar 3306 six cylinder engine. Further investigation into reducing noise levels resulted in the cooling fan being moved away from the operator (this being a "remote" hydraulically driven fan) and the radiator intake etc., being shrouded from the operator's cab. This, in addition to the provision of a glass windscreen in the cab on the rear facing side, achieved the expected results.

The cost of the modifications to the 936 in reducing noise levels as indicated in Figure 2 was some A$15,000.

Noyes MPV

As was applied to the PJB and Eimco machines, engine bay covers were engineered for these vehicles that also featured inner lining with insulation matting retained with perforated stainless steel sheeting. Due to the different configuration of the MPV a single piece engine bay cover was made that had a swing up section at each end. The swing up sections allowed access to radiator and V-belts at the front, and flame trap etc. at the rear. Major engine work necessitates the full



EIMCO 936 LHD - NOISE ATTENUATION READINGS

		MACHINE BEFORE MODIFICATIONS	GULLWING DOORS, SOUNDPROOFING,ETC.	WINDSCREEN,DUCTING, FAN MOVE+COVERS	EXTRA WINDSCREEN BEHIND DRIVER
LEFT EAR	IDLE	82 dB(A)	78.5 dB(A)	79.5 dB(A)	78.5 dB(A)
	FLIGHT	99.9 dB(A)	99.5 dB(A)	86 dB(A)	86 dB(A)
RIGHT EAR	IDLE	80.6 dB(A)	77.5 dB(A)	80 dB(A)	78.5 dB(A)
	FLIGHT	99.6 dB(A)	98.5 dB(A)	88.4 dB(A)	86.5 dB(A)

READINGS TAKEN AT THE OPERATOR´S CABIN

FIGURE 2

cover assembly to be removed.

Noise reductions achieved on the MPV fleet are shown on Table 1, and cost some A$6,000 to complete.

Domino Myne Grader

Lined, gull wing covers were again utilised on this machine with further benefits being gained by judicious placement and lining of the scrubber water tank. Significant noise reductions were evident on completion, but were primarily in the area of mechanical noise. It quickly became very apparent that the noise created by the operation of the hydraulic pumps (main machine drive via hydrostatic motors, plus ancillary functions for steering and blade control), was of higher frequency and intensity, and was not as well subdued by the soundproofing measures taken.

Sound reduction wraps were specially made for the pumps and the machine chassis box sections altered to reduce resonance. These measures were somewhat successful in reducing the hydraulic noise as is shown by the results in Table 1. Experience with this machine clearly illustrates the different approach necessary for successful reductions of noise of different frequencies, and the apparent ineffectiveness of suppression materials and methods are good at lower frequencies (<1000 Hz), compared with results for higher frequencies, e.g. hydraulic noise.

DOMINO MYNE GRADER *

Prior to Modification	Stationary Tests (No hydraulics	Low Idle	78 dB(A)
	Mobile Tests (includes Hyd. Pumps etc.)		
After Modification	Stationary Tests (No hydraulics)	Low Idle	72 dB(A)
	Mobile Tests (includes Hyd. Pumps etc).	High Idle	82 dB(A)
		Average	92 dB(A)
		Peak	94 dB(A)

NOYES MPV

Prior to Modification	High Free Idle (stationary)	Driver's Ear	97 dB(A)
	Low Idle (stationary)	Driver's Ear	84 dB(A)
	Mobile Test	Driver's Ear	102dB(A)
After Modification	High Free Idle (stationary)	Driver's Ear	93 dB(A)
		Passenger's Ear	93 dB(A)
	Low Idle (650 rpm)	Driver's Ear	79 dB(A)
	Mobile Test	Driver's Ear	94 dB(A)

EIMCO 913 LHD *

Prior to Modification	Flight (High free idle)	Left Ear	94.8dB(A)
		Right Ear	96.6dB(A)
After Modification	Flight (High free idle)	Left Ear	91.4Db(A)
		Right Ear	91.8Db(A)
	Idle	Left Ear	76.8Db(A)
		Right Ear	78.2Db(A)

** All measurements at the operator's cab*

Table 1

Continuous Miners

The continuous miners that have been modified at Oaky Creek all feature driving cabs on the machine. As such they exhibit a level of exposure to noise for the driver that may be ameliorated by adoption of remote control. However, the general results outlined in the paper have broad applicability to the section crew, and give indications as to best operator positioning with regard to minimising noise exposure.

Initial soundproofing work has been completed on a Jeffrey 2048 and comprised primarily of machine deck and side covers. Subject to confirmation with underground measurements, there seems to have been some success with this first attempt as attested to by operating crews. In addition to improved cover design, a token side window was installed in the driver's cab, this affording some noise and splash protection, but also gaining operator acceptance from the viewpoint of reflections, etc. A full set of noise measurements has been taken for this machine on the surface and these will be cross referenced when underground noise survey work is completed 1994/1995. The tests done on the machine before and after the overhaul indicate that the changes made has a significant impact with regard to noise suppression - see Table 2.

The principles employed with the inclusions on the 2048 were enhanced on the overhaul of the Joy 12CM20. The 12CM20 is now equipped with totally enclosed sides that also provide a safer, flat working platform and maintain the cleanliness of the motors and pumps etc. Extensive cover plates have been provisioned over the rear of the cutting head, i.e. in the conveyor throat area, and over the middle of the conveyor boom. These covers, together with sprays and flaps are expected to favourably impact on both noise and dust. A much larger side window was fitted to the cab of the 12CM20 and careful attention paid to blanking off noise transmission paths into the operators cab. A change of major significance was to replace the single hydraulic motor/pump management with a double motor/pump set-up, effectively splitting the roofbolting demand and providing machine functions off one pumpset.

An extensive sound survey was conducted on this machine in "free space" conditions on the surface, and comparison of these results to a similar 2048 survey and published Joy 12 SCM30 indicates that worthwhile sound reductions have been achieved in most areas. These same results also appear to show the noise results of different design approaches in main and east-west conveyors. The results are given in Table 3.

Absolute confirmation of the benefits achieved will only be realised with the 12CM20 surveyed in an operational mode underground. Results from this survey will be directly comparable with the initial readings shown in Appendix 1.

Table 2

Operator Position	MACHINE OPERATING MODE - BEFORE AND AFTER MODIFICATIONS															
	Pumps Only		Heads Up & Running		Heads Down & Running		Both Conveyors On		Conveyors & Heads Running		Tramming Forward		Tramming Reverse		Drill Rigs Operating	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Drivers Cabin	83.9	78.9	90.7	91.6	88.7	89.3	103.9 *	102.1 *		102.9	89.9	93.9	93.6	91.9	N/A	N/A
Cable Hand	74.5	76.3	86.4	86.7	84.3	106.3	99.6	99.6			86.3	85.3	85.6	85.9	N/A	N/A
Drill Operators - Standbye	76	72.9	87.9	87.8	85.3	84.4	105.5	99.7			84.4	83.6	86.2	84.4	N/A	N/A
Drill Operators - Drivers Side Platform	** 88.1	** 85.7													*** 87.5/ 87.1	*** 86.1/ 86.8
Drill Operators Off Drivers Side Platform	87.6	86.1													*** 92.4/ 88.5	*** 91.7/ 87.4

Noise Test Results - Jeffrey 2048

Pre = Before O/Haul
Post = After O/Haul Incorporating Sound Suppression

* Results for Main Conveyor only
** Pumps on Bolting Mode
*** 1 Drill Rig operating/2 Drill Rigs Operating.

Table 3

	MACHINE OPERATING MODE							
OPERATOR POSITION	MACHINE PUMP (ONLY)	HEADS UP & RUNNING	HEADS DOWN & RUNNING	BOTH CONVEYORYS RUNING	BOTH CONVEYORS AND HEADS RUN	MACHINE TRAM - FORWARD	MACHINE TRAM - REVERSE	DRILL RIGS OP.
DRIVERS CABIN	81 (12SCM30 81 (OCC-PK) 74 (OCC-AV) 103 (2048-PK) 78.9 (2048-LEQ)	82 (12SCM30) 89 (OCC-PK) 79 (OCC-AV) 110 (2048-PK) 91.6 (2048-LEQ)	90 (OCC-PK) 79.4 (OCC-AV) 107.5 (2048-PK) 89.3 (2048-LEQ)	101 (12SCM30) 113 (OCC-PK) 100 (OCC-AV)	103 (12SCM30) 114 (OCC-PK) 101 (OCC-AV) 119.5 (2048-PK) 102.9 (2048-LEQ)	85 (12SCM30) 91 (OCC-PK) 82 (OCC-AV) 109 (2048-PK) 93.9 (2048-LEQ)	92 (OCC-PK) 82 (OCC-AV) 112.5 (2048-PK) 91.9 (2048-LEQ)	79 (12SCM30)
CABLE HAND	79 (OCC-PK) 67 (OCC-AV) 107.5 (2048-PK) 76.3 (2048-LEQ)	88 (OCC-PK) 73 (OCC-AV) 105.5 (2048-PK) 86.7 (2048-LEQ)	84 (OCC-PK) 72 (OCC-AV) 105.5 (2048-PK) 83.7 (2048-LEQ)	117 (OCC-PK) 103 (OCC-AV) 116 (2048-PK) 99.6 (2048-LEQ)	117 (OCC-PK) 103 (OCC-AV)	84 (OCC-PK) 74 (OCC-AV) 113.5 (2048-PK) 85.3 (2048-LEQ)	83 (OCC-PK) 73 (OCC-AV) 111.5 (2048-PK) 85.9 (2048-LEQ)	
OFF-DRIVERS SIDE STANDBYE	72 (12SCM30) 76 (OCC-PK) 64 (OCC-AV) 107.5 (2048-PK) 72.9 (2048-LEQ)	86 (OCC-PK) 76 (OCC-AV) 116 (2048-PK) 87.8 (2048-LEQ) 75 (12SCM30)	88 (OCC-PK) 77 (OCC-AV) 114.5 (2048-PK) 84.4 (2048-LEQ) 103 (12SCM30)	116 (OCC-PK) 103 (OCC-AV) 117.5 (2048-PK) 99.7 (2048-LEQ)	117 (OCC-PK) 103 (OCC-AV) 106 (12SCM30)	84 (OCC-PK) 73 (OCC-AV) 103 (2048-PK) 83.6 (2048-LEQ) 78 (12SCM30)	85 (OCC-PK) 74 (OCC-AV) 107.5 (2048-PK) 84.4 (2048-LEQ)	
DRILL RIG OPERATORS DRIVERSSIDE	89 (OCC-PK) 79 (OCC-PK)							79 (12SCM30) 92 (OCC-PK) 80 (OCC-PK) 111.5 (2048-PK) 86.8 (2048-LEQ)
DRILL RIG OPERATORS OFF-DRIVERS SIDE	72 (OCC-PK) 66 (OCC-AV)							79 (12SCM30) 94 (OCC-PK) 85 (OCC-AV) 113.5 (2048-PK) 87.4 (2048-LEQ)

OCC PK & OCC AV are results from tests undertaken on overhauled 12cm20 inclusive of significant sound suppression work.

NB: Sound sweep indicates noise from pumps significant cover plate cut outs are a high noise source.

Conclusions

It is considered that progress is being made in reducing noise emissions of some underground equipment and that in some instances the reductions render the machines reasonably acceptable in a modern, mining environment. It is recognised that in the case of some items of equipment there is further work to be done.

The progress made is encouraging and the results probably indicate the quantum improvement that is feasible prior to major redesign being warranted. The process of sound suppression has benefit also in the specification of hearing protection devices - HPD's. Spectral analysis of noise in the longwall face area, continuous miner face area, and for the diesel fleet, has been utilised to enable correct specification of HPD's to match actual requirements at Oaky Creek. The work force has a recommended range of HPD's in two categories, one suitable for continuous face use and occasional diesel vehicle exposure, and one best suited to diesel vehicle drivers.

This analysis and specification process results in the provision of HPD's that give effective protection without "overkill"; a greater suppression of noise than is necessary could be dangerous in a variety of underground situations.

Use of HPD's by the Oaky Creek Colliery work force was surveyed at the start of the NERDDC project to ascertain general acceptance of safety rules relating to hearing protection around noisy equipment. Following introduction of modified equipment and toolbox talks to specifically discuss the issues and inform the work force, a further survey on the use of HPD's was conducted. This survey showed an increased usage rate, with later incidents at the Colliery indicating a greatly heightened awareness of hearing loss, the need for ongoing sound suppression measures, and the ongoing requirement for use of HPD's.

Oaky Creek is committed to continuing to retro fit sound suppression where practicable, to all vehicles in use, and to assist in promoting new equipment specifications to address noise issues.

The better understanding of the noise problem, and automation of equipment that cannot be practically modified for sound suppression, will improve the environment for all employees.

The improvement of equipment used underground will be greatly assisted by the adoption of a common measurement regime - i.e. locations for measurement under given operating conditions, as this will enable more reasonable comparisons to be made and more accurate quantification of improvements gained in the field.

A suggested measurement regime is appended - Appendix 3.

The Author acknowledges the kind permission of Oaky Creek Coal Pty Ltd to present data included in this paper.

Related References

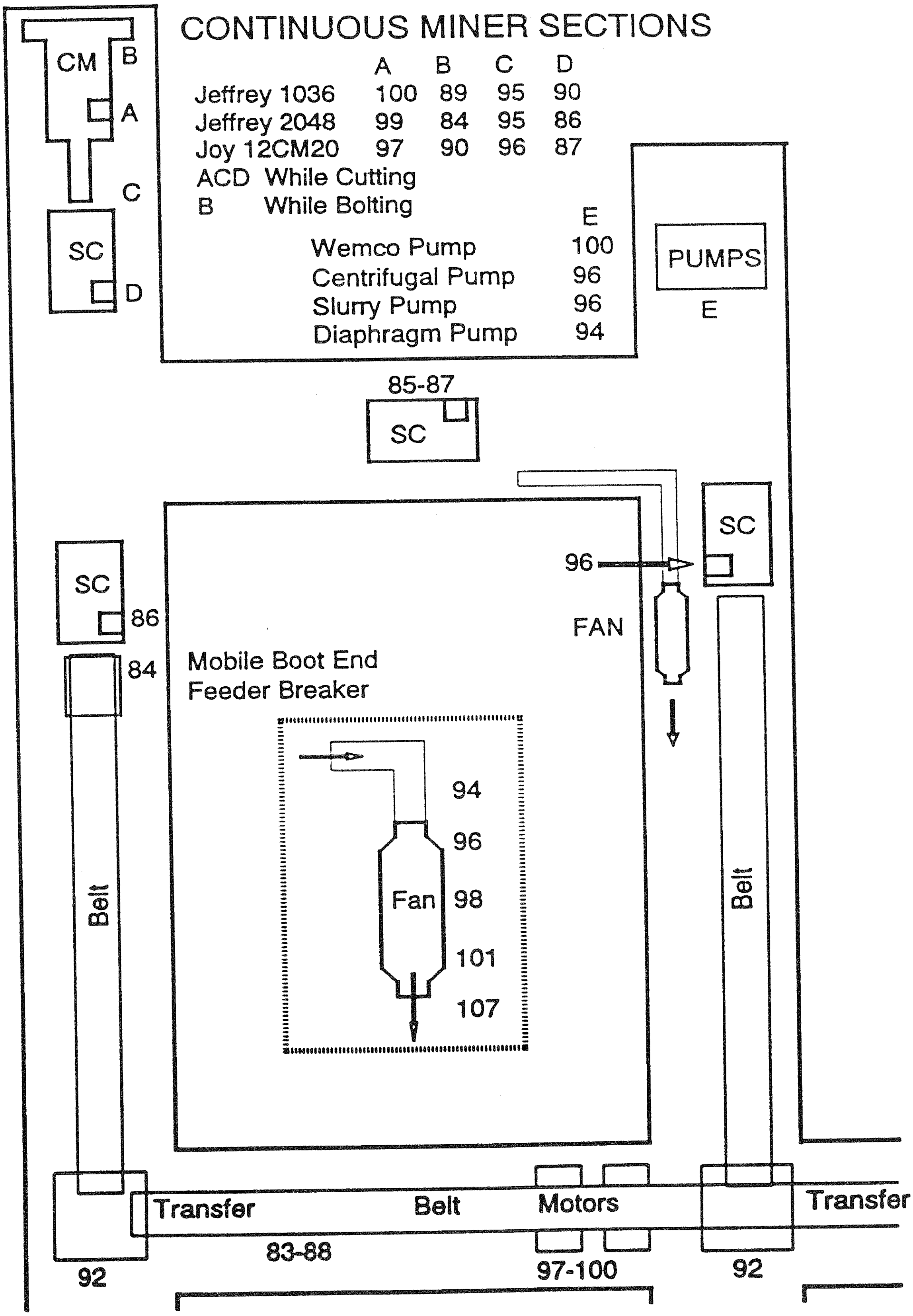
"Managing Noise Emissions and Exposures in Underground Coal Mines"
- Adrian O'Malley (ACIRL)
(QCO/DME Conference at Yeppoon, Qld., September 1994)

"Airborne Dust Control on High Productivity Longwall Faces"
- M.D. Downs (Oaky Creek Coal)
(ACIRL Seminar at Artarmon, N.S.W., November 1993)

"Longwall Environmenal Hazards With Particular Reference to Airborne Dust and Noise"
- M.D. Downs (Oaky Creek Coal)
(QCO/DMG Conference at Yeppoon, Qld. August 1992)

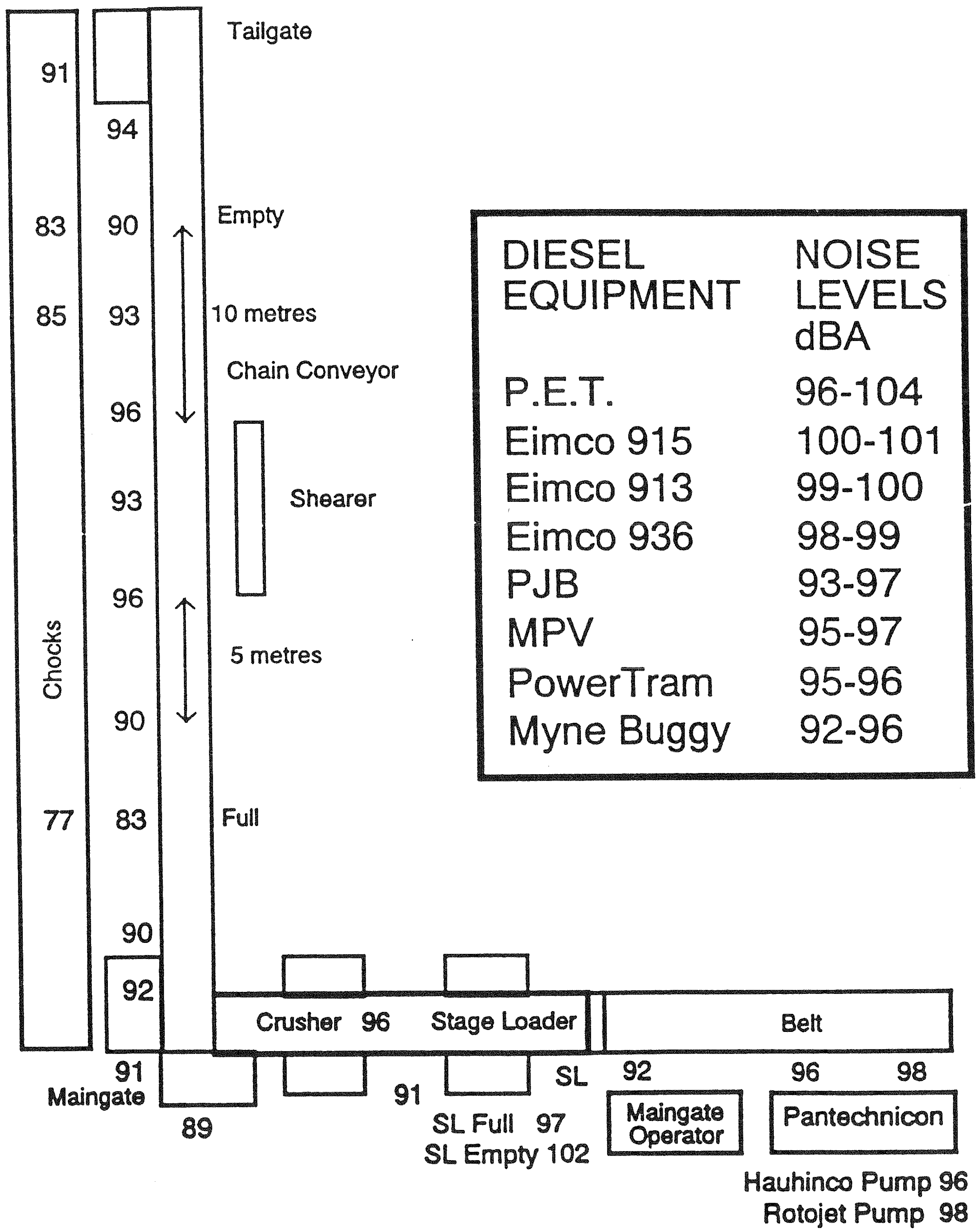
APPENDIX 1

SOUND LEVELS MEASURED UNDERGROUND AT OAKY CREEK MINE - dBA



SOUND LEVELS MEASURED UNDERGROUND AT OAKY CREEK MINE - dBA

LONGWALL EQUIPMENT



DIESEL EQUIPMENT	NOISE LEVELS dBA
P.E.T.	96-104
Eimco 915	100-101
Eimco 913	99-100
Eimco 936	98-99
PJB	93-97
MPV	95-97
PowerTram	95-96
Myne Buggy	92-96

APPENDIX 2

Appendix 2

LONGWALL FACE EQUIPMENT

SHEARER:	Anderson Strathclyde AM500 DERDS 3.3kv 2 x 450 kw motors (3.3 kv) Drums 2.1m diameter, 1100mm web, point attack picks No cowls fitted Meco track chainless haulage system (cf Eichkoff)
AFC:	1050mm wide, 2 x 34mm inboard chains, closed pans spill plate height 200mm over standard Standard Meco 300t dog bone joints 2 speed motors @ 522 kw, 3.3kv Chain speed 1.26 m s^{1-}(fast)
BSL:	1200mm wide, almost fully enclosed/sealed 2 x 150 kw motors at discharge end (3.3kv) Return sprocket interlaced with MG AFC drive 2 x 26mm mid board chains Klockner Becorit crusher running at 370 rpm Crusher powered by 2 x 150 kw motors, 3.3 kv
CHOCKS:	4 leg chock-shields, 800 T rating Forward and in-chock walkways Operating height 3.5m max.

NB: Sound survey results relate to the shearer travelling from tailgate to maingate cutting approximately 2.5m (leaving a bottom bench of some 0.7m) at between 10 and 15 metres per minute. Coal strength approximately 10 MPa.

DIESEL EQUIPMENT

Domino Pet)
Eimco 915) powered by Caterpillar 3306, six cylinder diesel engine -
Eimco 936) rated approximately 150 h.p.
Powertram)

Eimco 913)
Noyes MPV) powered by Caterpillar 3304/MWM four cylinder diesel engines -
Myne Buggy) rated 200 h.p. nominal

PJB - powered by a six cylinder diesel engine.

NB: All vehicles feature flame traps on induction and exhaust via wet scrubbers.

APPENDIX 3

NOISE LEVEL MEASUREMENT REGIME

1. Noise to be measured with the machine in an open area - L_{max}, L_{min}, L_{pk}, L_{eq}.

2. Measurements to be taken at the nominal operators ear position.

3. Assessment of noise levels to be substantially per AS 2012-1977 (Method for Measurement of Airborne Noise from Agricultural Tractors and Earthmoving Equipment), AS1259-1982 (Sound Level Meters) and AS1269-1983 (Hearing Conversation)

4. Noise levels at the drivers nominal left ear under the following conditions:

   a. Pumps only (m/c functions)
   b. Heads turning - head up
   c. Heads turning - head down
   d. Main conveyor and (Mid Height)
   e. E-W conveyors
   f. Heads turning and both conveyors
   g. Tramming - forward
   h. Tramming - reverse

5. Noise levels at the cable hand's position - i.e. 1 metre to the rear of the driver's cab and 1/2m to the right hand side.

6. Noise levels for the drill operator - at standbye position 1 meter to the rear and 1/2m to the left of the miner.

   Test per (5) above

7. Noise levels for the drill operators - at the operators ear for both sides of the machine.

   a. Pumps only - **in bolting mode**
   b. One drill rig working
   c. Both drill working

8. Sound sweep - to identify the peak noise emanation on the machine. To be measured at the sides of the machine only at a distance 0.5 metre from the side of the machine. Sound sweep on both sides, approx. 1.25m from ground.

   - Expected outcomes to be a noise level (worst value) and location point relative to the drivers cab (or equipment off side mark), under the following conditions:

     a. Pumps only (m/c functions);
     b. Pumps and conveyors;
     c. Pumps, conveyors and tramming.