# THE CONTROL OF NOISE IN THE FOUNDRY INDUSTRY

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## INTRODUCTION

The Foundry Industry is involved in the casting of molten metal into prepared moulds in order to produce engineering or decorative components which because of their complexity of shape would be difficult, if not impossible to create by other means such as cutting. While most common metals are cast for one purpose or another, by far the greatest tonnage produced is in the steel-founding and iron-founding industries.

## NOISE EXPOSURE

The diversity of techniques and tasks undertaken in the Industry, together with the variation in the degree of automation utilised, makes it very difficult to generalise as at workers' levels of exposure to noise. To give some idea, however, Figure 1 provides an indication of levels in a labour-intensive iron foundry with some 100 or so workers. To summarise, an analysis of the noise exposure levels of tasks associated directly with the moulding/casting process, ie discounting such tasks as pattern-making, core-making, fettling and machining, is presented in Table 1.

Table 1 Summary of exposure to noise in the Foundry Industry

EXPOSURE LEVELS OVER 8-HOUR WORKING DAY

| Less than 85dBA | 85-90dBA | 90-95dBA | 95-100dBA | 100-105dBA |
|---|---|---|---|---|
| 0% | 8% | 25% | 28% | 39% |

If we assume that forthcoming EEC-based legislation will set a daily personal noise exposure level of 90dBA initially, with the intention that this criterion shall be reduced to 85dBA, it is clear that the Foundry Industry has very serious problems. A variety of associated but subsidiary tasks which have been left out of the analysis above are also noisy, including:-

| | | |
|---|---|---|
| Pattern-making | : | 86dBA |
| Fettling, shot-blasting machine | : | 96dBA |
| " manual shot-blasting | : | 114dBA * |
| " disc grinding | : | 100dBA |
| " pedestal " | : | 95dBA |
| " swing-frame " | : | 94dBA |

* Note that this operation is carried out in a booth, primarily to retain the grit. The worker is heavily dressed in safety clothing which includes boots, chaps, apron, gauntlets and a pressurised helmet to exclude dust. We have experienced situations where, in order to get the helmet on the operator has to discard his ear-muffs; no-one had thought to suggest he replace them with ear plugs! The result was that his 8-hour dose of noise exposure was received within about the first ten minutes of work, even allowing for a small

THE CONTROL OF NOISE IN THE FOUNDRY INDUSTRY

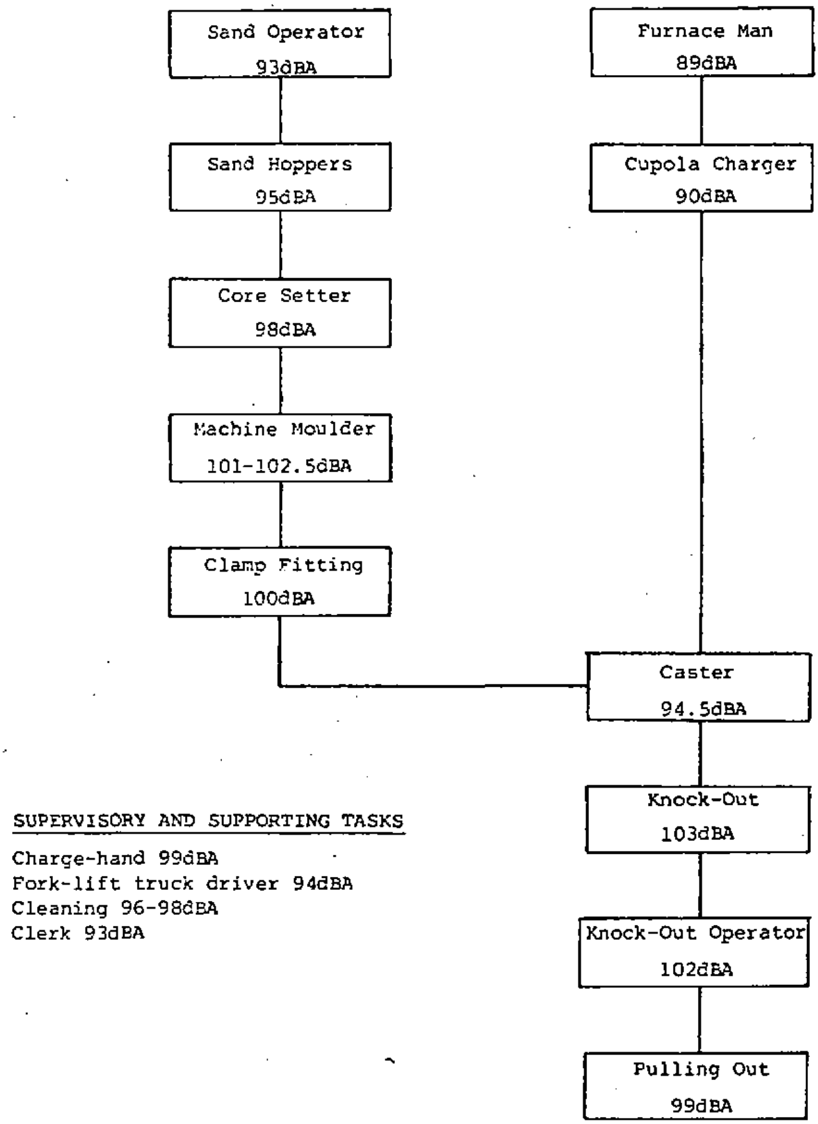



FIGURE 1 Daily equivalent continuous sound levels of occupations within a labour-intensive iron foundry

amount of attenuation to be provided by the helmet and ignoring any additional contribution to noise from the air supply.

There is evidence that despite the presence of the Wilson Report, the Yellow Peril, and The Health and Safety at Work, etc Act, several foundries within the United Kingdom have, even at this stage, still not carried out a noise survey, let alone embarked upon a programme of noise control. Nevertheless, the Industry does recognise its future responsibilities and in order to alert foundry-men to the implications of impending legislation a conference was held in Birmingham earlier this year, the theme of which was that noise in the foundry is Everybody's Problem.

BACKGROUND NOISE

While noise exposure in the foundry is usually considered to be caused by the machines and processes in which the workers are directly involved, it is important not to overlook the contribution to total noise at the ear which is caused by essentially steady background noise. Levels of background noise vary from foundry to foundry and from one part of the foundry to another. However, typical levels without any production taking place can vary from 80dBA to over 95dBA. Consequently, such levels will influence many workers' noise exposure to some extent and there are benefits to be gained from quietening the contributory sources.

Background noise is generally caused by one or more of the following:-

| | | |
|---|---|---|
| Furnaces | : | 90dBA |
| Cupola fans | : | 90-98dBA |
| Shop ventilation | : | 80dBA |
| Dust/fume extract systems | : | 80-85dBA |
| Compressors | : | 85dBA |
| Poor maintenance | : | Up to 90dBA |

Anyone with even a relatively basic knowledge of industrial noise control will recognise that standard and well-proven solutions such as duct attenuation acoustic enclosure, screening and attendance to basic maintenance requirements can potentially handle most of the above sources. The technical difficulties and cost of reducing these problems to a net result of less than 80dBA are small.

It is worth expanding on the matter of maintenance because all too often one comes across examples of noise problems which are the direct result of poor or total lack of maintenance. While it is recognised that foundries are very hostile environments in which to operate machinery becuase of dirt, high temperatures, fumes and dust, etc, there is no doubt that by maintaining the plant to avoid noise problems, operational efficiency will be improved. Examples where lack of maintenance is particularly noticeable in increasing noise are:-

Fan bearings. In extreme cases bearing wear can cause the impeller to touch the casing. Not only will substantial noise be caused but also the additional load could result in the drive motor overheating.

Fan out-of-balance. Wear of the impeller or an uneven build-up of dirt on the impeller can cause noise and/or vibration problems, and accelerate wear.

THE CONTROL OF NOISE IN THE FOUNDRY INDUSTRY

Absorptive silencers. The common problems are break-down of the absorptive in-fill and clogging of perforated inner liners. The latter problem is typical of wet collectors which have been permitted to run dry and of dry dust collectors. Clearly, operational practice should include a standard cleaning procedure at regular intervals. If a silencer becomes clogged its acoustic performance can be totally negated. In extreme cases this could occur within one or two weeks following cleaning.

Compressed air systems. Leakage at joints and fractured pipework will cause excessive high-frequency noise. Also, the cost of wasted compressed air can be considerable. Because we can't see air leaking to waste we tend to ignore it; in practice, even small continuous leaks can account for 80% of the air which has to be compressed.

Vibration isolation. Again, the severe operating environment can cause break-down of vibration isolation mounts. It is important that the initial selection of vibration isolation products and materials, together with their protection in use, is given adequate consideration.

General engineering, fasteners, etc. Nuts and bolts working loose, and not being replaced correctly after servicing are often responsible for noise from vibrating plant.

## MOULDING MACHINERY

Reference to Figure 1 shows that the workers who are operating the moulding machines - commonly known as jolt/squeeze machines - are subjected to a daily exposure of typically 101 to 102.5dBA, and therefore require considerable attention to their noise exposure.

The essential description of the operation is that a mould-box, which is simply a four-sided box without top or bottom, is placed on the table of the jolt-squeeze machine to which is already attached a half-mould pattern. An over-head hopper containing moulding sand is then opened to permit sand to fall into and fill the mould box. At the same time the table vibrates vertically in order to compact the sand into the mould box. When the box is full to overflowing, the sand flow and the vibration are both stopped, a platten is swung across over the top of the mould box and the table is raised in order to squeeze the sand down into the box. The whole operation occurs in a short time and Figure 2 shows a time history recorded during normal production when several machines were operating together. Not only is the graph complicated to analyse, but where there is a great deal of shop-floor activity with production taking place all round the measuring station, it is exceedingly difficult to keep an eye on the action, whilst at the same time noting the noise events being displayed on the time history. Each type of machine or process should, therefore, be examined in turn with the minimum of background noise.

FIGURE 2 Production Noise Adjacent to Moulding Machine

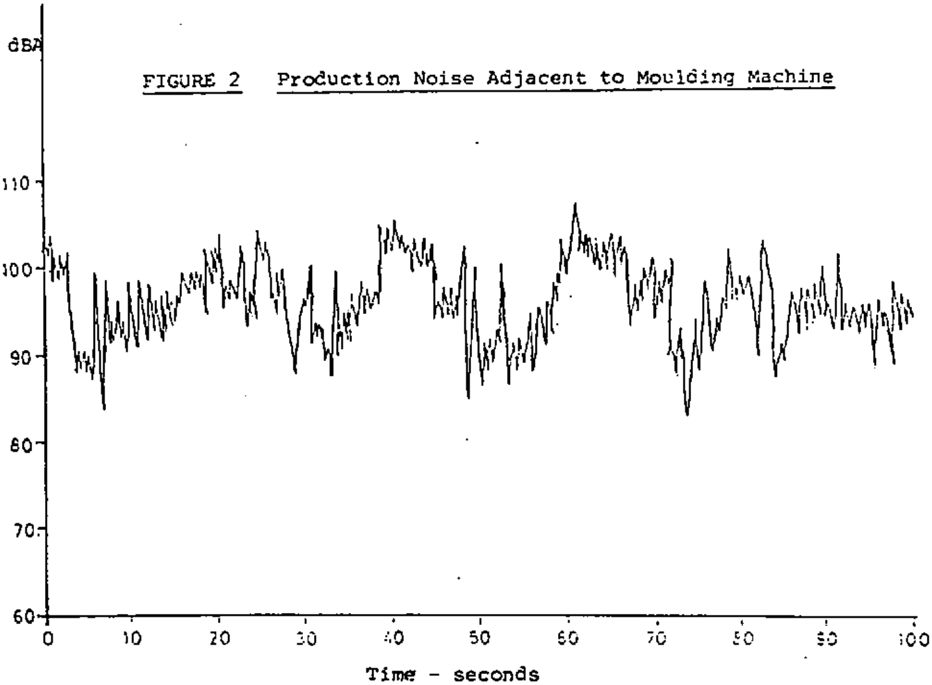
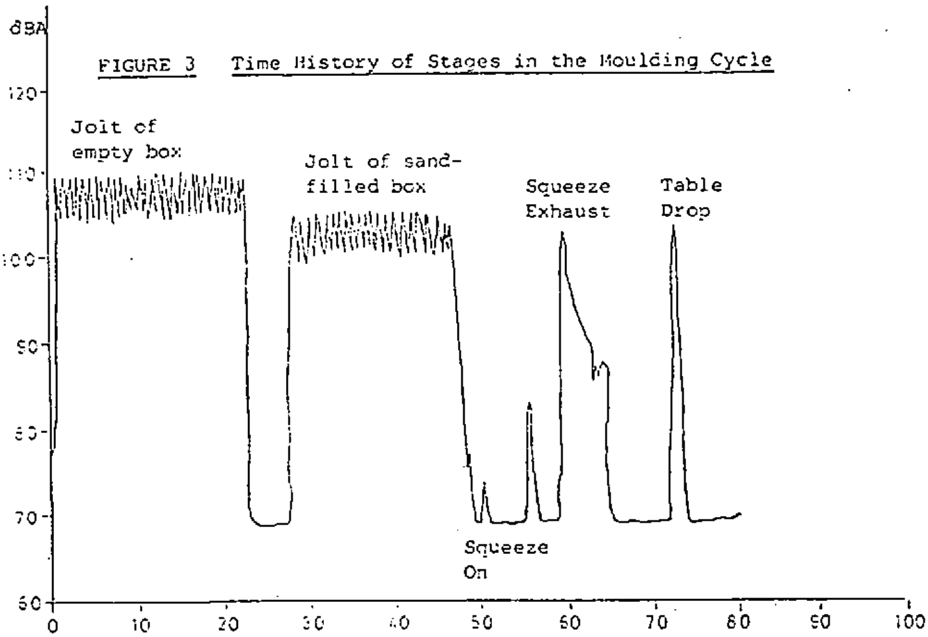



Figure 3 shows that jolting should not be initiated until there is sand in the box, thereby reducing the emission of noise by 4 or 5dBA. Even then, the jolting action should be kept to the shortest possible time in order to minimise the equivalent continuous sound level involved in mould production. It was also concluded that there is no justification in applying silencing to the "sqeeze on" cycle, although the "squeeze-exhaust" stage certainly required attention. A separate investigation, on the level of impact noise produced when the table of the machine was dropped to its start position, showed that if the lowest possible table latch position was utilised, then reductions of up to 9dBA in table impact noise might be attained. An alternative solution to impact noise would involve the use of energy-absorbing buffer stops or parallel shock-absorbers to cushion table fall.

FIGURE 3 Time History of Stages in the Moulding Cycle

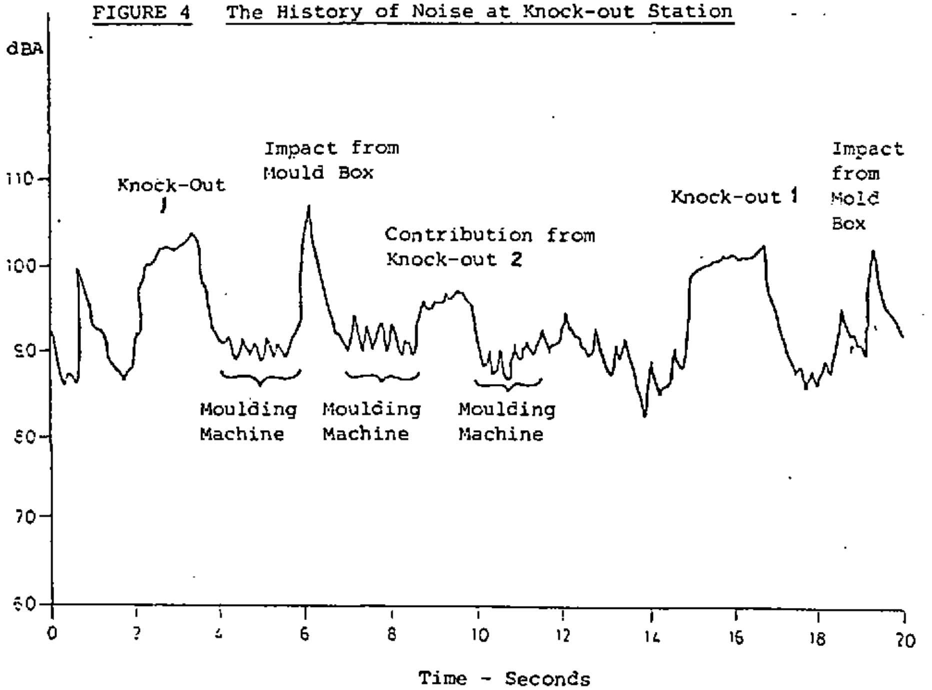



KNOCK-OUT NOISE CONTROL

A complete mould consists of two half-mould boxes filled as described above and then clamped face-to-face. After the mould has been filled with molten metal and allowed to cool sufficiently for the casting to solidify, the casting has to be removed from the mould. This is done by vibrating the mould either on a steel deck or on a suspended knock-out rig. In both cases, vibration causes the sand to break up and drop out of the box, together with the casting which can be raked clear. As was seen in Figure 1, knock-out workers will suffer up to 103dBA from an un-treated suspended knock-out system, together with associated noise-producing activities in the area. These latter include the now empty mould boxes being dropped back onto the steel-decked conveyor track.

Figure 4 shows the time history of noise at the ear of the employee responsible for operating a vibratory knock-out. Several distinct events occur in quick succession and, indeed, some may even occur simultaneously. In this particular case, there were two similar machines being operated in close proximity and consequently the operator of one machine was being subjected to noise from the second machine, as well as receiving background noise from other parts of the foundry. Consequently, as well as receiving noise from his own vibratory knock-out machine at a level of 100-103dBA, together with a peak impact level of 106dBA when the empty moulding box was thrown back on to the conveyor track, the operator was also affected by the second knock-out machine at 96-97dBA, empty moulding boxes from the second knock-out station peaking at 94-97dBA, and nearby-by moulding machines which contributed up to 92dBA. The damaging effect which each of these sources would have depends not just on the sound pressure level but also on their duration. Consequently, the vibratory machine itself could be a more serious noise source than the impact noise from a moulding box falling on the track, even though the latter produced the higher amplitude.

FIGURE 4 The History of Noise at Knock-out Station




A series of experiments carried out involving the dropping of moulding boxes produced the following results.

| | |
|---|---|
| Standard box dropped on to steel plate from maximum height: | 105dBA peak |
| Deep box dropped onto steel plate from lowest practicable height: | 102dBA peak |
| Standard box dropped on to steel plate from lowest practicable height: | 97dBA peak |
| Standard box dropped on to damped steel plate from lowest practicable height: | 92.5dBA peak |

These results serve to show, first, the value of analysing noises at source, and second, just how effective simple noise-control can be in making substantial overall improvements.

THE CONTROL OF NOISE IN THE FOUNDRY INDUSTRY

## EFFECTIVE NOISE CONTROL

There is no doubt that a comprehensive understanding of the mechanics which produce noise will lead to the selection of the most cost-effective solution. To aid this selection it would be very useful if a list of all possible solutions to noise problems in the foundry could be coupled to the degree of noise reduction which each would produce. Unfortunately, the ideal solution in one case, turns out to be inappropriate in the next. The most important conclusion is that thorough understanding of the mechanics of the problem will lead directly to the obvious solution.

To provide some indication of what can be achieved by way of noise reduction in the foundry, a number of examples are listed below:

| | | |
|---|---|---|
| Elimination of compressed air-leakages | : | up to 20dBA |
| Silencing of compressed-air blow guns | : | up to 25dBA |
| Silencing intakes of forced-draught fans | : | up to 10dBA |
| Silencing fume-extraction intakes | : | 10dBA |
| Cladding of fume-extraction fan systems | : | 10dBA |
| Reduction of furnace roar | : | 5dBA |
| Screening of furnace from working area | : | 12dBA |
| Damping of impact surfaces | : | up to 8dBA |
| Mechanical maintenance | : | up to 10dBA |
| Silencing of hydraulic systems | : | up to 15dBA |
| Acoustic enclosure of hydraulic pumps/compressors | : | 25dBA |
| Avoiding need to jolt empty moulding boxes | | 5dBA |
| Reduction in number of jolts per cycle | | 3dBA |
| Provision of sound havens | : | up to 30dBA |
| Silencing of pneumatic clutches | : | 20dBA |
| Relocation of employees away from noisy area | : | at least 5dBA |
| Reduction of vibratory-screen running time | : | up to 5dBA |
| Introduction of new machinery | : | up to 10dBA |

Finally, whilst no one should be under any illusion that compliance with forthcoming legislation will be easy for the foundry industry, it is essential to recognise that the level of technology now available for the diagnosis and solving of noise problems is not only high, but continues to develop.

# NOISE CONTROL IN THE COAL MINING INDUSTRY; THE UNDERGROUND NOISE ENVIRONMENT

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## HISTORICAL BACKGROUND AND CHANGES IN TECHNOLOGY

Although a degree of mechanisation of coal mining was introduced into some British coal mines before the first World War, the major changes from hand getting or partially mechanised operations to fully mechanised mining have taken place during the last thirty years.

Unfortunately, reliable information on noise levels underground prior to the 1960's is not available but it is likely that occupational noise levels were not generally excessive in terms of currently accepted criteria. However, there were notable exceptions to this, an example being a coal face where hand held compressed air powered picks were used to excavate the coal and break up the larger lumps.

There were also variations in extraction methods in different coalfields which gave higher noise exposures in some Collieries, compared to others elsewhere. Traditional methods of "long wall" mining with individual "stalls" or work places involved the excavation of coal by undercutting, drilling and blasting followed by hand loading into wheeled tubs or on to belt conveyors.

Ventilation was effected by simple arrangements of doors and sheets with little or no powered assistance. Transport of mineral and materials, until the advent of belt conveyors, was by wheeled tubs and steel rope haulages powered by remote engines, sometimes located at the pit top.

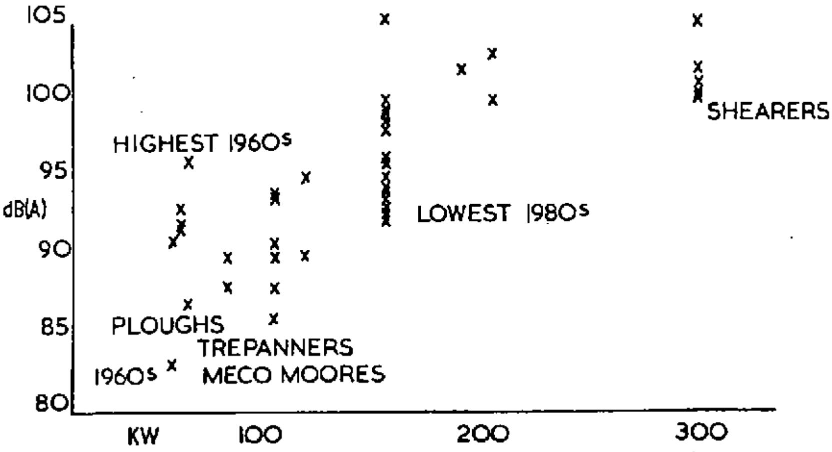
A typical modern Colliery, where 20,000 tonnes of coal can be produced from a single coal face in one week provides a significant contrast.

On such a face, the shearer cutter/loading machine will typically be of 300 kW and produce noise levels up to 105 dB(A) at the operator during cutting.

Over the main period of mechanisation, noise levels measured at coal face getting/loading machines have increased [1]. This increase can be related to greater power, speed and seam thickness extracted at each pass of the machine.

Although face conveyor noise increased significantly with the introduction of armoured chain conveyors, there has recently been an indication of a reduction on some faces. This has resulted from the elimination of fixed machine haulage chains, the introduction of heavy duty chain conveyors with increased mass, and the damping effect of a deep layer of mineral being conveyed with fewer interruptions to continuous flow.

The mitigating factor in regard to noise at the coal face is that manpower has been reduced by more than 75% when compared to the days of hand loading.




COAL FACE CUTTING/LOADING MACHINES
OPERATORS EAR

Elsewhere underground, the conventional method of tunnelling involving drilling, blasting and loading has generally given way to semi-continuous methods utilising large and powerful cutting/loading machines.

There have been some benefits from the change, in that compressed air drilling with its associated very high noise exposures, typically in excess of 105 dB(A) LEQ (8 hours), have been reduced. However, this technique is still necessary in very hard strata and in large diameter shaft sinkings.

Machines used to excavate access tunnels cut the rock using either arrays of picks in a flat mat or picks mounted in a boom rotating type cutting head. The main noise source to which the operator is exposed is therefore usually pick impact on the strata. However, noise from on-board hydraulic power packs and electric motors can also contribute significantly to the noise exposure of the operators.

Other significant noise sources required with tunnelling work are auxiliary fans and duct work often associated with dust filtration units. These have also increased significantly in power capacity and noise levels in recent years.

New drivages are now often ventilated by 90 kW fan units, compared to 25 kW units of 10 years ago.

NOISE CONTROL IN THE COAL MINING INDUSTRY

BRITISH COAL POLICY

Faced with this general increase in noise levels how does an organisation with a work force of 134,000 spread over 104 collieries deal with the problem?

The adopted policy is directed towards legislation both current and forthcoming, but far more important is our obligation to the health and safety of our work force. A major initiative was launched in 1985 which strengthened previous work, this was known as the Managers scheme for noise control. The organisation for the control of the scheme is headed by the Manager of Mine Environment at the Headquarters Technical Centre who has an engineer co-ordinating all the work on noise control. Also based at the Technical Centre are a team of Research Engineers whose task is to work on long term problems raised by the industry.

At each of the nine area coalfields an engineer is responsible for noise control at the collieries within their domain. This leaves a responsible person at each colliery and outstation to carry out noise surveys, often assisted by noise measurers.

Having established an organisational structure, major policy has been directed under six headings:

1. Training and Education
2. Research
3. Suppliers Policy
4. Audiometry
5. Hearing Protection
6. Measurement and Control.

Training and Education

The first problem was to train each colliery and outstation nominee to a suitable level of competence. Courses cover subjects in Basic Acoustics, Principles of measurement, Legislation, Noise Control (including practical solutions), Medical aspects and Hearing protection, and an introduction to the current research topics is presented.

Many areas hold in house conferences for all levels of senior mangement to keep them aware of major changes in policy.

A comprehensive training package has been produced for use at our many training centres where sessions on noise are incorporated in many other courses. This still leaves an extremely large proportion of the workforce who will not receive any education into the problems of noise within the industry. To cover this problem, it is proposed that all employees will be given a hand book which will cover both the awareness of the problem of noise and give and introduction into the Corporation's policy. This will be followed by a poster and video promotion. The National Union of Mineworkers have recently offered assistance in a joint promotion on noise and hearing protection, an encouraging initiative.

Research

As previously mentioned all topics are directed by the need of the industry and Manager Mine Environment directs the research programme to these ends. Topics under review will be discussed later.

Suppliers Policy

An initial voluntary code to obtain noise emission levels from suppliers was unsuccessful. A proposal has been given to the Board's Technical Directors for an approval scheme which will ask manufacturers to reduce the noise level measured at the operator of a machine to 90 dB(A) in the working environment. After the initial approval has been granted any further orders for the same machine when delivered will be accompanied by a test certificate ratifying levels in the approval before the machine is accepted.

Audiometric Services

At present audiometry is carried out in house on new entrants and re-entrants and also on men regularly exposed to +105 dB(A). These +105dB(A) men are re-examined annually.

It is proposed to erect audiometric booths at all major collieries, with smaller units and outstations (Workshops etc) served by a four booth mobile unit. Tests will then be carried out on new entrants and re-entrants who will be re-examined after 12 months service and then at four yearly intervals; for existing employees the frequency will be every four years. If any test indicates a slight hearing loss,-the subject will be retested within 24 months.

Hearing Protection

Policy for hearing protection is contained in Notes of Guidance. These notes set out a system for the selection and distribution of protectors from an approved list in order to give the correct level of attenuation to suit the working environment. It is proposed to replace protectors regularly (ie 3 months) rather than adopting any form of maintenance scheme.

Pressure is being applied by our legal department to apply compulsory wearing of protectors in plus 90 dB(A) zones, negotiations with the unions are to take place, and it is hoped it could become a condition of employment.

NOISE MEASUREMENT AND CONTROL

The main problems with measurement and assessment, apart from the obvious physical difficulties underground, are firstly limitations on instrumentation;

all instruments must be "intrinsically safe" (IS), and secondly, the variability of noise sources, operator positions and other variables such as type of strata and speed of cutting.

At the present time, the "Manager's Scheme for Noise Control" requires that all workplaces and other areas where men may be exposed to significant noise, must be surveyed.

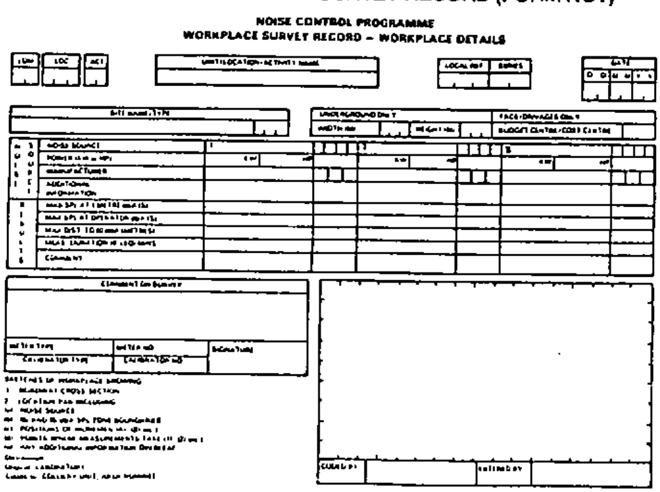
The method used is to measure maximum dB(A) levels at a reference point of 1 metre from each noise source and at the operator's working position for each source. The 90 dB(A) boundaries are also defined. Where noise is variable, sample "average" levels using the sound level meter in Leq mode are measured. This could be, for example, cutting noise from a tunnelling machine at the operator's ear.

The information is recorded on a standard survey sheet which is also computer coded for input to a data bank. Zones with levels above 90 dB(A) are coloured orange or green dependent on whether they are normally manned or not. In the near future, it is likely that 85 dB(A) zones will also be identified to comply with the forthcoming legislation.

Where possible, an assessment is made of whether men are exposed to 90 dB(A) LEQ (8 hours) or above. Dosimeters are normally only used if noise exposure is very high or there is great variation in noise exposure.

For routine surveys, each mine has a CEL 283 (IS modified) sound level meter. More detailed surveys are carried out by Area HQ staff using a CEL 193 (IS modified) sound level meter with attached octave filter set.

WORKPLACE SURVEY RECORD (FORM NC1)


NOISE CONTROL PROGRAMME
WORKPLACE SURVEY RECORD – WORKPLACE DETAILS

The first method of noise control is to plan work areas so that men and noise sources are kept as far apart as is practicable.

The siting of auxiliary ventilation fans, conveyors drive heads, transfer points and loading points, compressors, hydraulic power packs and pumps all come into this category.

Control can be effected at source, for example, in the damping of impact noise at mineral transfer points, or noise can be reduced by enclosure of a man or machine, although the latter option requires care in some underground locations where heat build up can be a problem.

Noise specifications are drawn up for all major new installations of fixed plant such as main mine fans, winding engines, etc. for the Corporations contractors.

## FUTURE DEVELOPMENTS

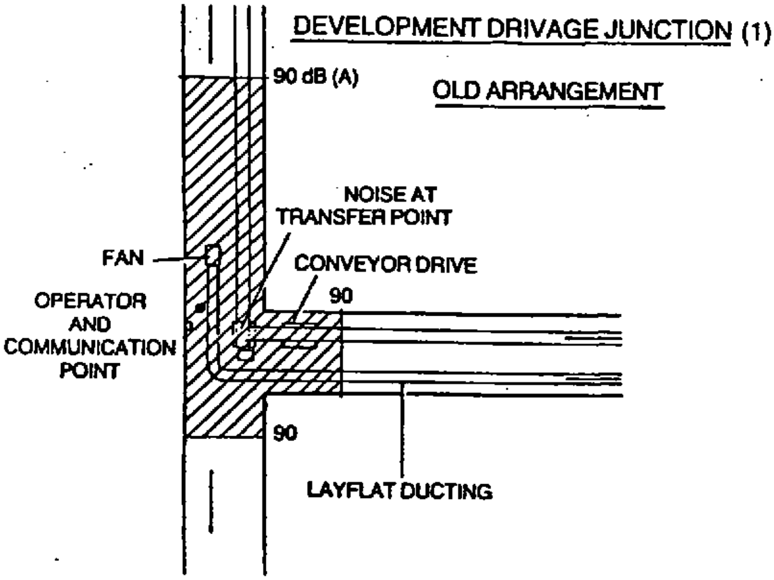
To assist in the planning of new installations a computer program has been developed to predict the noise climate in any working environment either on the surface or underground. This program is called NOISPRED [2].

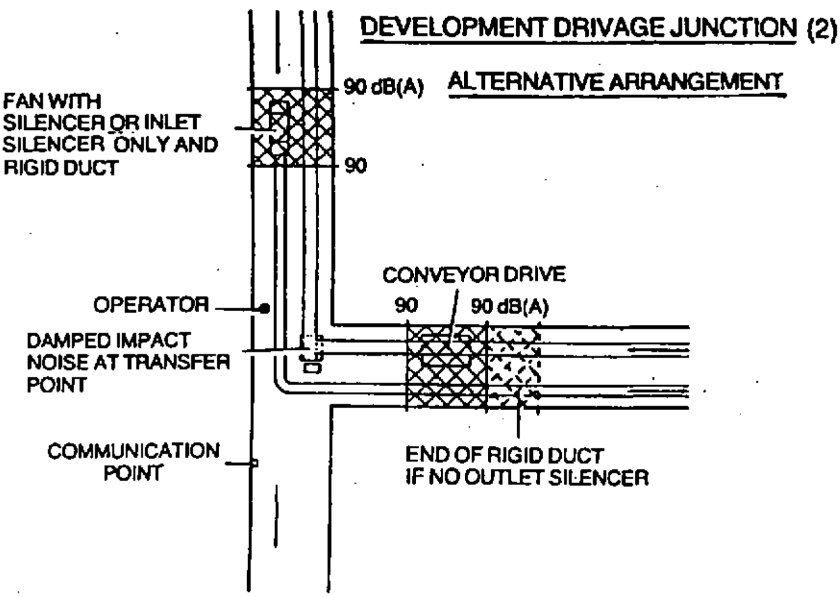
It operates by first defining the boundaries of the environment, which could be for example a coal preparation plant or an underground development heading. The noise sources are then positioned within the boundary and the noise data for each source in terms of either its sound power or sound pressure level at one metre is input to the computer. The noise climate generated by the interaction of the various sources is then plotted in the form of noise contours. Results can be given in dB(LIN), dB(A) or any octave band which may be selected.

Transporting the personnel to their workplace within the mine often subjects them to excess levels of noise, for some people up to an hours travel per day. Research work into quieter manriding systems originally looked into the wheel/rail as the source of the noise. Since in most cases we are dealing with well worn wheels running on track of relatively poor standard it was soon evident that gains from dealing with this source were to be minimal. So taking a leaf from other rail operators, greater success has been obtained by totally enclosing the cars and adding internal absorption. A reduction of up to 10 dB(A) has been achieved. Ventilation of these cars by means of acoustically lined ducts has made total enclosure acceptable to the work force.

Fans are a major noise source within the mining industry; from large main units for total mine ventilation to smaller auxiliary units of up to 90 kW power, for local ventilation underground.

Manufacturers of auxiliary fans have been asked to carry out major redesigning and it is hoped that the increased efficiency as well as power savings will lead to a reduction in the noise emission from the units.


DEVELOPMENT DRIVAGE JUNCTION (1)
OLD ARRANGEMENT
90 dB (A)
NOISE AT TRANSFER POINT
FAN
CONVEYOR DRIVE
90
OPERATOR AND COMMUNICATION POINT
90
LAYFLAT DUCTING


DEVELOPMENT DRIVAGE JUNCTION (2)
ALTERNATIVE ARRANGEMENT
90 dB(A)
FAN WITH SILENCER OR INLET SILENCER ONLY AND RIGID DUCT
90
CONVEYOR DRIVE
OPERATOR
90
90 dB(A)
DAMPED IMPACT NOISE AT TRANSFER POINT
COMMUNICATION POINT
END OF RIGID DUCT IF NO OUTLET SILENCER

NOISE CONTROL IN THE COAL MINING INDUSTRY

In addition fans are the main noise source on prime movers when they are used for cooling purposes. Most cooling systems have been reliant on steel plate blades in the construction of the fans. A typical unit being run at 3,000 rpm, by redesigning the blade profile and casting it in a durable resin to give the same air flow as the plate bladed unit it has been possible to reduce the rotational speed to 1600 rmp. A 12 dB(A) noise reduction has been achieved. Reductions in noise levels have been obtained by redesigning the cooling fan of a bi-directional electric motor. On one such unit a reduction of 8 dB(A) has been obtained.

Many machines in the mining industry transport the mineral away from the cutting area by means of a scraper conveyor, ie steel flight bars pulled by a chain across a steel trough.

Impact noise is produced by the various steel elements reacting with each other, and then being radiated by the large steel decks of the troughs. To reduce this noise, laminated decks using an air gap damping technique has been tried. Initial tests show that this considerably deadens the radiating surface offering a reduction in the noise emitted of up to 10 dB(A) [3].

Many of these developments mentioned have recently been incorporated into the modification of the design of a large road heading machine which in its original form subjected the operator to noise levels of 97 dB(A) when not cutting. By alterations to the hydraulic circuit, then building these hydraulics into an enclosure, modifying the cooling fan on the main electric motor and using the damping technique on the scraper conveyor levels of 89/90 dB(A) have been obtained.

This leads us to mention one major source of noise to be investigated, that is the noise produced by the cutting of the coal or rock. Work in the United States indicates that the cutting head is one of the major noise sources acting as a radiator for the energy produced at the pick point. Work has just begun on this topic and should occupy many man hours into the future.

ACKNOWLEDGEMENTS

The authors wish to thank Mr C T Massey, Head of Mining, Headquarters Technical Department and Mr A W Tuke OBE, Area Director, North Yorkshire Area for permission to publish this paper. The views expressed are those of the authors and not necessarily of the British Coal Corporation.

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