Training of Mine Ventilation Personnel in South Africa

By J. BURROWS*

SYNOPSIS

Competent ventilation personnel are required in large South African mines in order to meet legal requirements and to ensure that mines are ventilated effectively and economically.

The philosophy of the present training system is explained and the techniques used, results achieved and problems encountered are discussed.

The training function of mine ventilation officers and of the ventilation training section of the Chamber of Mines of South Africa is explained.

INTRODUCTION

Ventilation departments are required on large metalliferous mines in South Africa. The legal responsibilities of these departments which are defined in Regulation 2.16.1 of the Mines and Works Act and Regulations of the Republic of South Africa[1] relate mainly to examining and reporting on the mine's water supply, dust allaying appliances, dust sampling and ventilation conditions. This regulation has not altered appreciably since it was first promulgated in 1917.

These legal responsibilities are often termed 'routine' and many other duties such as the planning of air and cooling requirements, checking the performance of fans and cooling plants and providing management with specialist advice on all matters relating to mine ventilation are now major responsibilities of mine ventilation staff.

With the annual power costs of mine ventilation exceeding R10 million it is obvious that competent, well-trained staff are required, not only to satisfy the legal requirements, but also to ensure that the mines are ventilated effectively and economically.

The Department of Mines recognizes either the Elementary or Advanced Certificates in Mine Ventilation, both of which are issued by the Chamber of Mines of South Africa, as proof that a person is competent to meet the legal requirements. The mining companies, however, appoint only holders of the Advanced Certificate as senior ventilation officials.

Table I below summarizes the number and qualifications of persons engaged in mine ventilation in South Africa.

TABLE I

	Certificated		
Graduates	Advanced	Elementary	Uncertificated
10	184	146	109

Nine of the graduates are employed either in the head offices of the mining companies or by the Chamber of Mines. Senior members of the ventilation departments would probably be classified as specialist technicians who are required to relate certain theory and practice of such varied disciplines as mining engineering, mechanical engineering and air-conditioning. The educational qualifications of the uncertificated staff range between standards 8 to 10, most of the staff having passed only standard 9 in mathematics and science.

TRAINING PHILOSOPHY

Training can be defined loosely as a process which enables persons to do something which they could not do before they were subjected to such a process.

Bebb[2] has given a more concise and very practical definition of the modern concept of training. He defines training as

> 'a method of improving individual performance by the systematic management of the learning of new behaviour to meet the organization and individual needs'.

The modern concept of training is therefore seen to be performance-orientated, based on sound principles of learning and aimed at achieving behavioural change in order to meet clearly defined job needs.

Performance orientation

To be effective, training must lead to improved job performance. It is therefore essential when preparing any training programme that the job be examined carefully. This analysis will determine what the learners must actually do and also what they need to know to be able to perform effectively. The modern concept of training stresses that training needs to go beyond an improvement in knowledge. An improvement in work performance is essential.

Principles of learning

Educational and industrial psychologists have, as a result of their extensive research work, been able to establish that learning depends mainly upon three factors, namely, the learner, the learning material and the learning technique.

THE LEARNER

The principles relating to a learner are as follows: Only a learner can learn, he cannot be taught. It is therefore essential to provide a learning situation which motivates the learner. This is best achieved by satisfying the learner's needs for accomplishment, responsibility and recognition during the learning process.

THE LEARNING MATERIAL

To ensure that learning is effective the learning material must be meaningful, presented in logical sequence and in optimum size steps.

THE LEARNING TECHNIQUES

The following points are important when selecting a learning technique:

(i) Learning is most effective when it is applied in practice. Passive learning should be avoided and active participation must be encouraged.

(ii) A feedback system should be built into any programme. This feedback must be an on-going process and should enable the learner to identify and correct his own errors.

(iii) Learning is reinforced by practice and controls should be reduced as performance improves.

*Ventilation Training Officer, Chamber of Mines of South Africa.

(iv) The learner should be encouraged to practice what he has learnt in as many different situations as possible.

LEARNING OBJECTIVES

If learning is to be effective it is important that the learner and the trainer should know precisely what is required.

Management by learning objectives (MBLO) contains many of the essentials needed for behavioural change whether this change be in skills, knowledge or attitudes. It also provides effective integration between learner and trainer. The characteristics of MBLO are that the learner knows what is expected from him, that he is given an opportunity to learn and that he is informed of his progress.

Role of the ventilation training section

The Ventilation Training Section of the Chamber of Mines endeavours to operate as managers of the learning environment. Its role is to plan, organize, lead and control the learning of mine ventilation personnel.

The systems approach is adopted and is shown in Fig. 1 below.

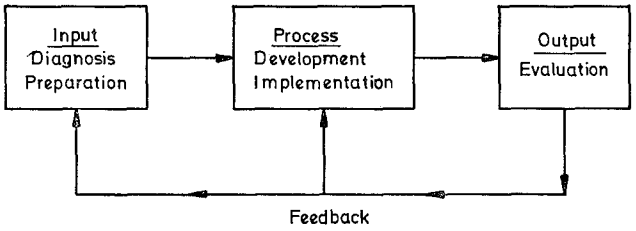

Fig. 1.

Diagnosis is essentially an analysis of the performance problem in order to determine whether training is the most economic and effective method of improving performance.

Preparation takes place after training has been selected as the best solution. The training officer determines the objectives and performance standards required, measures the skills which are already in existence and selects the method of measuring the degree of improvement.

Development is concerned with selecting the best learning materials, techniques and strategies. The feedback system is considered during this stage.

Implementation entails carrying out the training programme

Evaluation is the final step and consists of evaluating the training so that the efficiency and effectiveness can be improved further.

Role of ventilation officers

A fundamental of this approach to training is that the line supervisor must accept responsibility for training his staff. The main responsibilities in this regard are to provide the learners with an opportunity to learn and to practice, and to provide coaching when performance is inadequate. In addition, ventilation officers assist the ventilation training officers in determining needs and in evaluating training effectiveness.

Without the support and commitment of the line supervisors on-the-job, this, or any other training programme cannot succeed, for the training officer can only assist and guide.

TRAINING METHODS

The methods which are used to train mine ventilation personnel attempt to satisfy the criteria mentioned above. Due cognizance is also taken of the wide geographic spread of the learning population and of the different work requirements of individual mines or groups.

In practice, training is given 'on-the-job' and on centralized courses. In both instances learner-centred techniques are used whenever possible. Practical skills and theoretical knowledge are learnt during the 'on-the-job' training while the centralized courses are concerned mainly with advanced theory and calculations. Figure 2 below shows the idealized training cycle from the novice to senior ventilation official stage.

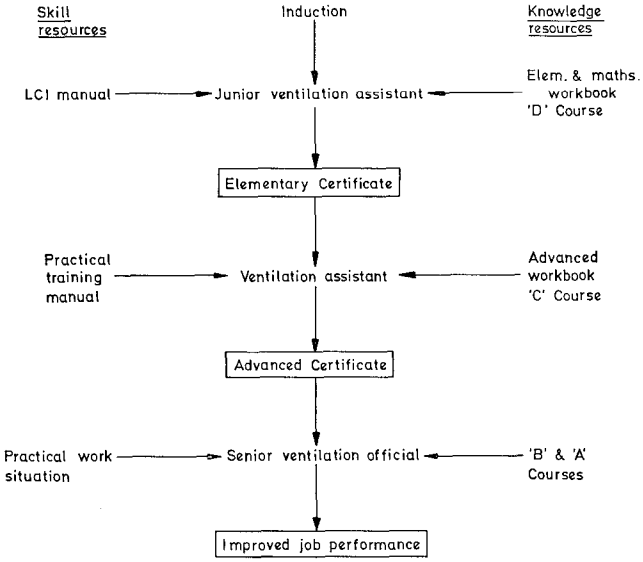

Fig. 2.

Extracts of some of the various training manuals and courses are included in the appendix and a more detailed description has been given by the author in a previous publication.[3]

An examination of this training cycle will reveal that it provides the learner with an opportunity to learn by integrating theory and practice. The improvements in his knowledge and skill become evident by his passing the relevant examinations and, more important, by his improved work performance.

RESULTS ACHIEVED

The success of these training programmes should be judged mainly on whether the work performance of mine ventilation personnel has improved and whether the number of qualified staff has increased.

It is very difficult to say whether an employee's performance has improved because of training unless there are meaningful criteria to measure before and after training. Broadly speaking, it can be said that there is an improvement in the work performance of all ventilation staff. Proof of this will be seen in the general improvement of their routine work, in their quest for more demanding work and by the increased responsibilities which are now given, and confidently accepted, by mine ventilation personnel. There are already a number of senior ventilation personnel who have completed the cycle shown in Fig. 2 and whose competence on the job validates the above claims. However, this does not imply that there are no failures or problems.

The pass rate in the ventilation examinations has improved considerably. Today approximately 80 per cent of those persons who follow the training cycle in Fig. 2 obtain the elementary certificate and approximately 60 per cent obtain the advanced certificate. These figures should be viewed against a pass rate of approximately 40 per cent and 20 per cent, respectively, before the training programmes were commenced.

Also, there is an improvement in the morale and a reduction in labour turnover of mine ventilation departments. It would be unrealistic to claim that training is wholly responsible for either of these last mentioned factors but it is generally accepted that improved performance leads to greater job satisfaction.

Another benefit which has been obtained from these training programmes is that the gap between research workers and practising ventilation officers has been bridged. The 'A' Courses in particular have provided forums where researchers can explain their theories to ventilation officers who are then able to apply them in practice and report back on their findings. In many instances useful recommendations have been made.

PROBLEMS ENCOUNTERED

Obviously, in a training programme of this nature there have been many problems. Some of them have been solved while others are still present.

Technical literature

A major problem at the commencement of the training programme was the lack of adequate technical literature. This problem was overcome initially by using notes prepared by the ventilation training section. Recently, however, the Chamber of Mines of South Africa and the Mine Ventilation Society of South Africa have published a series of books on mine ventilation. These publications are proving invaluable in the training programme; their titles are

(1) 'Routine Mine Ventilation Measurements' published by the Chamber of Mines.
(2) 'Mine Ventilation Notes for Beginners' by W. L. le Roux, published by the M.V.S.
(3) 'The Ventilation of South African Gold Mines' published by the M.V.S.
(4) 'Psychrometry and Psychrometric Charts' by A. W. T. Barenbrug, published by the Chamber of Mines.

Students in South Africa are very fortunate that these publications are so readily available. Furthermore, articles which appear in technical journals such as *The Journal of the Mine Ventilation Society of S.A.* assist considerably in providing up-to-date information.

Selection of staff

Regrettably, too many of the new entrants to mine ventilation departments do not have the necessary potential for holding future senior positions.

Training, no matter how good it is, cannot develop potential. If the present trend continues it may become necessary to change considerably the present methods of utilizing the ventilation staff on mines. Automatic monitoring and computer usage may mean that a smaller, highly-skilled staff will replace the larger, broadly-skilled staff of today. This situation may improve considerably when better use can be made of all the human resources in this country.

Responsibility for training

Once a training department or educational institute becomes involved in training there is a pronounced tendency for the men 'on-the-job' to relinquish their training responsibilities. This has proved the case in many instances in the training of mine ventilation personnel.

Senior ventilation officers are responsible for the quantity and quality of their staff's work. Since this is dependent to some extent on their training, it follows logically that the ventilation officers should be responsible for training. The training department must provide guidance, expert advice and know-how to assist them in meeting these responsibilities.

It is also essential to have close liaison, feedback systems and follow-up procedures between training and operating staff. At the moment this is mainly verbal but it is hoped to improve matters in the near future.

Over-qualified staff

There is always a danger of producing too many trained staff. A person who is over-qualified for a job can often prove more of a liability than one who is under-qualified.

Due to the reasons mentioned above, and to the ever-increasing need to improve mine environments, this situation is unlikely to occur amongst mine ventilation personnel in South Africa.

However, it is the responsibility of mine management to ensure that persons who are competent are provided with the opportunity to use their skills and, if capable, to develop additional skills.

FUTURE TRAINING

Training needs and methods will certainly alter in the future. The magnitude of the change will depend to a large extent upon the human resources available and on the changes in the methods of mining and ventilation.

Closed-circuit television is likely to be added to the existing techniques and new skills such as noise and illumination control, computer usage and programming are likely to be required. In addition, ventilation personnel will have to become more skilled at analyzing the results of computer calculations.

Managerial skills and the ability to communicate effectively are often as important as technical know-how, particularly in large organizations. Training will thus be needed in this regard. However, training in subjects such as motivation, human relations, participative management, and so on, is of little practical value unless a supportive management style exists at work.

The training methods described above are likely to alter as research into human behaviour and the learning processes continues. However, the concept of performance criterion, learning objectives and the role of the learner are certain to be of paramount importance in any new methods.

ACKNOWLEDGEMENTS

The author wishes to thank all those persons who have assisted in preparing and implementing the training programmes discussed in this paper. The support and criticism of the group ventilation engineers and mine ventilation personnel are particularly appreciated.

REFERENCES

1. Mines and Works Act (Act No. 27 of 1956, as amended) and Regulations. Regulation No. 2.16.1.
2. Bebb, M. Management of training. Institute of Personnel Management of South Africa. Jhb. 1974.
3. Burrows, J. H. The selection and training of ventilation officials. *J. Mine Vent. Soc. S.Afr.*, vol. 25, 1972, pp. 225-237.

APPENDIX

EXTRACT FROM THE ADVANCED WORKBOOK

Section 8: AIRFLOW PRESSURE SURVEYS

Reading Matter: Chapter 35, pages 13-15.

Introduction

The section commences by explaining what is meant by pressure surveying and goes on to explain why pressure surveys should be undertaken. The six main reasons for performing pressure surveys are listed.

The four common methods of pressure surveying are then explained and the advantages and disadvantages of each method are given.

To complete the section reference is made to various papers published on pressure surveys and you are well advised to read them.

Objectives

You must extract a summary of the following points from the reading matter:

1. Define a pressure survey.

.....

.....

2. List six reasons why pressure surveys are performed.

.....

.....

.....

3. Name the four most common methods of pressure surveying and give a brief explanation of each.

.....

.....

.....

.....

Self test

This self test should be completed *after* you have studied your list of objectives for section 8. Remember, the purpose of this test is to let you know how well you are learning.

1. Give five reasons why pressure surveys are performed.

.....

.....

.....

(10 marks)

2. Briefly describe the 'trailing hose' method and the 'density' method of pressure surveying.

.....

.....

.....

.....

.....

(10 marks)

Total $\times 5 =$ %

TIME TABLE FOR A 'D' COURSE

Date	A.M.		P.M.	Evening objectives
Monday	Introduction mathematics and slide rule		Heat	Gases, Psychrometry
Tuesday	Heat Gases	L U N C H	Psychrometry	Airflow, Dust
Wednesday	Airflow		Dust	Fans, Vent. practice
Thursday	Fans Ventilation practice (Group discussion)		Revision	Revision (N.B. Regulations)
Friday	Examination		Course review and appraisal	

EXTRACT FROM THE LCI MANUAL

Task 2: 'SELECTS, CHECKS AND ASSEMBLES INSTRUMENTS'

Purpose of task

It is essential that the learner has reliable instruments to be used in his routine work, and this should be ascertained before going underground.

Resources available

(1) Previous field books.
(2) 'Routine Mine Ventilation Measurements'.
(3) Instruction booklets issued by manufacturers of the methanometer and Draeger detectors.
(4) Book on Fanakalo or mines' 'Language Laboratory'.
(5) Other members of the ventilation department.

Performance standard expected — Learner able to:

(a) Prepare field books for following day's work.
(b) Check and pack an anemometer and stopwatch.
(c) Fill and test an aluminium puffer.
(d) Clean and check a tape.
*(e) Clean and check a clino rule.
(f) Check, repair defects and pack a whirling hygrometer.
(g) Check, repair defects and pack a kata thermometer.
(h) Fill thermos flask with hot water and pack.
(i) Clean, examine and pack water sample bottle.
(j) Clean and examine a pressure gauge and needles.
(k) Clean and examine a water tube gap stick.
(l) Check, repair defects and pack a manometer.
(m) Prepare a konimeter slide.
(n) Clean, test and assemble (ready for use) a konimeter.
*(o) Test and pack a methanometer.
*(p) Clean and examine bottles for CO_2 sampling.
*(q) Clean, check and pack a Draeger for gas sampling, plus tubes.
(r) Give clear instructions to his Bantu assistant as to where and when he will meet him next day.

Test situation

Without referring to any notes the learner must be able to enumerate and demonstrate the above operations to the satisfaction of the C.V.O. or other designated person.

*N.B. Sections (e), (o), (p), (q) may not apply to certain mines.

EXTRACT FROM THE PRACTICAL TRAINING MANUAL

Task: MEASURING THE PERFORMANCE OF A MAIN COOLING PLANT.

Key points

(1) Examine the layout of the plant.
(2) Measure the operating conditions at the plant, i.e. pressures, temperatures, flow rates and power.
(3) Calculate the input power and the duty of the evaporator and condenser and do a heat balance.
(4) Plot the refrigerant cycle on the pressure-enthalpy diagram.
(5) Calculate the performance of the plant.
(6) Report on your observations and make recommendations for improvement.

Reading matter

(1) Chapter 37, pp. 1-6, the pressure-enthalpy handout and the list of formulae issued by the Ventilation Training Section of the Chamber of Mines.
(2) 'Mine Ventilation Notes for Beginners' by W. L. le Roux. Notes 56-60.
(3) The relevant sections of Chapter 10 of the textbook 'The Ventilation of South African Gold Mines'.