

RR 25/91

COMRO

ACCLIMATIZATION SERVICES TO THE MINING INDUSTRY: STATISTICS FOR 1990

J J HITGE, R M FRANZ, P C SCHUTTE and A J KIELBLOCK

Underground Environment

RESTRICTED REPORT NO. 25/91
PROGRAMME REFERENCE NO. GE3H
OCTOBER 1991

KEYWORDS: ACCLIMATIZATION
HEAT STROKE
HEAT TOLERANCE

INTENDED FOR THE USE OF MEMBERS OF THE CHAMBER OF MINES OF SOUTH AFRICA ONLY

© Chamber of Mines of South Africa 1991

This publication is a copyright under the Berne Convention. In terms of the Copyright Act No. 98 of 1978, no part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording or by any information, storage and retrieval system, without permission in writing from the Chamber of Mines of South Africa.

PREFACE

This report is an annual review of the prevailing status of heat acclimatization practices and procedures in the mining industry. Its primary purpose is to provide an analysis of the extent to which new developments are implemented and of their cost-effectiveness. It also quantifies the magnitude of the problem of underground heat with respect to worker exposure and assesses the efficacy of existing selection and acclimatization procedures with respect to the incidence of heat stroke.

It should be appreciated that existing procedures are currently being replaced to a large extent by Heat Stress Management, a procedure which will be more acceptable and cost-effective than conventional selection and acclimatization procedures currently in use. COMRO will be closely involved in monitoring and assisting with the conversion from these existing procedures to Heat Stress Management, and the content of future annual reviews will take cognizance of this new development in the industry.

D G WYMER
Director
Underground Environment

SUMMARY

This report is designed to convey information to mine management, environmental engineers, training personnel and acclimatization supervisors that will allow an appraisal of their mine's position with regard to heat acclimatization of workers and the incidence of heat stroke relative to the mining industry in general.

A total of 41 mines employed heat tolerance testing and heat acclimatization of workers during 1990. Four categories of procedures are identified, namely

- (a) mines where only the heat tolerance test (HTT) is performed (seven mines),
- (b) mines where climatic room acclimatization (CRA) is an adjunct to the HTT (20 mines),
- (c) mines where microclimate acclimatization (MCA) and CRA are used in conjunction with the HTT (12 mines),
- (d) mines where only MCA is used in conjunction with the HTT (two mines).

The average number of unproductive shifts per man for the four categories are, respectively, 1,0; 2,2; 1,5 and 1,0. This should be viewed against the industry-wide average of 1,7 shifts per man. These figures indicate a considerable savings in unproductive shifts compared with the period 1986 to 1989 when the average number of unproductive shifts per man ranged from 1,8 to 2,0. The savings can be ascribed to an improvement in the application of the HTT and MCA procedures as well as to the direct allocation of intermediately-heat-tolerant individuals to underground work places where wet-bulb temperatures were 30,0 ° C or less. In fact, at one mine the direct allocation of intermediately-heat-tolerant individuals made it possible to dispense with MCA completely.

During 1990, 132 routine assessments of heat tolerance test and acclimatization centres were conducted. The most frequently observed deviations from recommended procedures during this period were inadequate environmental temperature control and unsatisfactory hygienic conditions in climatic chambers. The lack of familiarity with current procedures displayed by some acclimatization supervisors during routine assessments is disconcerting, particularly in the light of the disappointing attendance at refresher courses during the same period. The status of acclimatization supervisors should be reviewed, not only in terms of their present responsibilities, but also in anticipation of the implementation of Heat Stress Management as an alternative to existing procedures.

Seven heat stroke incidents were reported to COMRO during 1990. Six occurred in underground work places, three of which were fatal and one occurred in a surface climatic chamber. Major factors contributing to these incidents were (in order of descending prevalence) severe heat stress, dehydration as a result of inadequate water intake, excessive alcohol consumption less than 12 hours before the incident, incorrect transfers, illness, obesity and ventilation failure.

CONTENTS

LIST OF TABLES	(v)
LIST OF FIGURES	(v)
1 INTRODUCTION	1
2 DATA ACQUISITION	1
2.1 Selection, Acclimatization and Training	1
2.2 Heat Stroke Investigations	1
3 RESULTS AND DISCUSSION	2
3.1 Extent of Heat Tolerance Testing and Acclimatization Procedures : 1990	2
3.1.1 Physical selection test (PST)	3
3.1.2 Heat tolerance testing, and climatic room and microclimate acclimatization	3
3.1.3 Heat tolerance testing and heat acclimatization statistics : 1986 - 1990	6
3.2 Industry Standards for Heat Tolerance Test/Acclimatization Centres and Personnel	9
3.2.1 Assessment of heat tolerance test and acclimatization centres	9
3.2.2 Acclimatization superintendents and supervisors : attendance and performance at courses	11
3.3 Heat Stroke Statistics	12
3.3.1 Incidence	12
3.3.2 Causal factors	12
3.3.3 Treatment	14
4 CONCLUSIONS AND RECOMMENDATIONS	14
5 REFERENCES	15
APPENDIX I : ACCLIMATIZATION SERVICES TO MINES : QUESTIONNAIRE	17

LIST OF TABLES

1.	Summary of the application of selection/protection procedures for 1989 and 1990	2
2.	Comparison of results of selection/protection procedures : 1986 to 1990	7
3.	Summary of major deviations from recommended procedures observed during quarterly assessments of Heat Tolerance Test and Acclimatization Centres during 1990	10
4.	Attendance and performance of superintendents and supervisors at training courses during 1990	11
5.	Summary of heat stroke incidents reported to COMRO during 1990	12
6.	Analysis of heat stroke incidents for 1990 : (a) causal factors and (b) irregularities during treatment	13

LIST OF FIGURES

1.	Distribution of workers requiring heat acclimatization during 1990	4
2.	Utilization of basic procedures (in terms of workers undergoing the heat tolerance test (HTT), microclimate acclimatization (MCA), climatic room acclimatization (CRA), and direct allocation of intermediately-heat-tolerant individuals to underground work places where wet-bulb temperatures were 30,0 ° C or less)	5

1 INTRODUCTION

The Underground Environment division of COMRO is responsible for rendering the following acclimatization services to mines:

- (a) quarterly assessments of each heat tolerance test and acclimatization centre, followed by a report to mine management;
- (b) compilation, distribution and revision of detailed codes of practice governing heat tolerance testing and acclimatization procedures;
- (c) training of all acclimatization supervisors and the presentation of refresher courses and management information seminars at regular intervals;
- (d) assistance with the implementation of developments in physical selection procedures, heat tolerance testing, and heat acclimatization practices including microclimate acclimatization; and
- (e) investigating heat stroke incidents, as well as analysing causal factors.

As an extension of these services, the present report was compiled with two main objectives, namely

- (a) to provide an analysis of the application of existing selection and acclimatization procedures in the mining industry for the year 1990, and
- (b) to provide Industry with heat stroke incident statistics for the same period. In addition, the acclimatization statistics for the period 1986 to 1990 were analysed to establish the extent to which newer developments in the field of heat tolerance testing and acclimatization have been implemented and to assess their cost-effectiveness. This will enable management at individual mines to review their own programmes and their position relative to Industry as a whole.

2 DATA ACQUISITION

2.1 Selection, Acclimatization and Training

Relevant data were obtained by questionnaire (see Appendix I). Information on supervisor training, refresher courses and quarterly assessments of heat tolerance test and acclimatization centres was obtained from records held at COMRO.

2.2 Heat Stroke Investigations

Each heat stroke incident reported to COMRO during 1990 in accordance with GPC Circulars No. 65/79, 59/80 and 77/81 was subjected to an inquiry conducted at the mine

In question by a senior COMRO staff member. Each inquiry included an interview with all witnesses to the incident, all individuals with whom the victim had regular contact and where possible, an interview with the victim as well. Documents such as relevant ventilation reports, acclimatization records, and mine records were obtained from management. Standard medical reports dealing with the treatment of, recovery from, and various other aspects of heat stroke were also examined. Information gained in this way was treated as confidential and mines and individuals therefore remain anonymous.

3 RESULTS AND DISCUSSION

3.1 Extent of Heat Tolerance Testing and Acclimatization Procedures : 1990

During 1990, 41 mines (35 gold and 6 platinum) employed heat tolerance testing and/or heat acclimatization of workers (Table 1). These procedures were carried out at 35 surface acclimatization centres. All mines where heat acclimatization was mandatory used the heat tolerance test (HTT) as a standard selection procedure.

Table 1 SUMMARY OF THE APPLICATION OF SELECTION/PROTECTION PROCEDURES FOR 1989 AND 1990

Method	Year	n*	Total Through Climatic Chamber	Total Heat Tolerance Tested	Total Hyper-Heat-Tolerant	Total MCA	Total Shifts	Shifts/Worker
HTT and CRA	1989	18	133 896	124 952	68 182	N/A	296 223	2,2
	1990	18	119 443	114 961	64 607	N/A	260 875	2,2
HTT MCA and CRA	1989	11	124 261	122 495	53 286	46 880	199 204	1,6
	1990	8	106 041	102 717	46 709	36 338	155 570	1,5
HTT and MCA	1989	1	3 711	3 711	1 748	1 612	3 711	1,0
	1990	2	9 786	10 074	7 377	2 063	10 074	1,0
HTT only	1989	5	33 543	33 543	12 922	N/A	33 543	1,0
	1990	7	33 739	33 764	14 461	N/A	33 959	1,0
TOTAL	1989	35	295 411	284 701	136 138	48 492	532 681	1,8
	1990	35	269 009	261 516	133 154	38 401	460 478	1,7

*n denotes climatic chambers, not mines.

According to the procedures employed, the mines could be divided into four categories:

- (a) mines where only the heat tolerance test (HTT) is performed (seven mines);
- (b) mines where climatic room acclimatization (CRA) is an adjunct to HTT (20 mines);

(c) mines where microclimate acclimatization (MCA) and CRA are used in conjunction with the HTT (12 mines);

(d) mines where only MCA is used in conjunction with the HTT (two mines).

The underground labour force on the 41 mines totalled 352 287, while the average percentage of men requiring acclimatization was 63,5 in 1990 compared with 65,5 per cent in 1989. On any particular mine, workers requiring acclimatization during 1990 varied from 17,1 per cent to 100 per cent of the underground labour force (see Figure 1). On eight mines the entire underground labour force required acclimatization.

The total number of men who entered climatic chambers for purposes of HTT and/or CRA during 1990 was 269 009 compared with 295 411 during 1989. The figure for 1990 includes 32 873 men who required reassessment of heat tolerance and/or reacclimatization due to transfers, and /or absence from work in heat. The industry-wide average number of shifts per man required to prepare for work in hot environments during 1990 was 1,7 compared with 1,8 shifts per man required in 1989 (Table 1). This decrease is attributable to the continued improved utilization of HTT and MCA, and direct allocation of intermediately-heat-tolerant individuals to underground work places where wet-bulb temperatures were 30,0 ° C or less.

Men deemed heat intolerant during 1990 totalled 9 637 or 3,6 per cent of those subjected to heat acclimatization procedures.

3.1.1 Physical selection test (PST)

The PST is at present only used on nine mines as a selection device for men allocated to sections where the wet-bulb temperature is 27,4 ° C or less, and for whom work rates can be regarded as strenuous (GPC Circular No. 33/85). A total of 40 097 men underwent the PST during 1990. Of this total, 28 616 men (71,4 per cent) were classified as A-category, 10 185 (25,4 per cent) as B-category and 1 296 men (3,2 per cent) as C-category.

3.1.2 Heat tolerance testing, and climatic room and microclimate acclimatization

During 1990, a total of 261 516 men were tested for heat tolerance. Of these, 133 154 (50,9 per cent) were classified as hyper-heat-tolerant. Of the remaining 128 362, 26 827 (20,9 per cent) were classified as intermediately-heat-tolerant and 38 401 (29,9 per cent) underwent microclimate acclimatization (Figure 2). As a result, a total of 198 382 men (75,9 per cent of all those tested for heat tolerance) were posted underground without having had to be subjected to unproductive climatic room acclimatization procedures.

On an industry-wide basis, 95,2 per cent of workers passing through acclimatization and heat tolerance test centres were tested for heat tolerance during 1990. This figure remained almost the same as for 1989. The fraction tested for heat tolerance on individual mines ranged between 64,5 and 100 per cent of workers passing through acclimatization

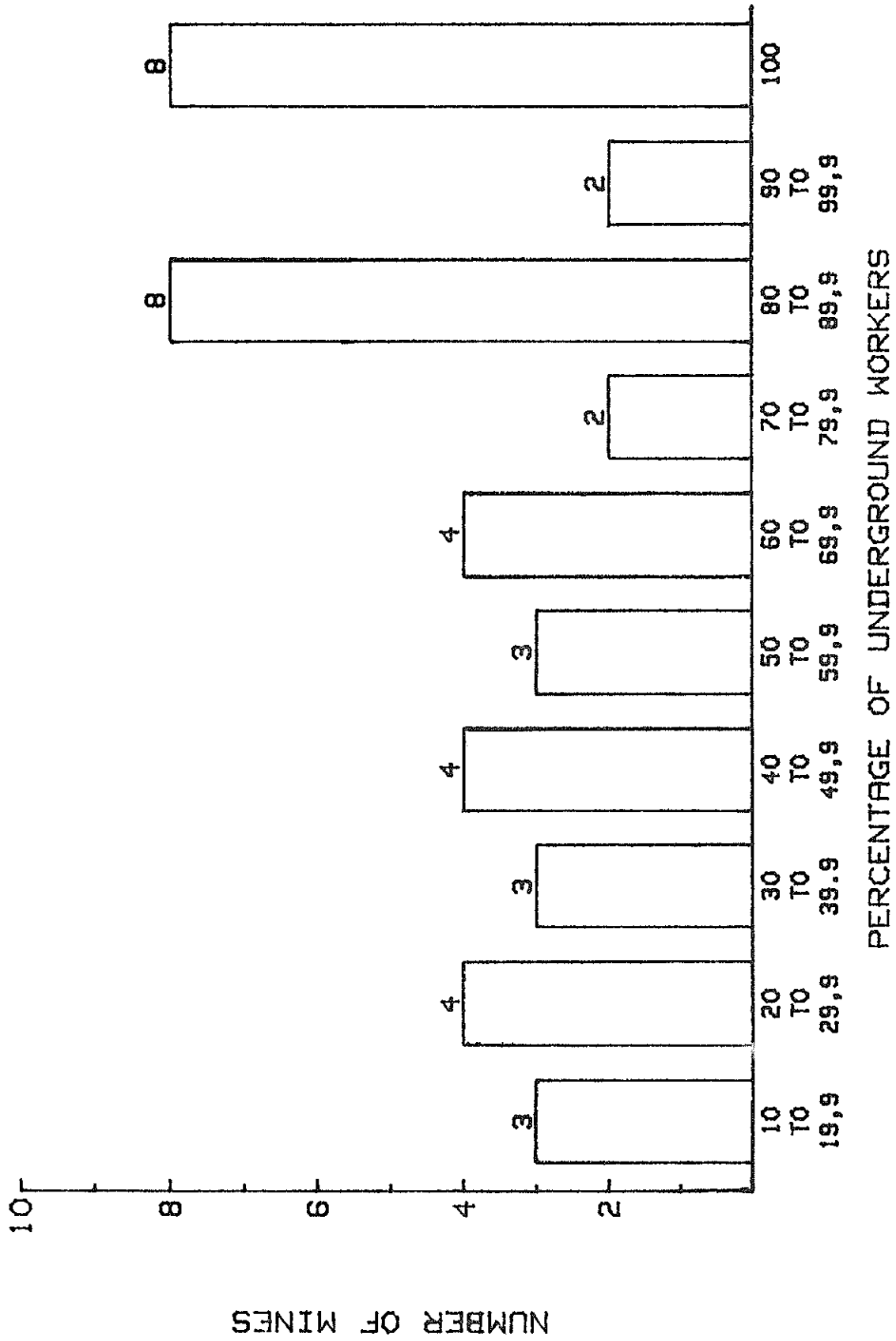


Figure 1 DISTRIBUTION OF WORKERS REQUIRING HEAT ACCLIMATIZATION DURING 1990

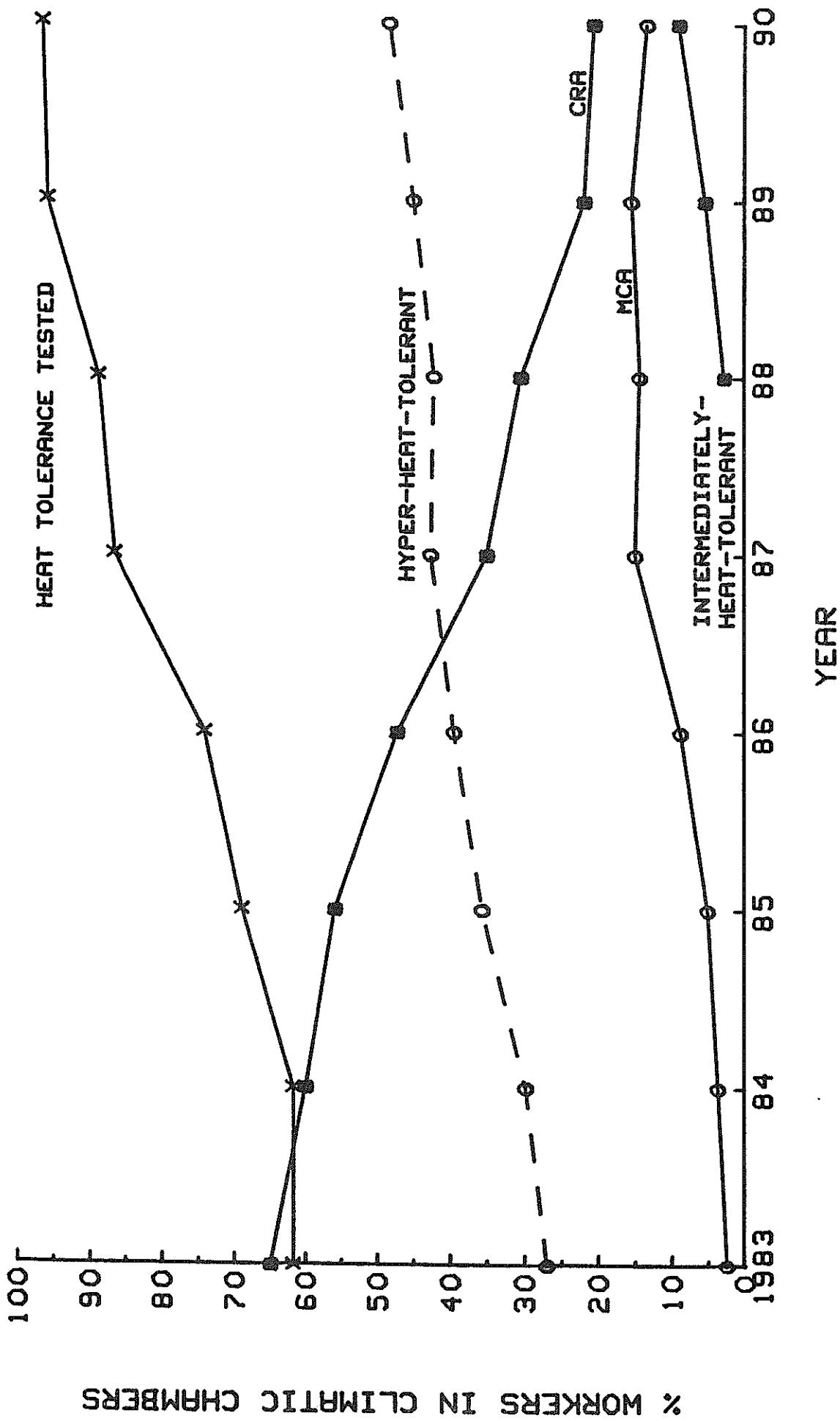


Figure 2 UTILIZATION OF BASIC PROCEDURES IN TERMS OF WORKERS UNDERGOING THE HEAT TOLERANCE TEST (HTT), MICROCLIMATE ACCLIMATIZATION (MCA), CLIMATIC ROOM ACCLIMATIZATION (CRA), AND DIRECT ALLOCATION OF INTERMEDIATELY-HEAT-TOLERANT INDIVIDUALS TO UNDERGROUND WORK PLACES WHERE WET-BULB TEMPERATURES WERE 30.0° C OR LESS

centres, as only 29 of the 41 mines tested all workers requiring acclimatization. This suggests that the full potential of the HTT as a means of reducing the number of unproductive shifts spent in climatic chambers remains under-exploited on several mines. In many instances workers requiring reacclimatization are placed directly onto an acclimatization programme in the climatic chamber without first determining their prevailing level of heat tolerance. In other words, the decision whether they need acclimatization and, if so, the acclimatization period required, is based purely on the period of absence from work in heat and the environmental conditions of the working area. Ideally, all workers who require acclimatization, including those requiring reacclimatization, should first be tested for heat tolerance; the outcome of the HTT should then determine whether acclimatization is required and, if so, the particular acclimatization regimen to be followed.

On mines employing the HTT as well as CRA, the average time spent in the climatic chamber during 1990 was 2,2 shifts per worker. The same rate applied to the previous year. The average time spent in the climatic chambers of the 12 mines using HTT, MCA and CRA was 1,5 shifts per man in 1990 compared with 1,6 shifts per man in 1989. On the two mines where only MCA was used as the method of acclimatization, the average time spent in the climatic chamber was necessarily only 1,0 shift per worker. On the mines using MCA, 54 086 men (48,0 per cent of those tested) were classified as hyper-heat-tolerant while 38 401 men (34,0 per cent of those tested) qualified for MCA. The percentage of men eligible for MCA on these mines varied between 5,2 and 64,7.

3.1.3 Heat tolerance testing and heat acclimatization statistics : 1986 - 1990

The number of mines selecting workers on the basis of the heat tolerance test and subsequently applying heat acclimatization procedures increased from 36 in 1986 to 41 in 1990 (Table 2). Over the same period the portion of the underground workforce requiring heat acclimatization decreased from 73,3 per cent (1986) to 63,5 per cent (1990). The actual number of workers who entered climatic chambers for purposes of the HTT and/or CRA showed a concomitant decrease from 395 266 in 1986 to 269 009 in 1990.

Table 2 COMPARISON OF RESULTS OF SELECTION/PROTECTION PROCEDURES : 1986 TO 1990(1-4)

	1986	1987*	1988	1989	1990
1. Number of mines	36	36	39	40	41
2. Percentage of underground work force requiring acclimatization	73,3	73,6	68,2	65,5	63,5
3. Number of workers through acclimatization centres	395 266	375 875	321 206	295 411	269 009
4. Total number of shifts on HTT/CRA	790 531	740 686	641 368	532 681	460 478
5. Average number of shifts per worker on HTT/CRA	2,0	2,0	2,0	1,8	1,7
6. Number of men tested for heat tolerance	294 224	326 231	286 809	284 701	261 516
7. Percentage of '3' tested for heat tolerance	74,4	87,0	89,3	96,4	97,2
8. Number of men classified hyper-heat-tolerant	159 600	163 736	138 618	136 138	133 154
9. Percentage of men classified hyper-heat-tolerant	54,2	50,2	48,3	47,8	50,9
10. Number of men performing MCA	38 051	59 470	48 788	48 492	38 401
11. Number of men performing CRA	190 447	135 076	100 937	67 668	58 061

* 1987 statistics include 29 499 workers reacclimatized as a result of strike action.

This downward trend in the number of men subjected to climatic chamber procedures can be ascribed to the following factors:

- (a) recent advances in environmental engineering that have resulted in the systematic reduction of temperatures in underground work areas over the period in question (5); and
- (b) an increased awareness and more effective implementation of recommendations that certain work categories can be safely exempted from heat tolerance testing and heat acclimatization procedures.

The percentage of underground workers tested for heat tolerance steadily increased from 74,4 in 1986 to 97,2 in 1990 (Figure 2). The pass rate for the HTT was 50,9 per cent in 1990 compared with 47,8 per cent the previous year.

Greater utilization of the HTT and, to a lesser extent, the more general implementation of MCA over the period of review led to a substantial reduction in the number of workers undergoing CRA. During 1986, 190 447 men performed conventional CRA procedures (48,2 per cent of all those in climatic chambers) while the corresponding figures for 1990

were 58 061 (21,6 per cent). Similarly, the average number of shifts each worker spent in the climatic chamber decreased from 2,0 during the period 1986 - 1988 to 1,8 during 1989. A further reduction to 1,7 shifts per worker occurred during 1990.

MCA as a method of acclimatization has not been as widely implemented as expected and no increase in the number of mines using MCA occurred over the period 1986 to 1990.

By the end of 1990 less than 35 per cent of mines using these selection and protection procedures were employing MCA. Only 14,7 per cent of the total number of workers subjected to the HTT performed MCA during 1990. The potential of MCA as a means of reducing unproductive time spent on CRA was, nevertheless, illustrated on two mines where implementation of MCA allowed the abolition of CRA. On these mines the average time each worker spent in the climatic chamber was 1,0 as opposed to 1,5 shifts per man on mines where both MCA and CRA were used. The saving realized by these mines totalled 4 893 shifts.

The impact of HTT and MCA on unproductive shifts (as compared with CRA) is illustrated in Figure 2, as well as in Tables 1 and 2. Further perspective is provided by considering the alternative, namely, the extent of CRA in the absence of the HTT and MCA: the average cost of achieving heat acclimatization through conventional CRA amounts to 4,7 manshifts per year⁽⁶⁾, which, when multiplied by the number of workers who required acclimatization over the period 1986 - 1990 results in a total of 7,8 million unproductive shifts. Since unproductive manshifts actually numbered 3,17 million, a saving of 4,63 million shifts has been realized through the improved implementation of the HTT and MCA over the period under review. The saving realized during 1990, as determined on the above basis, was 803 864 shifts.

The potential of differential heat tolerance testing was illustrated on one mine where MCA was discontinued owing to the direct allocation of intermediately-heat-tolerant individuals to underground work places with wet-bulb temperatures of 30 °C or less. On the 18 mines that have implemented the refinement of the HTT 26 827 workers (23,8 per cent of those passing through the climatic chamber) were placed on production immediately without the need of any formal acclimatization. The benefit of this refinement should therefore be eminently clear.

The number of mines using the differential HTT increased from four in 1989 to 18 in 1990. The total number of workers involved increased from 18 625 in 1989 to 26 827 in 1990, an increase of 8 202 workers (44,0 per cent). The disparity between the increase in the number of mines employing differential heat tolerance testing and the increase in the number of workers involved is possibly an indication of the under-utilization of this procedure. An evaluation of ventilation reports with a view to greater utilization of differential heat tolerance testing should be seen as a priority.

3.2 Industry Standards for Heat Tolerance Test/Acclimatization Centres and Personnel

Heat tolerance test and acclimatization centres are assessed by COMRO on a quarterly basis. The primary objectives are to provide assistance where problems arise or are identified, to ensure that recommended procedures are adhered to, and to communicate new findings and their possible implications to acclimatization supervisors and staff. Training and refresher courses for mine staff are conducted regularly. From the statistics gathered on visits to centres and through the respective courses, it is possible to obtain a fair assessment of Industry's standards.

3.2.1 Assessment of heat tolerance test and acclimatization centres

During 1990, COMRO conducted 132 routine assessments of heat tolerance test and acclimatization centres. The aim of these assessments is to assist mine management in ensuring the correct application of recommended procedures and to advise acclimatization supervisors on matters relating to the application of selection and/or acclimatization procedures.

During the course of these assessments numerous deviations from recommended HTT and CRA procedures were observed. Major deviations are summarized in Table 3. The general impression remains one of concern, not only because of the excessive number of wasted shifts but also because of the potential for compromising the safety and well-being of workers. While hygiene has always been a major concern, the emergence of Acquired Immune Deficiency Syndrome (AIDS) as a growing threat has resulted in an increased need for high standards in this area. Steps have been taken at many centres to improve the standard of hygiene but a considerable incidence of unsatisfactory hygienic standards at heat tolerance test and acclimatization centres was still observed. The prevalence of such conditions decreased from 21,1 per cent of assessments in 1989 to 15,2 per cent of assessments in 1990, but further improvement is needed.

Table 3 SUMMARY OF MAJOR DEVIATIONS FROM RECOMMENDED PROCEDURES OBSERVED DURING QUARTERLY ASSESSMENTS OF HEAT TOLERANCE TEST AND ACCLIMATIZATION CENTRES DURING 1990

Deviation	Percentage of Visits
1. Incorrect thermal conditions in climatic chamber and/or rest room	50,8
2. CRA procedures incorrectly performed	13,6
3. HTT procedures incorrectly performed	9,8
4. Knowledge/competence of supervisors not up to standard	24,2
5. Poor records/record keeping	4,5
6. Inaccurate/inferior measuring equipment. Condition of measuring instruments used in acclimatization centre not up to standard	13,6
7. Unsatisfactory physical and hygienic conditions in climatic chamber	15,2

Note: CRA = Climatic Room Acclimatization
HTT = Heat Tolerance Test

An increase in the prevalence of unsatisfactory environmental control from 35,9 per cent in 1989 to 50,8 per cent in 1990 was observed. Inadequate environmental temperature control could be related largely to deficient heating plants and control systems, faulty measuring instruments, poorly maintained climatic chambers, and the inability of some acclimatization personnel to operate control systems correctly.

It is important to consider the implications:

- (i) Poorly controlled rest room temperatures lead to artificially elevated body temperatures, resulting in unnecessary medical referrals and wasted shifts.
- (ii) Incorrect thermal conditions in the climatic chamber reduce the HTT to a meaningless exercise. When conditions are too hot the pass rate decreases and the number of unproductive shifts escalates. In addition, those being acclimatized require more shifts to satisfy the 'clear day principle' and a greater number of workers are, after seven or more unproductive shifts, classified as heat intolerant. Furthermore, excessive thermal conditions increase the risk of heat stroke occurring in the climatic chamber. When conditions are too cool, men with an inferior degree of natural heat tolerance are more likely to be classified as hyper-heat-tolerant, and would then be susceptible to the development of heat disorders underground.

Assessments of heat tolerance test and acclimatization centres also revealed that although most supervisors were familiar with routine procedures, their knowledge of procedures to be applied in situations not commonly encountered was inadequate. Examples are the inability to institute the correct course of action in the event of excessively high body temperatures, the recognition and treatment of heat disorders, as well as reluctance to cancel a shift when persistent environmental temperature deviations necessitate such an action.

3.2.2 Acclimatization superintendents and supervisors : attendance and performance at courses

There are at present 131 qualified acclimatization supervisors in the industry of whom 125 are active. The corresponding figures for superintendents are 68 and 14. In most instances superintendents have been given additional responsibilities and are no longer directly involved with heat tolerance test and acclimatization procedures.

Four full training courses (one of the request of a specific mine), and three refresher courses were held during 1990. A total of 59 men participated in this programme. Full training courses were attended by 23 candidates, of whom 21 (91 per cent) passed (see Table 4).

Table 4 ATTENDANCE AND PERFORMANCE OF SUPERINTENDENTS AND SUPERVISORS AT TRAINING COURSES DURING 1990

Group	PASSED		FAILED		TOTAL	
	n	Ave. Mark %	n	Ave. Mark %	n	Ave. Mark %
Superintendent	8	89,9	2	64,0	10	84,7
Supervisor	13	85,7	0	-	13	85,7

Note: The minimum requirement is an average mark of 70%.

As was the case during 1989, attendance at refresher courses was disappointing. In most cases only supervisors recommended by COMRO staff members on grounds of poor performance during routine assessments attended these courses. Of the 139 individuals conducting selection and protection procedures only 36 (25,9 per cent) attended refresher courses during 1990. Considering that all active supervisors and superintendents should attend a refresher course at least once every two years, an attendance rate of 50 per cent should be expected.

3.3 Heat Stroke Statistics

3.3.1 Incidence

During 1990, seven heat stroke incidents were reported to COMRO (see Table 5). All but one of the incidents occurred in underground work places and three fatalities were recorded. The corresponding figure for 1989 was six non-fatal incidents (all in underground work places).

Table 5 SUMMARY OF HEAT STROKE INCIDENTS REPORTED TO COMRO DURING 1990

Case	Date of Incident	Outcome	Age (Yrs)	Environment (°C)		Job Description Activity	Acclimatization	
				Wet bulb	Dry bulb		Type	Duration
1	90/01/16	Fatal	41	36,2	38,3	Winch Operator	HTT	
2	90/01/31	Fatal	42	31,8	32,8	Timber Installer	Not acclimatized	
3	90/02/14	Fatal	40	31,9	32,3	Timber Installer	CRA	4 (n = 5)*
4	90/04/05	Non-fatal	34	28,0	31,0	Machine Operator	Not acclimatized	
5	90/04/18	Non-fatal	27	31,5	36,0	Machine Operator	CRA	5 (n = 5)*
6	90/10/16	Non-fatal	30	35,8	37,2	Machine Operator	CRA	4 (n = 5)*
7	90/12/27	Non-fatal	38	31,7	33,8	Block Stepping	HTT	

*n denotes days of acclimatization required in order to work in the underground environment where the incident occurred.

3.3.2 Causal factors

An analysis of causal factors in the incidence of heat stroke is given in Table 6. More specific details concerning the physical activity and the environmental conditions under which heat stroke occurred, as well as the acclimatization procedures, are given in Table 5. In five cases a combination of two causal factors was noted, in one case a combination of three causal factors occurred, while in the remaining case a combination of four causal factors occurred. Causal factors in decreasing order of prevalence were as follows:

- (a) Severe heat stress: six cases (86 per cent) were associated with thermal conditions in excess of recommended upper limits.

- (b) Dehydration: three cases (43 per cent) were associated with dehydration. In two cases no water was consumed during the shift although drinking water was freely available. In two cases excessive alcohol consumption contributed to dehydration.
- (c) Transfers: two cases (29 per cent) were associated with incorrect transfers.
- (d) Illness: in two cases (29 per cent) incipient disease was present.

In view of the observation that drilling could be categorized as 'hard' work, high metabolic rates could be implicated in three of the seven cases.

In the case of the heat stroke which occurred in a climatic chamber during a heat tolerance test, circumstantial evidence suggests the cause to be dehydration as a result of excessive alcohol intake the previous day, combined with an increased susceptibility to hyperpyrexia, due to an underlying ear infection from which the worker had been suffering at the time. The latter was established only after the incident. (This was the first incidence of heat stroke recorded in a climatic chamber since 1987, when five of the twelve heat stroke cases reported during that year occurred in climatic chambers on mines.)

Table 6 ANALYSIS OF HEAT STROKE INCIDENTS FOR 1990 : (A) CAUSAL FACTORS AND (B) IRREGULARITIES DURING TREATMENT

	CASE NO.							FREQUENCY OF CAUSAL FACTORS (PREVALENCE %)
	1	2	3	4	5	6	7	
(A) CAUSAL FACTORS								
1. Severe heat stress	x	x	x	x	x	x		86
2. Dehydration	x			x	x		x	43
3. Alcohol				x			x	29
4. Incorrect transfers			x		x			29
5. Illness				x			x	29
6. Obesity		x						14
7. Ventilation error						x		14
(B) IRREGULARITIES DURING HEAT STROKE TREATMENT								
1. No body temperatures measured	x	x		x	x	x		71
2. Incorrect treatment	x	x	x	x	x			71
*OUTCOME	F	F	F	NF	NF	NF	NF	

*NF = Non-fatal

F = Fatal

3.3.3 Treatment

In five of the cases reported during 1990 incorrect treatment was applied and in five cases no body temperatures were measured.

4 CONCLUSIONS AND RECOMMENDATIONS

- The decline in the percentage of workers performing CRA and the concomitant decrease in unproductive shifts spent in climatic chambers observed over past years continued during 1990. This can be ascribed, firstly, to the use of the HTT as a primary selection procedure at all mines where acclimatization is mandatory and, secondly, to the use of MCA and the direct allocation of intermediately-heat-tolerant individuals.
- On the basis of current statistics it is evident that certain mines are not using the HTT to its full potential and that recommendations regarding the exemption of certain work categories from heat tolerance testing and heat acclimatization are not being fully implemented. It is recommended that individual mines review their own situations with regard to exploiting the full potential of the HTT and that the exemption of workers on the basis of the nature of their underground duties be given a high priority.
- At this stage MCA is still the only cost-effective alternative to conventional climatic room acclimatization. Optimum utilization of MCA procedures can, in conjunction with the direct allocation of intermediately-heat-tolerant individuals, eliminate the need for CRA. The application of MCA has diminished compared with 1989 due to the direct allocation of intermediate heat tolerant individuals to underground work places where wet-bulb temperatures were $\leq 30,0^{\circ} \text{C}$.
- Mines not directly allocating intermediately-heat-tolerant individuals to appropriate underground thermal zones should determine whether the prevalence of underground work places where the wet-bulb temperature is $30,0^{\circ} \text{C}$ or less would make direct allocation feasible; this could further reduce non-productive shifts and possibly, as has been done at one particular mine, eliminate the need for MCA. Mines should, therefore, consider the feasibility of differential heat tolerance testing as a means of reducing the number of unproductive shifts.
- An analysis of heat stroke incidents occurring underground during 1990 identified severe heat stress and dehydration as the main predisposing factors, and the failure to apply correct treatment as a possible factor contributing to the 43 per cent mortality rate. This indicates a need for improvement in the education of workers regarding the hazards of working in heat and in the training of workers in the recognition and correct treatment of possible heat stroke cases. In view of this

observation an earlier proposal⁽⁶⁾, viz. that means be investigated to create an awareness of heat stroke amongst workers with specific reference to predisposing factors, early signs and symptoms as well as treatment, is reiterated.

- When one considers that incorrect transfers may have played a contributing role in two (29 per cent) of the reported heat stroke incidents, there may be justification for developing a short training programme for manpower officers in order to deal with the allocation of labour in accordance with the level of heat tolerance or the acclimatization procedure applied.
- Observations made during quarterly visits to climatic chambers suggest that the standard of Acclimatization Supervisors is inadequate. In order to improve this situation it is recommended that Industry consider upgrading the status of the Acclimatization Supervisor. The following considerations are offered:
 - (a) the position of Acclimatization Supervisor is not particularly attractive at present and therefore unlikely to attract worthwhile candidates;
 - (b) to be more cost-effective, flexible and realistic, selection and acclimatization practices are likely to become more complex and it may become necessary to introduce the concept of a 'Quality Controller' to cater for the combined requirements of surface selection and underground acclimatization and placement.

5 REFERENCES

1. HITGE, J.J., SCHUTTE, P.C. and KIELBLOCK, A.J. Acclimatization services to the mining industry : Statistics for 1986, Research Report No. 29/87, Chamber of Mines of South Africa, Johannesburg, April 1987.
2. SCHUTTE, P.C., HITGE, J.J. and KIELBLOCK, A.J. Acclimatization services to the mining industry : Statistics for 1987, Research Report No. 17/88, Chamber of Mines of South Africa, Johannesburg, August 1988.
3. HITGE, J.J., SCHUTTE, P.C. and KIELBLOCK, A.J. Acclimatization services to the mining industry : Statistics for 1988, Research Report No. 1/90, Chamber of Mines of South Africa, Johannesburg, January 1990.
4. HITGE, J.J., FRANZ, R.M., SCHUTTE, P.C. and KIELBLOCK, A.J. Acclimatization services to the mining industry : Statistics for 1989, Restricted Report No. 44/90, Chamber of Mines of South Africa, Johannesburg, October 1990.
5. VAN DER MERWE, M. and VAN DER LINDE, A. Annual ventilation report for controlled gold mines for the period October 1988 to September 1989, Reference Report No. 6/91, Chamber of Mines of South Africa, Johannesburg, 1991.

6. SCHUTTE, P.C., KIELBLOCK, A.J. and HITGE, J.J. An appraisal of heat acclimatization practices and procedures in the South African mining industry with special reference to the incidence of heat stroke, Research Report No. 10/86, Chamber of Mines of South Africa, Johannesburg, January 1986.

APPENDIX IACCLIMATIZATION SERVICES TO MINES : QUESTIONNAIRE

1. Mine: _____
2. Labour complement on mine: _____
3. Underground labour force: _____
4. Highest prevailing wet-bulb temperature underground: _____
5. Percentage of underground labour force requiring acclimatization: _____
6. Total number of men tested for heat tolerance: _____
7. Total number of men classified as hyper-heat-tolerant after the heat tolerance test: _____
8. Total number of men classified as intermediately-heat-tolerant (only applies to HTT performed at 31,7° C wet-bulb): _____
 - (a) Number of intermediately-heat-tolerant individuals directly allocated to production underground (wet-bulb temperature $\leq 30,0$ ° C): _____
 - (b) Number of men subjected to microclimate acclimatization: _____
 - (c) Number of intermediately-heat-tolerant individuals subjected to climatic room acclimatization procedures: _____
9. Total number of men successfully acclimatized during standard climatic room acclimatization procedures (this figure should include men who failed the HTT and then performed climatic room acclimatization procedures): _____

10. Total number of men deemed heat intolerant: _____

11. Retesting/re-acclimatization of workers:

(a) Number of men retested for heat tolerance and/or re-acclimatized due to hospitalization and absenteeism: _____

(b) Total number of shifts spent on retests and/or re-acclimatization: _____

12. Total number of man-shifts devoted to heat tolerance testing and climatic room acclimatization during 1990 _____

13. For those mines still employing the Physical Selection Test (PST):

a) Total number of men subjected to the PST: _____

b) Number of men classified as A, B and C category in the PST: _____

14. Number of certified Acclimatization Supervisors:

a) Whites b) Blacks

15. Of those mentioned above how many are actively engaged as acclimatization supervisors:

a) Whites b) Blacks