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THE CONTROL OF THE WORKING ENVIRONMENT AT A UNIQUE CONSTRUCTION SITE

J.R. BOWKER

Central Electricity Generating Board, North Western Region, Stockport, Cheshire, United Kingdom

ABSTRACT

A description is given of some of the problems of control of the working environment in large scale tunnelling work. These include control of dust, fume and noise. Reference is made to some of the less obvious risk areas such as the use of surface coatings in steel pipes and the spraying of quick setting concrete on rock surfaces (shotcreting). The need for effective environmental monitoring is stressed and the conclusions draw attention to a number of factors that must be considered if environmental control is to be achieved.

The demand for electricity fluctuates during the day and from day to day. Large scale storage is impracticable and there is a need for generating plant which can achieve full load almost immediately to meet sudden changes in demand or breakdown of other plant. Experience has shown that this can be met by a pumped-storage station. The successful operation of three stations of this type led to a search for a suitable site for a larger and more efficient development. A site was found in a disused slate quarry in North Wales and, for various reasons, including that of being in an area of natural beauty, the decision was made to build the station underground. The mining and quarrying of slate had been one of the major industries of this part of North Wales and the effects on health of the inhalation of slate dust were well known. In some areas almost every household could tell of relatives dead or severely disabled from pneumoconiosis. With this historical knowledge a Management decision was made at a very early stage that the construction of Dinorwic Power Station would not add to this number.

The standard to be achieved was that recommended by the American Conference of Governmental Industrial Hygienists (A.C.G.I.H.)[1]; this repeats the advice given in a similar publication in 1973. This states that in a work place total dust should not exceed 10 mg/m^3, that respirable dust should not exceed 5 mg/m^3 and that if the quartz content of the dust exceeds 1% the level of respirable dust should be reduced in accordance with the formula: 10 mg/m^3/% Respirable Quartz + 2. The threshold limit value for respirable quartz is 0.1 mg/m^3.

EXCAVATION SEQUENCE AND EXPOSURE OF WORKERS

Work started in 1974 with the construction of access tunnels and ventilation shaft. It was known that in the excavation of tunnels, shafts and halls over 2 million tons of quartz containing rock would have to be removed. Although there is some geological variation the average quartz content is 25% with up to 40% in some areas. Excavation has been by conventional methods, the sequence being:

1. Drilling with compressed air driven multi-boom drills
2. Charging
3. Blasting
4. Roof scaling with hand tools and compressed air driven picks
5. Removal of debris with diesel engined shovel loaders and large diesel engined dump trucks
6. Spraying tunnel sides and roof with quick setting concrete as required (Shotcreting)
7. Face scaling and preparation for next sequence

Silica containing dust can arise from drilling, blasting, scaling and during the removal of debris, from other fumes and particulate matter from the use of explosives and from the exhausts of diesel engined vehicles and from particulate matter in shotcrete rebound.

Experience elsewhere had shown that the use of wet methods of drilling very effectively controls production of dust during that operation providing the equipment is kept in good working order. This method was adopted for underground drilling at Dinorwic. The debris produced by blasting is very dry. Continuous wetting down is essential if heavy dust contamination is to be avoided during removal by large mechanical loaders and dump trucks. A good supply of water at reasonable pressure is needed otherwise penetration of the pile is not good.

The ventilation requirements to remove dust that cannot be controlled by wet methods; to remove the fumes such as nitrogen oxides produced by blasting and the exhaust fumes from diesel engined vehicles are very considerable, particularly when several faces are being worked simultaneously.

In general a conventional overlap system of ventilation has been used in blind headings with scouring of the face and extraction of foul air. Other systems have been used to meet special circumstances and when the ventilation shaft and various inter-connecting tunnels were completed it was possible to install a more permanent system which could be extended and modified to deal with ever changing local circumstances.

MONITORING THE ENVIRONMENT

To show the effectiveness or otherwise of engineering control it was considered essential that a monitoring service be established. Emphasis was placed on the use of personal samplers although some static sampling has been done, particularly during special investigations of problem areas. The personal sampler in use is the Simpeds 70 Mk. 2 which only collects respirable dust. Filters are weighed before and after use and are analysed for quartz content by the direct--on-filter method with a high resolution infra-red spectrophotometer. It has been shown that up to 90% of the material collected on the filter comes from the exhaust of diesel engines and this contamination has added considerably to the difficulties of analysis. However, it has been possible to carry out a very considerable monitoring programme covering several occupational groups. Mean results from 930 personal samples taken during 1976–77 showed 2.38 mg/m^3 respirable dust, 0.131 mg/m^3 quartz with a mean quartz content of 5.5%.

Average figures for 1977 are as follows:

Occupational group	Quartz concentration (mg/m^3)
Miners	0.14
Loader drivers	0.15
Dumper drivers	0.05
Shotcreters	0.075
Others	0.11

These show that even for the occupational groups most at risk it was possible to get very close to the threshold limit value for quartz and if account is taken of total exposure time in the duration of underground excavation it seems unlikely that the threshold limit value was significantly exceeded.

In addition to routine sampling several special investigations have been carried out. These have highlighted problem areas and particular jobs where additional protective measures were necessary. Particular attention should be drawn to "jiggering" (scaling with a pneumatic tool), dry drilling and reaming which give rise to high dust levels and necessitates the use of personal protective equipment.

HEALTH SCREENING

Pneumoconiosis is a condition which develops slowly unless the dust levels are extremely high. Biological monitoring is obviously not a viable method of control. The total excavation period is of the order of 4 years. Engineering control has been shown to reduce dust levels to acceptable values and it is most unlikely that anybody will develop pneumoconiosis as a result of work on this construction project. It is equally unlikely that significant changes will be detected if exposure continues at similar levels during the remainder of a working lifetime providing that previous employment was not associated with heavy exposure to quartz containing dust. However, the history of occupational disease in the area suggested that it would be wise to carry out a simple pre--employment screening procedure before permitting underground work. This consisted of a nurse administered questionnaire designed to detect chest disease, a full-sized chest X-ray and simple respiratory function testing by spirometry. Doubtful cases were referred for medical examination. Men with detectable chest disease were excluded from underground work, the relatively few discovered were placed in work above ground level where dust exposure would be significantly less. Pre-employment screening was compulsory, follow-up examination by chest X-ray and spirometry is voluntary and has been made available at intervals of approximately 2 years. As expected, no significant changes have been detected but the results of examination and those of notional dust intake will be preserved and will be available for any future research work into the health of those who worked on the project.

OTHER PROBLEM AREAS

Noise

The widespread use of heavy diesel driven and compressed air operated plant produced some very high sound levels. Drilling equipment in particular gave rise to levels of 118–120 dB. Engineering control was found to be impossible and personal protective equipment had to be used. The attenuation characteristics of various types of ear defenders were examined and it was found that to achieve a sound level of 90 dB at the ear the use of both ear inserts and fluid seal ear muffs was necessary.

Shotcreting

Many of the surfaces left after blasting and scaling have given a thin coat of quick setting concrete to produce stability. This is applied by high pressure hose using compressed air driven equipment. The problems of noise, rebound and spray were well appreciated and appropriate protective equipment was provided. However, an unexpected outbreak of skin burns, some quite extensive, occurred. Investigation revealed that to achieve rapid setting an additive was put into the mix, this had caustic properties and was the cause of the injury. The solution was improved protective clothing, education of the work force and a more careful operating technique.

Surface coatings

The use of surface coatings to prevent corrosion of steel pipes has given rise to considerable interest. Such coatings are often complex mixes containing evaporating solvents, isocyanates and other potentially toxic chemicals. Not only was it necessary to consider effects on health but also the possibility of fire and explosion had to be taken into account.

Diesel fumes

The extensive use of diesel driven transport produced a large amount of exhaust fume. In general this was adequately controlled by the construction ventilation system. However, from time to time areas were found where the ventilation had been reduced on completion of excavation and where fumes tended to accumulate. Irritation of the eyes and upper respiratory tract indicated the need for partial re-instatement.

CONCLUSIONS

In this very brief summary of some of the problems of environmental control that can arise in large scale underground excavation, it has only been possible to sketch in the broad principles that need to be adopted. However, a number of general conclusions can be drawn.

Wet drilling is effective in preventing evolution of dust providing that equipment is kept in good order. The effects of loss of water were well illustrated by one particular incident when the supply pipe was severed; the two operators continued to drill in the absence of the water supply for about 1 1/2 hours. They happened to be wearing personal samplers. The exposures during the shift were 2.2 mg/m^3 quartz in one case and 1.7 mg/m^3 in the other. The levels during the period of dry drilling were of the order of 11.0 mg/m^3 and 8.5 mg/m^3 quartz respectively.

The ventilation requirements for the removal of diesel fume and dust, particularly the dust produced by removal of debris, are very considerable. In the design of the ventilation system account should be taken of average rock conditions and of expected traffic density. Changes in these conditions and in construction detail may render the ventilation less than fully effective and a flexible approach is necessary. Temporary ventilation systems are very susceptible to damage, constant inspection and immediate repair of damage are essential to the maintenance of an acceptable environment.

A number of jobs are associated with increased risk. The use of pneumatic tools for scaling gives rise to a high concentration of dust in the breathing zone. Engineering control is difficult and personal respiratory protection must be used. Reference has already been made to dry drilling; in general drilling can be done wet but the temptation to dry drill single holes for arch supports, extension of services, etc. is considerable and an efficient and knowledgeable supervision is essential.

Diesel fume can be reduced by careful maintenance and by exhaust treatment. The requirement to minimise contamination from this source must be established before the start of underground work.

Unacceptably high noise levels are produced by much of the large plant used in construction work. Compressed air-driven multi-boom drilling rigs are particularly noisy. There is a need for a radical redesign of this type of equipment to reduce noise at source.

Dust and fume can be controlled by engineering methods. However, environmental monitoring is essential in showing that engineering control is adequate and in demonstrating those jobs and those areas where particular care is necessary.

If engineering control can be shown to be adequate the need for biological monitoring is minimal. However, simple measures, such as chest radiography and spirometry, can be reassuring to employees.

The stimulus for adequate environmental control must come from the highest level of management. All levels of staff must be made aware of the need to achieve and maintain acceptable conditions and of the risks of not doing so. In planning production targets environmental control must be given full consideration and its effect must be realistically assessed. In drawing up training programmes the need to stress careful working practices and to draw attention to potential hazards must not be forgotten.

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REFERENCE

1. *Threshold Limit Values 1976*. Guidance Note EH 15/76. The Health and Safety Executive, London, 1977, p.12.