

The Reduction of Noise & Dust from Surface Mining Plant

Richard Warrior, Colin Gregg and Mark Dowdall
The Banks Group

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Presented by:

John Willis, Richard Warrior & Colin Gregg
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INTRODUCTION

The Company

The Banks Group is a privately owned developer of surface coal mines with operations throughout the North East, North West, Midlands and Scotland. Banks Group also develops commercial and residential property schemes, wind farms and waste management facilities.

The Group owns a fleet of over 100 items of civil engineering and mining plant, including bulldozers, dump trucks, excavators, motor graders and motor scrapers which are used on various sites operated by the company.

The company operates a '**Development with Care**' philosophy and has over the last 15 years implemented continuous improvements to its environmental management system in accordance with the Banks Group Environmental Policy.

The Project

In 2002, Banks commenced a major project to reduce noise emissions from the plant and machinery within its mining fleet, to minimise the impact upon the occupants of sensitive premises in the vicinity of its operations and on the environment as a whole.

This project also aimed to ensure that operations could be carried out in accordance with stringent planning conditions for noise which were applied by planning authorities in accordance with the advice in the Mineral Planning Guidance Note 11: '*The control of noise at surface mineral workings*'. (This has now been superseded by Annex 2 of MPS2 '*Controlling and Mitigating the Environmental Effects of Mineral Extraction in England*').

The guidance requires that operators of surface mineral workings do not give rise to noise which

exceeds the background sound level by more than 10 decibels (dBA).

A number of Bank operations were planned to occur in quiet rural areas where planning conditions had been set at levels as low as 45 dB LAeq (1hour) during the day to ensure that the occupants of surrounding premises were not exposed to unacceptable intrusion from noise.

The Solution

The site design for all sites operated by Banks involves measures to mitigate against noise. Acoustic barriers called baffle mounds are usually constructed around the working area to minimise noise and visual intrusion.

However, in view of the size of plant that Banks operate, this work alone would not produce sufficient reduction in the noise levels at the nearest sensitive premises and it was decided to contact the plant manufacturers to see what if anything could be done to reduce noise to an acceptable level.

The two main manufacturers of plant used by the Banks Group are Terex, who manufacture the O&K RH120 and RH200 excavators and Caterpillar who manufacture the remainder of Banks plant fleet including CAT D400, 777, 785 and 789 dump trucks.



Fig 1. Noise Readings were taken at 10m from the front and two sides

Initial noise surveys were carried out on all items of plant at a distance of 10 metres.

Dump trucks were measured from the front and the two sides to establish the sound levels emitted

during normal operation. The excavators were measured at 10 metres from the rear and the two sides.

Noise predictions were also carried out using three dimensional noise modelling software. This established that in order for the site to achieve the planning limits for the two proposed sites the plant noise emissions from the dump trucks and excavators would need to be reduced to below 83 decibels at 10 metres.



Fig 2. 3D Noise Modelling Software

A programme commenced with a pilot study on one Caterpillar 777D dump truck.

This rigid bodied dump truck has a capacity of up to 100 tonnes of overburden material.

Baseline noise assessments indicated that the sound pressure level measured for this machine was 94 decibels measured at 10 meters from the front and 89 decibels measured at each side.

The main noise source from these dump trucks was found to be the large fan which cooled the radiator and oil coolers at the front of the dump trucks. Noise measured at the sides of the dump truck identified that the exhaust outlet and engine compartments were also significant sources of noise which needed to be attenuated.

Contact with the plant manufacturers, Caterpillar and Terex, did not provide any practical assistance in dealing with the problem on existing plant. The plant manufacturers are restricted by an EC directive which only applies to dump trucks with a power output of under 500 kW. Most of our mining plant is above the 500 kW threshold and is therefore exempt from the noise limits for external noise. It was not possible to buy newer, quieter alternatives to our plant. Banks realised that to find a solution it would need to develop and implement its own noise reduction programme.

It was therefore decided that each of the noise sources would be considered in turn developing noise insulation methods that were sufficiently robust to survive the arduous working environment of a surface mining site.

The insulation would need to be easily removable to enable plant maintenance and repairs to be carried out. In addition the noise insulation should not cause the engine to overheat.



Fig 3. The open engine compartment of a CAT 777 dump truck before insulation was fitted

The first priority was to reduce noise at the front of the dump trucks and initial consideration was given to possibly reducing the fan speed but it was felt that this might reduce the flow of air through the engine and cause overheating.

An alternative solution was to adopt a methodology for reduction of airborne noise similar to that used elsewhere in industry to control noise from air ducting and extraction systems. This involved the design of an attenuator or splitter silencer to be placed over the inlet into the radiator grill.

The attenuator design involved a series of wing shaped sections constructed from galvanised, perforated steel sheets, formed over a metal framework and filled with mineral wool. These were stacked inside an extended nose cone with an extension to the bumper on the dump truck to protect the nose cone.



Fig 4. One of the wing sections of the splitter silencer

Noise was then tackled from the engine compartment itself.

This was achieved by fitting tailor-made acoustic panels lined with glasswool insulation and protected with perforated steel sheets inside the engine compartment.



Fig 5. Acoustic panels fitted to the sides of the engine compartment on a CAT 777

Insulation was also fitted to the top and bottom of the engine compartment. The existing bonnets with were lined with acoustic material and any gaps around the bonnets were filled in.

Underside doors were fabricated on the first CAT 777 but later it was decided that acoustic quilts would be easier to remove and maintain.



Fig 6. Engine compartment underside doors – these were later replaced with acoustic quilts

In view of the difficulties in making the complex shapes required to avoid the steering mechanisms and other control arms the bottom insulation consisted of a fitted acoustic quilt which Banks' engineers dubbed 'The Nappy'. This quilt is removable to allow access for routine maintenance and repair.



Fig 7. Prototype under body acoustic quilt – Later replaced with a fire retardant type

The dump truck exhaust was the final item to be tackled. The CAT exhaust is fitted with a relatively small rudimentary silencer as standard.



Fig 8. Standard CAT 777 exhaust silencer

Banks designed and fabricated a completely new and much larger exhaust silencer with a more convoluted route for the exhaust gases. This silencer was so large that amendments were made to the location of handrails and rear view mirrors on the CAT 777, to enable the silencer to be fitted.



Fig 9. Finished Prototype CAT 777 with exhaust in position

Noise tests of this amended dump truck delivered some very exciting results. The sound pressure level measured at 10 metres from the front of the vehicle had been reduced from 94dBA to 76dBA – a reduction of 18 dBA.

Subsequent testing on site meant that the spaces between the wings of the splitter silencer had to be increased by approximately 10mm to improve air flow and this reduced the attenuation efficiency by 2 dBA leaving a net reduction at the front of this machine of 16dBA.

The level measured at the sides had been reduced by 12 dBA from 89dBA down to 77dBA

on the exhaust side and down from 89dB by 11dB to 78dB on the opposite side.

The results gave the confidence to continue with the remainder of Banks plant fleet, modifying and improving the designs for a further 16 CAT 777 dump trucks that were fitted with noise insulation.

Noise Suppression On Excavators

The same basic approach was then used to reduce noise from two RH120 excavators and the RH200 excavator. This involved fitting acoustic panels and quilts to insulate the engine compartments and fitting splitter silencers to the radiators and hydraulic oil coolers.

Modified exhaust silencers were also fabricated and fitted to these excavators. The exhausts are tightly packed with mineral wool, which absorbed noise.



Fig 10. A sound insulated Terex RH120 showing:

A - oil cooler inlet and **B** - outlet attenuators,
C - the exhaust silencers and **D** - top engine attenuators.

E - A further two attenuators are fitted inside the counterweight at the rear of the machine

On the RH200 rather than replacing the existing exhaust silencers it was decided to add secondary silencers in series to the original units.

The reduction in noise on the RH120 excavators was 12 dBA from 90dBA to 80dBA. The RH200 has been reduced from 97 dBA measured at 10 metres to 82 dBA.

A further five CAT 785 dump trucks have also been insulated as part of the programme. The work on these larger dump trucks involved fitting extended nose cone silencers similar to the CAT 777's. The biggest problem faced on the CAT 785's was the exhausts.

The original twin silencers were slotted in between the skip and the air tank, unlike the CAT 777 or RH200 there was insufficient room to relocate the silencer or fit a secondary silencer. It was decided to replace the originals with a new type that would use all the available space.



Fig 11. Modified CAT 785 exhaust silencer

The 785 also uses a large underside quilt similar to the 777's 'Nappy'.



Fig 12. CAT 777 Underside quilt (The Nappy)

Due to the size and complexity of the CAT 785's engine compartment, it was decided to use a 'flame retardant' quilt, similar in construction to the 'Nappy', on the engine sides – rather than a steel panel and door construction. This initially saved time and was easier to install on site.

The sound level of the five CAT 785 dump trucks has been reduced from 93 dBA to 80dBA.



Fig 13. CAT 785 engine compartment – using quilts rather than panels and doors

Banks has also acoustically insulated seven CAT D400 articulated dump trucks with a reduction from 85dBA to 80dBA and two CAT 789 dump trucks the biggest dump trucks in Banks' fleet from 94dBA to 80dBA

Plant	Before (dBA)	After (dBA)	Reduction
CAT 777	91	80	11
CAT 785	93	80	13
CAT 789	94	80	14
CAT D400	85	80	5
O&K RH120	90	80	10
O&K RH200	97	82	15

Table 1 Sound level measurements taken on all plant at 10m before and after insulation

The initial design and modifications of all the plant discussed, has achieved remarkable results, but the harsh working environment on the surface mines caused damage to some of the insulation materials.

The initial materials that were used on the CAT 777 and CAT 785 exhausts were found to be insufficiently robust requiring an upgrade to the fleet to give a reasonable service life.



Fig 14. Damage to CAT 785 Engine side quilt

The underside quilts have also been modified on more than one occasion, to avoid them being ripped off.

The weight of the quilt was also reduced so that it could be easily removed, allowing access for servicing, inspections and cleaning of the truck. Banks are continually upgrading designs and materials to improve service intervals and ease of access for servicing.

All items of plant used on the noise sensitive sites have been fitted with 'Brigade' BBS TEK broad band reversing alarms which have proved to be very effective at reducing adverse comments from local residents whilst still providing an effective audible alarm in the vicinity of a reversing vehicle.



Fig 15. All mobile plant is fitted with Brigade broad band reversing alarms

In recognition of this work Banks were awarded the John Connell Award for Innovation by the Noise Abatement Society in 2004. The following year Banks received the NAS Environmental Pioneer Award in recognition of on the noise and dust control programme.

The same year Banks were also awarded two awards from the Governments coal mining regulators, the Coal Authority, for demonstrating environmental excellence at the Pegswood and Delhi surface mines operated in Northumberland.



Fig 16. Banks were presented with the NAS John Connell Award by David Blunkett MP at the Houses of Parliament in 2004

PROJECT TWO – DUST

Banks Group is also committed to reducing levels of airborne dust in and around its surface mines. In 2004 Banks commenced another major project to design and fit new dust suppression techniques.

Dust from surface mining operations can be emitted from a variety of activities including the movement of mobile plant along dry, un-surfaced haul roads, the excavation of overburden and loading into dump trucks and the tipping of excavated material to form an overburden store or to backfill.

The stocking and processing of coal can also lead to fugitive emissions of coal dust if appropriate mitigation measures are not applied.

Dust Generated on Haul Roads

Banks had traditionally used agricultural tractors and bowser which provided effective dampening to the haul roads of smaller surface mines. However as the distance from the re-filling lagoons to the haul roads of the larger sites grew – the time spent dampening the haul roads was reduced due to the amount of time taken to travel back and to fill up at water storage lagoons.



Fig 17. Using an agricultural tractor and bowser is effective on smaller sites

Banks initially tried a 'Spinning Disk' attachment fitted to the existing tractor and bowser to reduce the amount of water discharged onto the haul road. This extended the time spent dampening the haul road but due to the large width of the roads a second pass was required.

This system is useful on smaller sites or construction sites where there may be a restricted water supply, but on its own it did not provide a satisfactory solution for surface mining sites.

Banks strategy was to increase both the capacity of the bowser and the area that could be quickly dampened.

A Volvo A35 dump truck was converted to carry 25000 litres of water and fitted with two 'fishtail sprays' to the rear to apply water to the haul roads and a water canon for spraying over the tipping and stockpile areas.



Figs 18 & 19. A Volvo A35 dump truck converted into a water tanker with two 'fishtail' sprays for wide haul roads and a water canon

The new larger capacity tanker reduced the number of times the driver had to handle the heavy suction hogger, required to load water from a storage lagoon and also reducing the risk of injury and potential accidents.



Fig 20. The filling station takes approximately 6 minutes to fill 25000 litres

Re-filling times were further reduced by developing a water filling station. Water is pumped from the mining void to a storage lagoon and in turn

pumped to the bowser via a submersible pump. The tanker is fitted with a remote control and when the driver has positioned the vehicle under the hanging water pipe he can operate the pump without getting out of the cab.

The time taken to fill the tanker is approximately six minutes and generally the tanker takes approximately 30 minutes before it requires a re-fill.

Fugitive Dust from Excavation

The next source of dust considered was the excavation of overburden and loading into dumptrucks.

Mist sprays positioned in strategic positions on the boundary of the site near sensitive areas was one idea which had been practiced by the company at two sites during the 1990's. This was found to be very expensive and not very effective or sufficiently flexible for the constantly changing working area in a surface mine.

Banks strategy here was to reduce dust emissions at the source of emission. Experiments were carried out, strapping a diesel powered pressure washer to the back of an RH120 excavator supplied with 1000 litres of water stored in a plastic tank.

A flexible pipe was attached along the boom of the excavator and positioned with a few nozzles over the bucket and two on the front of the machine spraying under the bucket.

The tests were very encouraging with a spray of fine water droplets directed over the source of the dust. It was decided to design and install a full working system and fit it onto one of Banks RH120 excavators for further tests.

Providing sufficient water storage capacity was a major challenge to ensure that the system would not reduce production of the machine. The system was design to have sufficient capacity to be re-filled quickly at break times only. Banks estimated that it would require approximately 6000 litres of water to last for one day. The top deck of the RH120 was only big enough for one cubic meter lube-cube, which did not have the required capacity, so it was to build stainless steel tanks that would hang from the sides of the machine like panniers.



Fig 21. Terex RH120 fitted with water tanks holding approximately 6000 litres

A pump was required that could be powered by the machine and operated by the driver – the diesel powered pressure washer was not suitable. Initially a hydraulically powered pressure washer pump was used but after further trials it was clear that it was working at its maximum rate and although effective for the smaller RH120 excavator it would be further improved when it came to fitting a system on to the larger RH200. Another hydraulically powered pump used in the drain cleaning industry was sourced.



Fig 22. Spray Bars fitted to the excavator bars

The driver operates the system by pressing a switch on his joystick, energising a 'mag-clutch' connected to the hydraulic pump. This then powers the hydraulic motor on the water pump.

A number of pressure washer nozzles were fitted to a spray bar arrangement above and below the boom. These spray bars have been re-positioned on a number of occasions for the best performance.



Fig 23. 10 Tanks fitted to the RH200 – total capacity 16000 litres

Increasing the pump size increases the water used and requires a corresponding increase in waster storage capacity. A similar arrangement to the RH120 was designed to store the water with the extra capacity provided on tanks stored above the walkways.

The thickness of the stainless steel used for the fabricating the tanks was increased to make them more robust than the tanks fitted to the RH120 prototype and 10 smaller tanks were used on the RH200 in place of the two larger tanks fitted on the RH120. The water capacity was increased to approximately 16000 litres.

Although fitting a much larger pump, mag-clutch and tanks meant a higher cost, the dust reduction is exceptional so much so that when fitting a system a second RH120 Banks selected the same pumping system as used on the RH200.

On the second RH120 excavator Banks installed four larger tanks which were modified to increase the strength.



Fig 24, 25 and 26 The RH200 with dust suppression

Dust from Processing

Dust mitigation on coal processing plant routinely involve fitting of water mist sprays over feed hoppers and conveyor belts and drop chutes at discharge points. Banks has also developed automatic spray systems on some of our coal processing and stocking areas to reduce dust from open stocks and vehicle movements.



Fig 27. Dust Chute – fitted to the crushing plant at Delhi Surface Mine



Fig 28. Fine mist sprays fitted to TESAB Coal Crusher

Dust From Open Storage Areas

One of the largest automatic dust control systems that Banks has designed and installed is to provide irrigation to cover a coal stocking area of 430m long x 100m wide. This system has been installed at the Port of Blyth and consists of seven galvanised spray head towers, using Polaris spray heads.

The Polaris Spray Heads have a range of approximately 65m, depending on nozzle size and weather conditions.



Fig 29. Polaris Rain Head gives a 65m throw

The system is powered by a 55kW motor connected to a Lowara pump which pumps the water via 6 inch plastic butt-fusion welded pipe-work.



Fig 30. Lowara High Pressure water pump with 55kW Motor and Pressure Relief Valve

At Port of Blyth each tower is operated automatically from a Programmable Logic Controller (PLC) which is set up to spray for two minutes duration per head. On completion of its full cycle the system lays dormant for approximately one hour then recommences.

Between Spray Head operation the pump returns water back to the tank via a pressure relief valve (PRV). Any spray head can be selected to run by switching it on at the control panel with the system set to Auto.

Towers can be turned off from the control panel & the system will then bypass the tower and carry on with the spray cycle.

There is also a canopy mist system for train loading which is independent of the auto system and this can be operated at any time for any duration using 'On/Off' controls on the panel.

Individual operation of each spray head is possible by turning the system to manual if for instance there is a particular dust problem in a certain area of the site. Alterations to the timing cycles can be done by using a laptop to suit site conditions.



Fig 31. Polaris Rain Head operating in sequence at the Port of Blyth's 430m long Coal Compound. The system was designed and installed by HJ Banks Environmental Services in 2006.