GUIDELINE FOR A MANDATORY CODE OF PRACTICE FOR AN OCCUPATIONAL HEALTH PROGRAMME (OCCUPATIONAL HYGIENE AND MEDICAL SURVEILLANCE) ON THERMAL STRESS

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I **DAVID MSIZA**, Chief Inspector of Mines, under section 49(6) of the Mine Health and Safety Act, 1996 (Act 29 of 1996) and after consultation with the Council, hereby issues the guideline for an occupational health programme (occupational hygiene and medical surveillance) on thermal stress in terms of the Mine Health and Safety Act, as set out in the Schedule.

(Signed)

DAVID MSIZA
Chief Inspector of Mines

SCHEDULE

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DEPARTMENT OF MINERAL RESOURCES

MINE HEALTH AND SAFETY INSPECTORATE

GUIDELINE FOR THE COMPILATION OF A MANDATORY CODE OF PRACTICE FOR

GUIDELINE FOR THE COMPILATION OF A MANDATORY CODE OF PRACTICE FOR AN OCCUPATIONAL HEALTH PROGRAMME (Occupational Hygiene and Medical Surveillance) ON THERMAL STRESS

(Signed)

CHIEF INSPECTOR OF MINES

mineral resources
Department:
Mineral Resources
REPUBLIC OF SOUTH AFRICA

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PART A:
THE GUIDELINE

1 Foreword

1.1 In an attempt to address matters affecting the health of workers in the mining industry, a Mine Health and Safety Council tripartite sub-committee was established under the auspices of the MOHAC. MOHAC found it necessary that in order to address these matters a guideline for a mandatory COP on thermal stress be drafted.

1.2 Significant risks to health exist in mining. In order to protect, monitor and promote employees' health status, an occupational health programme is required where exposure to such significant risks occurs. MOHAC considered it appropriate to prepare a guideline covering both occupational hygiene and medical surveillance to ensure compliance to the requirements of the MHSA and to bring about uniformity of health standards.

1.3 Where the employer's risk assessment indicates a need to establish and maintain either a system of occupational hygiene measurements or a system of medical surveillance, or where either system is required by regulation, the employer must prepare and implement a COP based on this guideline.

1.4 Thermal stress management is a multifaceted approach to promote worker health and safety through minimising human thermal stress and the incidence of heat or cold disorders.

1.5 Occupational thermal exposure is a health and safety hazard of no uncertain dimensions and, typically, has to be dealt with through strategies which embrace environmental engineering, administrative controls and personal protection. This scenario finds application in most South African mines and associated surface operations. The fundamental perspective to retain, however, is that source control through engineering means represents the primary strategy, irrespective of the hazard in question (see paragraph 7.1, Part C, page 10). Conversely, personal protection is not a convenient alternative to source control; at best it merely serves as an interim cost effective expedient.

1.6 When categorising the thermal environment as required by the guideline, regard must be had to the SAMOHP issued by the DMR.

1.7 This guideline assists employers with the establishment of an Occupational Health Programme, but does not stipulate specific requirements for specific circumstances. It sets out a basic system for managing risk to health. The first component of any management system is finding out **what the situation**, secondly deciding **what to do about it**.

2 Legal status of guidelines and codes of practice

2.1 In accordance with section 9(2) of the MHSA an employer must prepare and implement a COP on any matter affecting the health and safety of employees and other persons who may be directly affected by activities at the mines if the Chief Inspector of Mines requires it. These COPs must comply with any relevant guidelines issued by the Chief Inspector of Mines (section 9(3)).

3 The objectives of the guideline

3.1 The objective of this guideline is to enable the employer at every mine to compile a COP, which, if properly implemented and complied with, would protect and improve the health of employees at the mine by monitoring and reducing their exposure to thermal stress. It provides guidance of a general nature on the required format and content for the COP and details sufficient technical background to enable the drafting committee at the mine to prepare a comprehensive and practical COP for their mine.

It sets out the two components of an Occupational Health programme namely:

3.1.1 Occupational Hygiene

3.1.2 Medical Surveillance

3.2 Where an employer is required in terms of regulation 9.2(2) or in terms of risk assessment, to establish and maintain a system of occupational hygiene measurements in respect of thermal stress, this guideline should assist the employer in doing so.

4 Definitions and acronyms

'abnormally hot environment'

- means any environment where DB > 37.0 °C and/or WB > 32.5 °C (For underground Operations),
- means the time weighted average WBGT Index, determined over a period of one hour, exceeding 30 in the environment in which an employee works .(For surface Operations).

'COP' means Code of Practice.

'CSM' means Cold Stress Management.

'DMR' means the Department of Mineral Resources.

'DB' means Dry-bulb temperature.

'GT' means globe temperature (Radiant heat)

'hot environment' means any environment where DB < 37.0 °C, Globe temperature < 37.0 °C, a WB range of 27.5 - 32.5 °C inclusive.

'HSM' means Heat stress management.

'MHSA' means Mine Health and Safety Act, 1996 (Act 29 of 1996) as amended.

'MHSC' means Mine Health and Safety Council.

'MOHAC' means Mining Occupational Health Advisory Committee.

'NIOSH' means the United States National Institute for Occupational Safety and Health.

'OEL' means Occupational Exposure Limit.

'OMP' means Occupational Medical Practitioner.

'ON SITE' means in the vicinity of where the mine is situated.

'RADIANT HEAT' means the electromagnetic transfer of heat energy without direct contact.

'SAMOHP' means the South African Mines Occupational Hygiene Programme Codebook.

'SIMRAC' means Safety In Mines Research Advisory Committee.

'WB' means Wet-bulb Temperature.

'WBGT Index' means a number which characterises the thermal conditions in the environment to which that number applies.

5 Scope

5.1 A COP for an occupational health programme on personal exposure to thermal stress must be prepared, in compliance with this guideline, and implemented in terms of regulation 9.2(2), which requires that a system of occupational hygiene measurements on personal exposure to thermal stress must be prepared and implemented when the results of the risk assessment conducted has identified that the following limits prevail:

- Heat >25.0 °C wet bulb and/or >32.0 °C dry bulb and/or 32.0 °C radiant temperature (monitoring level)
- Cold <10 °C equivalent chill temperature (monitoring level)

5.2 This guideline covers a basic Occupational Health Programme for the purpose of measuring occupational exposures to thermal stress and the linking of these exposures to employee medical records.

5.3 The Occupational Health Programme should through monitoring identify employees with significant exposures and, where necessary, should provide for the implementation of control measures. This guideline does not stipulate the control measures but only the hierarchy to be followed to control exposures.

5.4 Formal data returns on exposure levels will be used to establish and maintain an industry exposure database.

6 Members of the task committee

The following members of the Sub-committees have prepared the original document.

6.1 Occupational Hygiene Sub-committee

STATE	EMPLOYEES	EMPLOYERS
B A Doyle - Chairperson	D R Beukes	G Janse van Rensburg
R H McIntyre		A J Kielblock
M R Motlhamme		H Moorcroft
D Rowe		D Stanton
		E Steyn
		D E Wrigley

6.2 Occupational Medicine Sub-committee

STATE	**EMPLOYEES**	**EMPLOYERS**
E M Ohaju	W Mboniso	D Barnes
D V P Mathibeli	N White	R Dowdeswell
A van der Merwe		R Guild
		M A C La Grange
		S Shearer

6.3 The following persons/private

H Rex	Anglo Gold
S Schutte	CSIR Mining Tech

6.4 The following members have reviewed the original document.

Review Team

STATE	EMPLOYEES	EMPLOYERS
	Occupational Hygiene Sub-committee	
M P Huma (Chairperson)	H an Vuuren	M Beukes
T Motitimi	E Gcilitshana	J Du Plessis
J Legadima		M J Mepha
	Occupational Medicine Sub-committee	
D Mokoboto	H.van Vuuren	D B De Villiers
A van der Merwe	E Gcilitshana	Z Ellof

Part B: Author's Guide

1 The COP must, where possible, follow the sequence laid out in Part C 'Format and Content of the COP'. The pages as well as the chapters and sections must be numbered to facilitate cross-referencing. Wording must be unambiguous and concise.

2 It should be indicated in the COP and on each annex to the COP whether-

(a) the annex forms part of the COP and must be complied with or incorporated in the COP or whether aspects thereof must be complied with or incorporated in the COP; or

(b) the annex is merely attached as information for consideration in the preparation of the COP (ie compliance is discretionary).

3 When annexes are used the numbering should be preceded by the letter allocated to that particular annex and the numbering should start at one (1) again (eg 1, 2, 3, A1, A2, A3).

4 Whenever possible illustrations, tables, graphs and the like should be used to avoid long descriptions and/or explanations.

5 When reference has been made in the text to publications or reports, references to these sources must be included in the text as footnotes or side notes as well as in a separate bibliography.

Part C:
Format and Content of the Mandatory Code of Practice

1 Title page

The COP should have a title page reflecting at least the following:

1.1 name of mine;

1.2 the heading: 'Mandatory Code of Practice for an Occupational Health Programme on Thermal Stress';

1.3 a statement to the effect that the COP was drawn up in accordance with guideline Department of Mineral Resources Reference Number DMR 16/3/2/4-A2 issued by the Chief Inspector of Mines;

1.4 the mine reference number for the COP;

1.5 the effective date; and

1.6 revision dates (if applicable).

2 Table of contents

The COP must have a comprehensive table of contents.

3 Status of COP

This section must contain statements to the effect that:

3.1 the COP was drawn up in accordance with Guideline DMR 16/3/2/4-A2 of the Department of Mineral Resources issued by the Chief Inspector of Mines;

3.2 this is a mandatory COP in terms of sections 9(2) and (3) of the MHSA;

3.3 the COP may be used in an accident investigation/inquiry to ascertain compliance and also to establish whether the COP is effective and fit for purpose;

3.4 the COP supersedes all previous relevant COPs; and

3.5 all managerial instructions, recommended procedures (voluntary COPs) and standards on the relevant topics must comply with the COP and must be reviewed to ensure compliance.

4 Members of drafting committee

4.1 In terms of section 9(4) of the MHSA the employer must consult with the health and safety committee on the preparation, implementation or revision of any COP.

4.2 It is recommended that the employer should, after consultation with the employees in terms of the MHSA, appoint a committee responsible for the drafting of the COP.

4.3 The members of the drafting committee assisting the employer in drafting the COP should be listed giving their full names, designations, affiliations and experience. This committee must include competent persons sufficient in number effectively to draft the COP.

5 General information

General relevant information relating to the mine must be stated in this section of the COP. The following minimum information must be provided:

5.1 A brief description of the mine and its location.

5.2 The commodities produced.

5.3 The mining method or combination of methods used at the mine must be listed. This section must discuss the degree of mechanisation, taking care to identify the potential sources of thermal stress.

5.4 The general ventilation arrangements and/or cooling arrangements.

5.5 Other related COPs and management standards must be reviewed concurrently in order to avoid conflict of requirements as laid down by the mine. The objective would be to have an integrated system.

5.6 The unique features of the mine that have a bearing on this COP and cross-reference them to the risk assessment conducted.

6 Terms and definitions

Any word, phrase or term of which the meaning is not absolutely clear or which will have a specific meaning assigned to it in the COP, must be clearly defined. Existing and/or known definitions should be used as far as possible. The drafting committee should avoid jargon and abbreviations that are not in common use or that have not been defined. The definitions section should also include acronyms and technical terms used.

7 Risk management

7.1 Section 11 of the MHSA requires the employer to identify hazards, assess the health and safety risks to which employees may be exposed while they are at work, record the significant hazards identified and risk assessed. The employer must determine how the significant risks identified in the risk assessment process must be dealt with, having regard to the requirements of sections 11(2) and (3) that, as far as reasonably practicable, attempts should first be made to eliminate the risk, thereafter to control the risk at source, thereafter to minimise the risk and thereafter, insofar as the risk remains, to provide personal protective equipment and to institute a programme to monitor the risk.

7.2 To assist the employer with the risk assessment all possible relevant information such as accident statistics, ergonomic studies, research reports, manufacturers specifications, approvals, design criteria and performance figure for all relevant equipment should be obtained and considered.

7.3 In addition to the periodic review required by section 11(4) of the MHSA, the COP should be reviewed and updated after every serious incident relating to the topic covered in the COP, or if significant changes are introduced to procedures, mining and ventilation layouts, mining methods, plant or equipment and material.

8 Aspects to be addressed in the COP

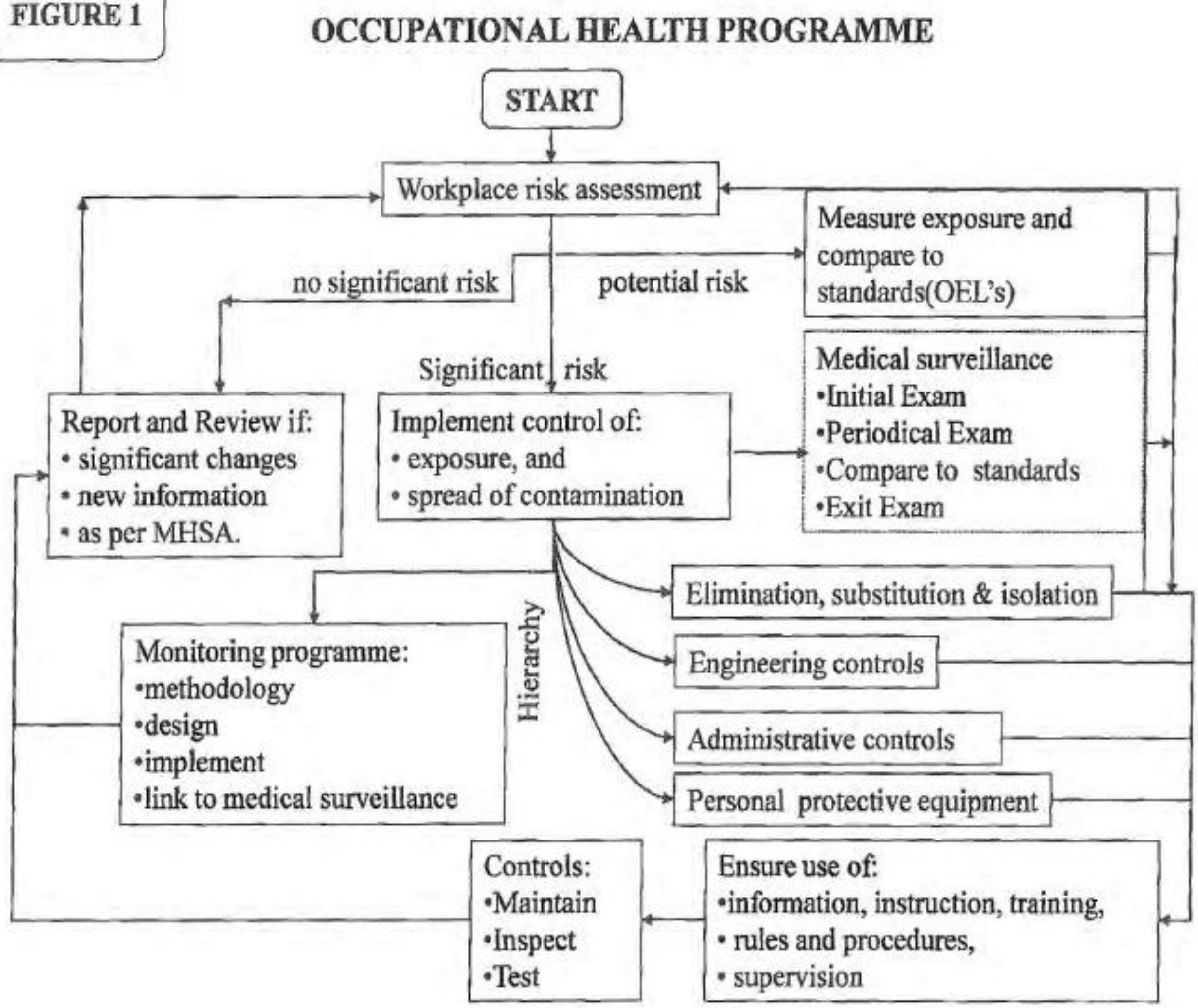
Where the employer's risk assessment indicates a need to establish and maintain either a system of occupational hygiene measurements or a system of medical surveillance, or where either such system is required by regulation, the following key elements must be addressed in the COP:

- Risk assessment and control.
- Monitoring programme.
- Hierarchy of controls.
- Medical surveillance.
- Reporting and reviewing.

These key elements are shown in Figure 1 below.

The Occupational Health Programme to be implemented on the mine must be summarised in the COP in a flow chart similar to Figure 1.

FIGURE 1



The Occupational Health Programme has two components namely:

- Occupational Hygiene; and
- Medical Surveillance.

8.1 Occupational Hygiene Programme

The employer must ensure that when undertaking an Occupational Hygiene Programme the following steps are included:

- Step 1: Risk Assessment and Control
- Step 2: Categorisation of the Thermal Environments
- Step 3: Thermal Stress Management (ie heat stress and/or cold stress management)
- Step 4: Measurement Methodology
- Step 5: Thermal Stress Monitoring
- Step 6: Reporting and Recording

For the purpose of this guideline thermal stress will be dealt with in two separate parts, namely:

Note:

PART 1: HEAT STRESS (Paragraph 8.1.1)

PART 2: COLD STRESS (Paragraph 8.1.2)

Steps 1-5 are covered separately in each part.

Step 6, paragraph 8.1.3 applies to both parts.

8.1.1 Part 1: Heat stress

8.1.1.1 Risk assessment and control

The COP must address the following points:

(a) The risk assessment process used must be described.

Note:

Where the available historical data is insufficient to enable professional judgement regarding the extent of any risk, acceptable methodologies eg such as stipulated by NIOSH or BRITISH STANDARDS BS EN 689 should be used.

Other reference material that could be used is-

- International Organisation for standardization ISO 7243
- *Analytical method for assessing and controlling hot environments based upon the wet bulb globe temperature (WBGT)_index ISO 7933*

(b) The activity areas must be described (see SAMOHP, Part A, section 2.2.2, Step 2) with reference to the:

(i) significant sources of heat stress to which employees are being exposed and would influence the environmental thermal load, eg geothermal gradient and rock temperature, machinery, high humidity, high radiant heat (see Annexure 2. Annexure 2 is for information only), auto compression, rate of work (strenuous work), restricted and inclined work areas etc, which have been identified, in the Activity Area;

(ii) health effects associated with exposure to heat stresses (high environmental heat loads and radiant temperature);

(iii) limits for each relevant parameter of the environmental thermal load on the mine eg

- Wet-bulb temperature in °C
- Dry-bulb temperature in °C
- radiant temperature (Globe temperature) in °C
- Velocity in m/s (stoping and general ventilation)
- Air volume per square meter of face in m^3/s (development)
- Indices (discomfort index, effective temperature
- wet bulb globe temperature, etc);

(iv) nature of the key workplace operations and activities that pose the greatest potential for exposure heat stress;

(v) occupations and number of employees who are being exposed to heat stress;

(vi) pattern, ie intermittent, continuous etc, duration and frequency of employee exposure to heat stress;

(vii) the actual exposure levels measured compared to occupational exposure limits;

(viii) control measures in place, ie substitution, engineering, administration, personal protective equipment etc, the additional control measures required to be instituted in order to reduce or maintain exposures to below the occupational exposure limits, and if applicable the planned programme of implementation; and

(ix) frequency of any ongoing monitoring to assess the effectiveness of the controls mentioned above.

8.1.1.2 Categorisation of the thermal environment

(a) The thermal environment must be categorised for the purposes of monitoring

Note:

Paragraph 2.2.2 of the SAMOHP sets out the sequential methodology to be used for the categorisation of the thermal environment. This methodology includes the following:

Step 1: Subdivide the mine into measurement areas;

Step 2: Subdivide the measurement areas into activity areas;

Step 3: Evaluate the risk assessment undertaken;

Step 4: Subject the data to an elementary but statistical analysis in order to categorise each defined activity area with a degree of confidence commensurate with the risk;

Step 5: (Optional) - depending on specific circumstances, needs or operations, mines may opt to implement heat stress management in terms of a heat stress index.

(b) The categorisation of the thermal environment must be clearly demarcated on a plan/sketch.

(c) The thermal environment must be reclassified when there is a need.

(d) Thermal environments must be re-assessed when inter-alia the following occur:

(i) exposure levels change due to controls being initiated and likewise when controls deteriorate;

(ii) employee complaints are received;

(iii) processes are changed (eg change in procedures, mining and ventilation layouts, mining methods, plant, equipment or material);

(iv) occupational illness occurs;

(v) change in exposure category occurs; and

(vi) other events warranting re-evaluation eg new regulatory initiatives.

Note:

This re-classification must only be done if results are proven and consistent. The monitoring strategy within that thermal environment must adopt to the new frequency of monitoring when either of the above occurs (ie 8.1.1.2 (c) and (d)).

8.1.1.3 Heat stress management (HSM)

(a) The COP must require a heat stress management programme to be implemented where the risk assessment determines a significant risk (ie category A, B and C, step 4, see SAMOHP). The following criteria must be addressed in this Thermal Stress Code of Practice and/or cross-referenced to the standard operating procedure addressing this programme:

(i) Structural Organisation for Heat Stress Management (see Annex 4);

(ii) Medical/Physical Examinations (see Annexure 5);

(iii) Heat Tolerance Screening (see Annexure 6);

(iv) Work Practices: Surface Opencast and Underground Operations (see Annexure 7);

(v) Absenteeism (see Annexure 8);

(vi) Water and Nutritional Requirements During Work in Heat (see Annex 9); and

(vii) Emergency Work (see Annexure 10).

Note:

The above annexes are extracts from the SIMRAC Project Report GAP 505, and are included for information purposes. It is further recommended that the project report be consulted in its entirety for more background information pertaining to this stress.

8.1.1.4 Measurement methodology

(a) The COP must require a data sheet to be drawn up and kept on record by the mine for each parameter of the environmental thermal load. Points to be addressed in this data sheet should include inter-alia the following:

(i) the instrument used;

(ii) specification/accuracy;

(iii) calibration/certification;

(iv) methodology (base-line survey and environmental monitoring); and

(v) data recording format.

8.1.1.5 Heat stress monitoring

Monitoring is to be conducted on an annual cycle period in compliance with regulation 9.2(7).

Note:

The category of the thermal environment in which persons are working must be allocated to all employees within that thermal measurement area.

(a) Formal Monitoring Period

Thermal monitoring for heat stress is to be conducted during the warmest quarter in the weather cycle, determined by the risk assessment. (Generally for surface operations this will be for the quarters - October to December and January to March).Underground operations monitoring should be conducted in accordance with the risk assessment.

Note:

The employer must ensure that in defining any particular thermal environment, the precautions listed below are heeded.

(i) Care should be exercised to detect trends where the thermal environment changes, especially from 'cool' to 'hot', or from 'hot' to 'abnormally hot'. Regular monitoring is clearly indicated, even if only on a random basis, and 'cool' environments should not be excluded, especially when marginal. The specific protocol would be dictated by prevailing circumstances, and, therefore, cannot be stipulated or prescribed;

(ii) Seasonal drifts could be crucial and to rely on winter temperatures may lead to an underestimation of the risk and *visa versa* [sic]. Environmental monitoring should take this into account.

(b) The employer must consider the following points with regards to workplace monitoring:

(i) For the purpose of defining the thermal environment from a Heat Stress Management point of view, dry-and wet-bulb, and globe temperatures, using a whirling hygrometer, or any other suitable instrumentation, may be used. This information may be extracted from existing, and continually updated, databases. Regular monitoring, even on a daily basis, is recommended under certain circumstances.

- The primary purpose of workplace monitoring is to verify the findings of the base-line survey, ie that environmental conditions still fall within the ranges applicable to the environmental heat load category (A, B, C or D) assigned to a particular workplace. In this regard, **workplace monitoring represents a review of the base-line survey** and, as such, provides input to the following base-line survey (to be carried out a year later).

- Workplace monitoring should be sufficiently sensitive to detect changes or trends in the thermal environment so that significant changes in the environmental thermal load can be detected timeously and dealt with in a pro-active manner, if at all possible. By 'significant' is meant that the environmental thermal load category is likely to or has changed. Of course, upward drifts are more critical in this regard.

(ii) For the monitoring programme to be effective it should be developed in house within the following framework-

Routine monitoring: All areas of work should be monitored in terms of the most relevant parameter of the prevailing thermal environment (eg wet bulb temperature) that is periodically done in accordance to the Heg classification as stipulated in step 4, paragraph 2.2.2 of the SAMOHP Code book.

Adjusted monitoring: Where prevailing conditions are close to upper limits (eg within the range of 1 to 2 °C dry or wet bulb) or where trends are discernible, the frequency of monitoring must be increased in accordance to the risk in order to manage the risk on a day to day basis.

(iii) The procedures to ensure that the above workplace-monitoring programme is adhered to must be described in the Code of Practice. Where corrective actions are necessitated, this information should also be logged in the workplace record.

(iv) In the event those thermal environments change significantly (ie a change of category takes place), two main scenarios exist.

- Firstly, the change could be of a temporary nature but if the category changes for the worse and employees are exposed, irrespective of personal consequences, the mine should undertake a formal investigation and record its findings. Such overexposures should be recorded on affected employees' medical records if overt indications of heat illness or disorders occur. In the event of incidents of heat exhaustion and/ or heat stroke, the DMR must be informed officially as required by the existing SAMRASS reporting system.
- Secondly, where such changes are permanent, eg as a result of improved ventilation/cooling practices or as a result of operational dictates, **the base-line survey should be updated on a quarterly basis.** The format of the report is the same, irrespective of whether or not such changes are permanent or temporary. (Shifts in environmental heat loads within a given category do not have to be reported.)

8.1.2 Part 2: Cold stress

8.1.2.1 Risk assessment and control

The COP must address the following points:

(a) The risk assessment process used must be described.

Note:

Where the available historical data is insufficient to enable professional judgement, acceptable methodologies eg such as stipulated in NIOSH or British Standard BS En 689 should be used.

Other reference material that could be used is:

- *Method of assessing thermal stress associated with exposure to cold environments ISO11079:2007*

(b) The activity areas must be described (see SAMOHP, Part A, section 2.2.3) with reference to:

(i) the significant sources of cold stress, to which employees are being exposed and would influence the environmental thermal load, eg air temperature, wind velocity, refrigerator rooms, etc which have been identified in the Activity Area;

(ii) the health effects associated with exposure to cold stress;

(iii) the limits for each relevant parameter of the environmental thermal load on the mine, eg:

- Drybulb temperature in °C;
- Equivalent chill temperature in °C;

(iv) the nature of key workplace operations and activities that pose the greatest potential for exposure to cold stress;

(v) the occupations and number of employees which are being exposed to cold stress;

(vi) the pattern, ie intermittent, continuous etc, duration and frequency of employee exposure to cold stress;

(vii) the actual exposure levels measured compared to occupational exposure limits;

(viii) the control measures in place, ie substitution, engineering, administration, personal protective equipment etc, the additional control measures required to be instituted in order to reduce or maintain exposures to below the occupational exposure limits, and if applicable the planned programme of implementation; and

(ix) the frequency of any ongoing monitoring to assess the effectiveness of the controls mentioned above.

8.1.2.2 Categorisation of the thermal environment

(a) The thermal environment must be categorised for the purpose of monitoring. The COP must address the following Points:

Note:

Paragraph 2.2.3 of the SAMOHP sets out the sequential methodology to be used for the categorisation of the thermal environment. This methodology includes the following:

Step 1: Subdivide the mine into measurement areas;

Step 2: Subdivide the measurement areas into activity areas;

Step 3: Evaluate the risk assessment undertaken;

Step 4: Subject the data to an elementary but statistical analysis in order to categorise each defined activity area with a degree of confidence commensurate with the risk.

(b) The thermal categorisation of these thermal environments must be clearly demarcated on a plan/sketch.

(c) The thermal environment must be reclassified when there is a need.

(d) Thermal environments must be re-assessed when inter-alia the following occur:

(i) exposure levels change due to controls being initiated and likewise when controls deteriorate;

(ii) employee complaints are received;

(iii) processes are changed (eg change in procedures, mining and ventilation layouts, mining methods, plant, equipment or material);

(iv) occupational illness occurs;

(v) a change in exposure category occurs; and

(vi) other events warranting re-evaluation, eg new regulatory initiatives.

Note:

Any re-classification must only be done once results are proven and consistent The monitoring strategy within that thermal environment must adopt to the new frequency of monitoring when either of the above occurs.

8.1.2.3 Cold stress management (CSM)

(a) The COP must require a cold stress management programme to be implemented where the risk assessment determines a significant risk (ie categories A and B, see SAMOHP, step 4). The following points must be addressed in this Code of Practice and or cross referenced to the standard operating procedure addressing this criteria:

(i) structural Organisation;

(ii) medical/physical examinations;

(iii) safe Work Practices and Supervision: Strategy for dealing with cold environments;

(iv) precautions to prevent cold stress eg personal protective equipment; and

(v) emergency work.

Note:

Annex 3 should be consulted when drawing up this management programme.

Annex 3 is for information only.

8.1.2.4 Measurement methodology (for cold stress)

The COP must require a data sheet to be drawn up and kept on record by the mine for each parameter of the environmental thermal load. Points to be addressed in this data sheet should include inter-alia the following:

(a) the instrument used;

(b) specification/accuracy;

(c) calibration/ certification;

(d) methodology (base-line survey & environmental monitoring); and

(e) data recording format.

8.1.2.5 Cold stress monitoring

Monitoring is to be conducted on an annual cycle period in compliance with regulation 9.2(7). Accurate meaningful results, which are representative of all full working shifts for that thermal environment, are obtained from this monitoring.

Note:

The category of the thermal environment in which persons are working must be allocated to all employees within that thermal measurement area.

For the purpose of defining the thermal environment from a Cold Stress Management point of view, dry-bulb temperatures and velocity, using any suitable instrumentation, may be used. This information may be extracted from existing, and continually updated, data bases. Regular monitoring, even on a daily basis, is recommended under certain circumstances.

(a) Formal Monitoring Period

Thermal monitoring for cold stress is to be conducted during the coldest quarter, as determined during the risk assessment.

(Generally for Cold Stress: Quarter - April to June and July to September)

Note:

In defining any particular thermal environment, the precautions listed below should be heeded.

Care should be exercised to detect trends where the thermal environment changes, especially from 'cool' to 'cold'. Regular monitoring is clearly indicated, even if only on a random basis, and 'cool' environments should not be excluded, especially when marginal. The specific protocol would be dictated by prevailing circumstances, and, therefore, cannot be stipulated or prescribed.

8.1.3 Reporting and recording

The COP must address the following points:

8.1.3.1 Occupational Hygiene measurement records (records to be kept by the employer on site)

The record keeping system to be kept for a minimum of five years, should inter-alia include information on the following-

(a) Reasons for any change of category in the thermal environment-

(i) controls not operating effectively;

(ii) events or factors which have influenced the results; eg refrigeration plants not operating;

(iii) ongoing monitoring;

(iv) standard operating procedures;

(v) control measures in place; and

(vi) future plans (hierarchy of controls).

(b) Hierarchy of Controls initiated (describe method used ie)-

(i) Elimination:

- Innovation (remote control).

(ii) Engineering controls at source:

- Dilute with ventilation;
- Cooling installations;
- Radiation barriers, etc.

(iii) Administrative controls:

- Self pacing to prevent fatigue;
- Safe systems of work;
- Reducing exposure time (work rest cycles);
- Drinking rules for employees, etc.

(iv) Personal protective equipment (PPE):

- Body cooling garments, etc.

Note:

Regulation 9.2(7) pertains to annual personal exposure mandatory reports which are required to be submitted to the regional principal inspector of mines.

8.2 Occupational medical surveillance

The COP must address the following points:

8.2.1 Occupational medical surveillance programme

8.2.1.1 The medical surveillance programme required either in terms of the risk assessment process or if required in terms of chapter 11 of the MHSA regulations must be described.

8.2.1.2 The method used to link monitoring and the hygiene register to medical records as required in terms of section 12(3) of the MHSA must be described.

Note:

A manual or computerised system can be utilised whereby this information is transferred. These systems may have to be customised in accordance with the operations specific needs or commercial programs can be acquired to perform this task. Effective communication between the Occupational Hygiene Practitioner and the Occupational Medical Practitioner is required to ensure that exposure history and medical manifestation of systems are meaningful.

8.2.1.3 Categories of medical examinations at which medical surveillance may be carried out

A procedure describing how the following examinations required by the MHSA will be conducted at the mine:

(a) **Initial examination** - in terms of section 13(2)*(c)* of the MHSA;

(b) **Periodic examination** - in terms of section 13(2)*(c)* of the MHSA;

(c) **Exit examination** - in terms of sections 17 and 19(2) of the MHSA.

8.2.2 Methodological standards for test techniques forming part of medical surveillance

8.2.2.1 The methodology used to comply with the legal requirements in respect of medical surveillance stipulated in section 13(2) of the MHSA, must be described in the COP.

Note:

The employer must ensure that for routine work, the anticipated work environment must be categorised as follows:

(a) For heat as (refer to Codebook paragraph 2.2.2 step 4 para 4):

(i) Category A;

(ii) Category B;

(iii) Category C; and

(iv) Category D.

Occupational exposures are derived from the base-line survey;

(b) And for cold as (refer to Codebook paragraph 2.2.3 step 4 point 3):

(v) Category A;

(vi) Category B;

(vii) Category C.

8.2.2.2 The procedure must be described to ensure that the above information is available to the occupational medical practitioner.

Note:

Heat and Cold disorders can occur and do occur in thermal environments without any significant change in environmental thermal load. Whenever such incidents occur, immediate and full investigations should take place, the primary purpose being to:

(a) prevent the recurrence of such incidents, and by collating such data,

(b) provide input to Heat Stress Management or Cold Stress Management programme review.

8.2.2.3 The protocol for employee monitoring must be described.

Note:

The protocol should be developed on the basis of the framework proposed in Annexure 5, section 1.3 'Heat as a Health and Safety Hazard: Information Base for Risk Assessment'. Annex 5 is for information only. Employee monitoring also provides input to medical surveillance and, consequently, these elements should be fully integrated. For work in an abnormally hot environment, fitness will be based on

(a) a satisfactory risk profile as determined by previous medical examinations; and

(b) the prevailing medical status and as determined by a special screening test.

Further guidance is provided in Annex 10 'Emergency Work in Abnormally 'Hot' Environments'. Annex 10 is for information only.

8.2.2.4 The procedure in force where work in 'abnormally hot' environments is to be undertaken must be described.

Note:

Any adverse consequences, as a result of such exposures, should be entered on the employee's medical record.

8.2.3 Medical surveillance according to health hazard

8.2.3.1 A system of medical surveillance that combines the requirements of medical surveillance for different hazards in such a way that these requirements are met effectively and efficiently, must be developed.

Note:

Frequently, employees are exposed to more than one hazard requiring medical surveillance. The medical surveillance in respect of each hazard should be done in parallel, and the mine's system of medical surveillance should be designed to avoid duplication. A single, similar test could suffice for the medical surveillance of more than one hazard. It could therefore be possible to use the same examination or test for the medical surveillance of more than one hazard, provided that the requirements of medical surveillance for each hazard are achieved.

PART D:
IMPLEMENTATION

1 Implementation plan

1.1 The employer must prepare an implementation plan for its COP that makes provision for issues such as organisational structures, responsibilities of functionaries and programmes and schedules for the COP that will enable proper implementation of the COP (A summary of and a reference to, a comprehensive implementation plan may be included).

1.2 Information may be graphically represented to facilitate easy interpretation of the data and to highlight trends for the purposes of risk assessment.

2 Compliance with the COP

The employer must institute measures for monitoring and ensuring compliance with the COP.

3 Access to the COP and related documents

3.1 The employer must ensure that a complete COP and related documents are kept readily available at the mine for examination by any affected person (describe the process).

3.2 The employer must ensure that a registered trade union with members at the mine or where there is no such union, a health and safety representative on the mine, or, if there is no health and safety representative, an employee representing the employees on the mine, is provided with a copy on written request to the manager. A register must be kept of such persons or institutions with copies to facilitate updating of such copies.

3.3 The employer must ensure that all employees are fully conversant with those sections of the COP relevant to their respective areas of responsibilities.

ANNEXURE 1:
Reference documents

(For information only)

1 The Mine Ventilation Practitioner's Data Book (1992). Section: Heat Stress. Topic: Stress.

2 'American Conference of Government Industrial Hygienists' Booklet TLVs and BEIs.

3 SIMGAP 505.

4 MHSC Handbook on Mine Occupational Hygiene Measurements Chapter 18 (thermal Environment).

5 Handbook in Environmental Engineering (published by Mine Ventilation Society of South Africa, as amended); Chapter 20 (Heat stress: origins and consequences) and Chapter 21 (Heat stress Management).

ANNEXURE 2
Radiant temperature

(For information only)

1 Radiant temperature

Radiation is the electromagnetic transfer of heat energy without direct contact. Radiant heating from the sun provides the best illustration. Despite the vacuum of space, sunlight strikes the earth's surface and is both absorbed and reflected, producing heat. Workers in hot environments exposed to high radiant loads will benefit from shielding. This, of course, explains the appeal of shade to those labouring in the sun. It is important to recognise that all objects radiate to other objects, thus the total thermal radiation to which a worker is exposed is the sum of all direct and indirect (reflected) radiation, minus the worker's radiation to cooler objects. For simplicity, when the radiant temperature is above about 35 °C (a common skin temperature during work in hot environments), the body will gain heat, whereas below 35 °C, the body loses heat through radiation.

Where radiant heat poses a potential problem, assessments must be conducted by means of a globe thermometer. Temperatures in excess of 37 °C should be regarded as an upper limit for sustained physical work and engineering controls must be invoked at this stage. Examples of how to control radiant heat include:

- radiant heat shielding,
- reduction of the temperature of the primary radiating surfaces,
- protective garments, and
- general design features.

For most people the pain threshold for an elevated skin temperature is 45 °C.

Finally, while most heat stress indices embrace radiant temperature, such indices must not be implemented unless under the direction of a recognised and experienced occupational hygienist.

1.1 Wet-bulb Globe Temperature (WBGT)

WGBT is calculated by adding seven tenths of the reading in degrees Celsius obtained with a naturally ventilated wet bulb thermometer to one fifth of the reading in degrees Celsius obtained with a globe thermometer and adding that sum to one tenth of the reading in degrees Celsius obtained with a dry bulb thermometer.

The WBGT index requires knowledge of the natural wet-bulb temperature (t_{nwb}), the globe temperature (t_g), and the dry-bulb air temperature (t_a). The WBGT is calculated for indoor exposure, or outdoor exposure with no solar load.

$$\mathbf{WBGT = 0.7t_{nwb} + 0.3t_g}$$

For outdoors sunlight exposure:

$$\mathbf{WBGT = 0.7_{tnwb} + 0.2t_g + 0.1t_a}$$

1.2 Calculating the WBGT

Where the employee is continuously exposed to a hot environment, the environmental heat exposure is considered as a series of hourly time-weighted averages. Where the employee's exposure is intermittent (interrupted at least each 15 minutes by breaks spent in cool areas), the time weighting should be performance for periods of two hours.

For jobs in which heat exposure and effort are intermittent, the time-weighted average must be derived by recording the time spent at each task including rest periods, and the corresponding times spent in hot locations and in cooler locations during recovery.

The two-hour time-weighted average is calculated by the following equation:

$$\text{Average WBGT} = \frac{WBGT_1) \times (T_1) + WBGT_2) \times (T_2) + \ldots + (WBGT_n) \times (T_n)}{(T_1) + (T_2) + \ldots + (T_n)}$$

In the above equation, $WBGT_1$, $WBGT_2$, and $WBGT_n$, are measured values of WBGT for the various work and rest intervals during the total time period. T_1, T_2 and T_n, is the duration of the respective intervals in minutes.

ANNEXURE 3
Cold stress

(For information only - abstract from ACGIH booklet)

Cold stress

Definitions and Acronyms

'Frostbite'

Means the actual freezing of tissue. Any exposed skin is subject to frostbite when the air temperature is below zero or when wind speeds are high. Frostbite can lead to scarring, tissue damage, and possible amputation and may cause permanent disability. Symptoms of frostbite vary from swelling of the skin accompanied by slight pain in mild cases to tissue damage without pain or with burning pain or prickling in severe cases. Frostbitten skin is subject to infection and therefore must not be treated lightly. Affected area should be warmed slowly to normal temperatures. Medical attention should be received for severe cases.

'Hypothermia'

Means when the deep body or 'core' temperature drops below 35 °C. At this point the body loses its ability to prevent heat loss. The onset of hypothermia is a gradual process. Initially the victim has a sensation of cold, followed by pain. As exposure time or cold increase the sensation of pain is reduced and overall numbness develops. Additional symptoms include a decrease or absence of shivering, reduced memory and confusion, drowsiness, slurred speech, irritability, impaired co-ordination, dexterity and general muscular weakness. Hypothermia is a serious condition and can lead to coma and death if not treated quickly. Victims of mild hypothermia should be rewarmed in a warm bed or bath or with warming packs and blankets. Victims with severe hypothermia must receive immediate medical care from experienced medical personnel.

W/m^2 means Work rate in Watts expressed in terms of body surface area in square metres.

1 Introduction

Fatal exposures to cold among workers have almost always resulted from accidental exposures involving failure to escape from low environmental air temperatures or from immersion in low temperature water. The single most important aspect of life-threatening hypothermia is the fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in Table 1. Workers should be protected from exposure to cold so that the deep core temperature does not fall below 36 °C; lower body temperatures will very likely result in reduced mental alertness, reduction in rational decision making, or loss of consciousness with the threat of fatal consequences.

Pain in the extremities may be the first early warning of danger to cold stress. During exposure to cold, maximum severe shivering develops when the body temperature has fallen to 35 °C. This must be taken as a sign of danger to the workers and exposure to cold should be immediately terminated for any workers when severe shivering becomes evident. Useful physical or mental work is limited when severe shivering occurs.

Since prolonged exposure to cold air or to immersion in cold water, at temperatures well above freezing can lead to dangerous hypothermia, whole body protection must be provided.

(a) Adequate insulating dry clothing to maintain core temperatures above 36 °C must be provided to workers if work is performed in air temperatures below -4 °C. Wind chill cooling rate and the cooling power of air are critical factors. (Wind chill cooling rate is defined as heat loss from a body expressed in watts per meter squared which is a function of the air temperature and wind velocity upon the exposed body). The higher the wind speed and the lower the temperature in the work area, the greater the insulation value of the protective clothing required. An equivalent chill temperature chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2. The equivalent chill temperature should be used when estimating the combined cooling effect of wind and low air temperatures on exposed skin or

when determining clothing insulation requirements to maintain the deep body core temperature.

(b) Unless there are unusual or extenuating circumstances, cold injury to other than hands, feet, and head is not likely to occur without the development of the initial signs of hypothermia. Older workers or workers with circulatory problems require special precautionary protection against cold injury. The use of extra insulating clothing and/or a reduction in the duration of the exposure period are among the special precautions, which should be considered. The precautionary actions to be taken will depend upon the physical condition of the worker and should be determined with the advice of a physician with knowledge of the cold stress factors and the medical condition of the worker.

TABLE 1: Progressive clinical presentation of hypothermia

Core Temperature	
°C	**Clinical Signs**
37.6	'Normal' rectal temperature
37	'Normal' oral temperature
36	Metabolic rate increases in an attempt to compensate for heat loss
35	Maximum shivering
34	Victim conscious and responsive, with normal blood pressure
33	Severe hypothermia below this temperature
32 31	Consciousness clouded; blood pressure becomes difficult to obtain; pupils dilated but react to light; shivering ceases
30 29	Progressive loss of consciousness; muscular rigidity increase; pulse and blood pressure difficult to obtain; respiratory rate decreases
28	Ventricular fibrillation possible with myocardial irritability
27	Voluntary motion ceases; pupils nonreactive to light; deep tendon and superficial reflexes absent
26	Victim seldom conscious
25	Ventricular fibrillation may occur spontaneously
24	Pulmonary edema
22 21	Maximum risk of ventricular fibrillation
20	Cardiac standstill
18	Lowest accidental hypothermia victim to recover
17	Isoelectric electroencephalogram
9	Lowest artificially cooled hypothermia patient to recover

Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physicians.

Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physicians. [sic]

TABLE 2: Cooling power of wind on exposed flesh as equivalent temperature
(under calm conditions)

	Actual Temperature (°C)								
Estimated Wind Speed (in kph)	4	- 1	- 7	- 12	- 18	- 23	- 29	- 34	- 40
0	4	- 1	- 7	- 12	- 18	- 23	- 29	- 34	- 40
8	3	- 3	- 9	- 14	- 21	- 26	- 32	- 38	- 44
16	- 2	- 9	- 16	- 23	- 30	- 35	- 43	- 50	- 57
24	- 6	- 13	- 20	- 28	- 36	- 43	- 50	- 58	- 65
32	- 8	- 16	- 23	- 32	- 39	- 47	- 55	- 63	- 71
40	- 9	- 18	- 26	- 34	- 42	- 51	- 59	- 67	- 76
48	- 16	- 19	- 22	- 36	- 44	- 53	- 62	- 70	- 78
56	- 11	- 20	- 29	- 37	- 46	- 55	- 63	- 72	- 81
64	- 12	- 21	- 29	- 38	- 47	- 56	- 65	- 73	- 82
Wind speed greater than 64 kph have little additional effect	LITTLE DANGER In < 1 hr with dry skin. Maximum danger of false sense of security			INCREASING DANGER Danger from freezing of exposed skin within 1 minute.			GREAT DANGER Flesh may freeze within 30 seconds.		

Developed by U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Equivalent chill temperature requiring dry clothing to maintain core body temperature above 36 °C per cold stress TLV.

2 Evaluation and control

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32 °C. Superficial or deep local tissue freezing will occur only at temperatures below -1 °C regardless of wind speed.

At air temperatures of 2 °C or less, it is imperative that workers who become immersed in water or whose clothing becomes wet be immediately provided a change of clothing and be treated for hypothermia.

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

(a) If fine work is to be performed with bare hands for more than 10-20 minutes in an environment below 16 °C, special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be utilised. Metal handles of tools and control bars should be covered by thermal insulating material at temperatures below -1 °C.

(b) If the air temperature falls below 16 °C for sedentary, 4 °C for light, -7 °C for moderate work, and fine manual dexterity is not required, then gloves should be used by the workers.

2.1 To prevent contact frostbite, the workers should wear anti-contact gloves.

(a) When cold surfaces below -7 °C are within reach, a warning should be given to each worker to prevent inadvertent contact by bare skin.

(b) If the air temperature is -17.5 °C or less, the hands should be protected by mittens.

Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

2.2 Provisions for additional total body protection are required if work is performed in an environment at or below 4 °C. The workers should wear cold protective clothing appropriate for the level of cold and physical activity:

(a) If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment.

(b) If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outerwear should be changed, as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of inner layers by sweat. If work is done at normal temperatures or in a hot environment before entering the cold area, the employee should make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee should change into dry clothes before entering the cold area. The workers should change socks and any removable felt insoles at regular daily intervals or use vapour barrier boots. The optimal frequency of change should be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.

(c) If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items should be supplied in auxiliary heated versions.

(d) If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work should be modified or suspended until adequate clothing is made available or until weather conditions improve.

(e) Workers handling evaporative liquid (gasoline, alcohol or cleaning fluids) at air temperatures below 4 °C should take special precautions to avoid soaking of clothing or gloves with the liquids because of the added danger of cold injury due to evaporative cooling. Special note should be taken of the particularly acute effects of splashes of 'cryogenic fluids' or those liquids with a boiling point that is just above ambient temperature.

3 Work-Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) or below -7 °C, heated warming shelters (tents, cabins, rest rooms, etc) should be made available nearby. The workers should be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, minor frostbite (frostnip), the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation or a change of dry work clothing provided. A change of dry work clothing should be provided as necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12 °C ECT, the following should apply:

(a) The worker should be under constant protective observation (buddy system or supervision).

(b) The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods should be taken in heated shelters and opportunity for changing into dry clothing should be provided.

(c) New employees should not be required to work full-time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.

(d) The weight and bulkiness of clothing should be included in estimating the required work performance and weights to be lifted by the worker.

(e) The work should be arranged in such a way that sitting still or standing still for long periods is minimised. Unprotected metal chair seats should not be used. The worker should be protected from drafts to the greatest extent possible.

(f) The workers should be instructed in safety and health procedures.

The training program should include as a minimum instruction in:

- Proper rewarming procedures and appropriate first aid treatment.
- Proper clothing practices.
- Proper eating and drinking habits.
- Recognition of impending frostbite.
- Recognition of signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur.
- Safe work practices.

TABLE 3: TLVs work/warm-up schedule for four-hour shift

	No Noticeable Wind		8 kp/h Wind		16 kp/h Wind		24 kp/h Wind		32 kp/h Wind	
Air Temperature °C (Sunny Skies)	Max Work Period	No Of Breaks	Max Work Period	No Of Breaks	Max Work Period	No Of Breaks	Max Work Period	No Of Breaks	Max Work Period	No Of Breaks
- 26 to -28	Normal	1	Normal	1	75 mins.	2	55 mins.	3	40 mins.	4
- 29 to – 31	Normal	1	75 mins.	2	55 mins.	3	40 mins.	4	30 mins.	5
- 32 to – 34	75 mins.	2	55 mins.	3	40 mins.	4	30 mins.	5		
- 35 to – 37	55 mins.	3	40 mins.	4	30 mins.	5				
- 38 to – 39	40 mins.	4	30 mins.	5						
- 40 to – 42	30 mins.	5								
- 43 and below										

Notes for Table 3:

1 Schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods of ten (10) minutes in a warm location and with an extended break (eg lunch) at the end of the 4-hour work period in a warm location. For

Light-to-Moderate Work (limited physical movement): apply the schedule one step lower. For example, at -35 °C with no noticeable wind (step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (step 5).

2 If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: (1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/m^2; (2) all non-emergency work should have ceased at or before a wind chill of 2250 W/m2. In general, the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatisation and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges because windy conditions rarely prevail at extremely low temperatures.

3 TLVs apply only for workers in dry clothing

4 Special Workplace Recommendations

4.1 Special design requirements for refrigerator rooms include the following:

(a) In refrigerator rooms, the air velocity should be minimised as much as possible and should not exceed 1m/s at the job site. This can be achieved by properly designed air distribution systems.

(b) Special wind protective clothing should be provided based upon existing air velocities to which workers are exposed.

Special caution should be exercised when working with toxic substances and when workers are exposed to vibration. Cold exposure may require reduced exposure limits.

Eye protection for workers employed out-of-doors in a snow and/or ice-covered terrain should be supplied. Special safety goggles to protect against ultraviolet light and glare (which can produce temporary conjunctivitis and/or temporary loss of vision) and blowing ice crystals should be required when there is an expanse of snow coverage causing a potential eye exposure hazard.

Workplace monitoring is required as follows:

(a) Suitable thermometry should be arranged at any workplace where the environmental temperature is below 16 °C so that overall compliance with the requirements of the TLV can be maintained.

(b) Whenever the air temperature at a workplace falls below -1 °C, the dry bulb temperature should be measured and recorded at least every 4 hours.

(c) In indoor workplaces, the wind speed should also be recorded at least every 4 hours whenever the rate of air movement exceeds 2 meters per second.

(d) In outdoor work situations, the wind speed should be measured and recorded together with the air temperature whenever the air temperature is below -1 °C.

(e) The equivalent chill temperature should be obtained from Table 2 in all cases where air movement measurements are required: it should be recorded with the other data whenever the equivalent chill temperature is below -7 °C.

Employees should be excluded from work in cold at -1 °C or below if they are suffering from diseases or taking medication which interferes with normal body temperature regulation or reduces tolerance to work in cold environments.

Medication that may affect Thermoregulation

Many classes of drugs, whether prescribed, over-the-counter, recreational, homeopathic, traditional or illicit, can predispose their users to heat-related illnesses. Certain medication and/or substances can interfere with normal thermoregulatory function in multiple ways, mediated through:

- the hypothalamus, which sets normal body temperature;
- heat perception, leading to behavioural change (heat avoidance);
- changes in cardiac output; changes in peripheral vasodilatation;
- Changes in sweat rate;
- Changes due to renal function and/or body hydration.

In terms of direct heat effects, the most pharmacological consequence is via the impact on sweat rate. Certain medication and/or substances can act on nerve endings of the sweat glands.

Medical consultation is recommended where a candidate is using drugs or medication including but not limited to:

- neuro- and psychotropic drugs, including recreational stimulants such as pseudo-amphetamines (eg Ecstasy),
- antihistamines commonly used for colds and flu,
- diuretics,
- beta-blockers,
- anti-epileptics,
- anti-spasmodics for stomach cramps.

Workers who are routinely exposed to temperatures below -24 °C with wind speeds less than eight kilometres per hour, or air temperatures below -18 °C with wind speeds above 2.2 m/s should be medically certified as suitable for such exposures.

Trauma sustained in freezing or sub-zero conditions requires special attention because an injured worker is predisposed to cold injury. Special provisions should be made to prevent hypothermia and freezing of damaged tissues in addition to providing for first aid treatment.

5 Cold Stress Monitoring

5.1 Introduction

For surface operations it seems likely that the nature and extent of environmental temperature monitoring and the need to initiate/discontinue heat and cold stress management programmes will in many instances be determined by seasonal drifts.

A possible scenario is outlined below.

SEASON	AUTUMN	WINTER	SPRING	SUMMER
ACTIVITY	Discontinue HSM; monitor dry-bulb and air to determine equivalent chill factor	Implement CSM	Discontinue CSM; monitor dry-bulb and wet-bulb	Implement HSM

Although CSM and HSM are two distinct programmes, they remain linked through ongoing mandatory monitoring of the thermal environment. Central co-ordination is therefore essential.

In the interim Occupational Hygienists will be required to implement a monitoring programme in order to assess risk. The parameters in question are dry-bulb temperature and air speed for the determination of wind-chill factor (regulation 9.2(2) and refer to ACGIH). A system of monitoring, including its derivation, is outlined below.

5.2 Basic considerations

The ACGIH interpretation of the equivalent chill temperature (ECT), converted to °C and approximated for convenience, is given below.

- > 5 °C (ECT): No risk
- 5 to -30 °C (ECT): Little danger for exposures of less than 1 hour
- < -30 °C (ECT): Increasing danger; exposed flesh may freeze in one minute (final category omitted as being unrealistic for SA conditions)

An air speed of 8 km/h (about 2 m/s) and above should be regarded as critical in changing the ECT from a 'No risk' to a 'Risk' category (ACGIH). Even at a dry-bulb temperature of 10 °C, an air speed of 16 km/h (about 4.5 s) and above could depress the equivalent chill temperature to critical levels. Air speeds on excess of 65 km/h have little additional effect.

Holmer and co-workers (1998) make the following distinctions:

- <18 °C dry-bulb: 'cold'
- < -30 °C (ECT): 'risk'

On the basis of the above considerations, the following monitoring system is proposed:

5.3 Proposed monitoring programme

5.3.1 Routine monitoring: Dry-bulb temperatures as supplied by the Weather Bureau (confirm relevance and accuracy) or any other direct measurement, if more applicable.

5.3.2 Dry-bulb < 18 °C (as per Weather Bureau): measure and record dry-bulb temperatures representative of critical work stations (ACGIH: < 16 °C).

5.3.3 Dry-bulb < 10 °C: measure and record, in addition, air speed and convert to ECT (ACGIH: air speed commences at -1 °C)

Actions:

- ECT > 5 °C: No risk; maintain monitoring of ECT
- ECT 5 °C but not -30 °C: Implement formal CSM programme
- ECT -30 °C: No-go; stop work/evacuate.

5.4 Categorisation

An occupational hygiene measurement system must be established according to regulation 9.2 and an annual report submitted to the DMR. This report is based on a categorisation of 'cold' working environments (SAMOHP Codebook).

Regulation 9.2(2) an occupational hygiene measurement system must be established (when): - cold: dry- bulb < 10 °C.

The categorisation system for the purpose of compiling the annual DMR report is given below.

CATEGORY	TEMPERATURE RANGE	INTERPRETATION	GENERAL ACTION
A 'Abnormally cold'	≤ -30 °C	Severe risk (frost bite)	Stop work; evacuate
B 'Severe cold'	≤ 5 °C but not ≤ -30 °C	Potential risk	Implement formal CSM[2]; no special precautions
C 'Cold'	> 5 °C	Negligible risk	Monitor equivalent chill temperature[3]

1 Temperature ranges are given in terms of equivalent chill temperature (ACGIH)

2 CSM: Cold Stress Management

3 For categorisation purposes, thermal environments in excess of 10 °C dry-bulb do not have to be reported

ANNEXURE 4
Structural organisation for heat stress management

(For information only)

Structural organisation for heat stress management

Definitions and acronyms

1 Introduction

By definition Heat Stress Management is based on multi-disciplinary inputs and control and it is proposed that overall control cannot be delegated but that it remains a management function. The multi-disciplinary nature of Heat Stress Management does, however, suggest the need for instituting some form of central co-ordination, a function which certainly can be delegated.

Heat Stress Management consists of two essential elements, namely:

- the detection of medical and physical contra-indications for work in heat, as well as gross or permanent heat intolerance by means of appropriate screening procedures; and
- The natural progression of heat acclimatisation on the basis of safe work practices.

An organisational framework for the control of Heat Stress Management is outlined in Figure 1.1. This should be viewed as a general guide which should be tailored to meet the particular requirements and organisational structure of each mine. The operational principle is that a system of regular review be instituted, for example on an annual basis. However, data acquisition and analysis should be sufficiently sensitive to identify untoward trends or incidents which would warrant immediate attention.

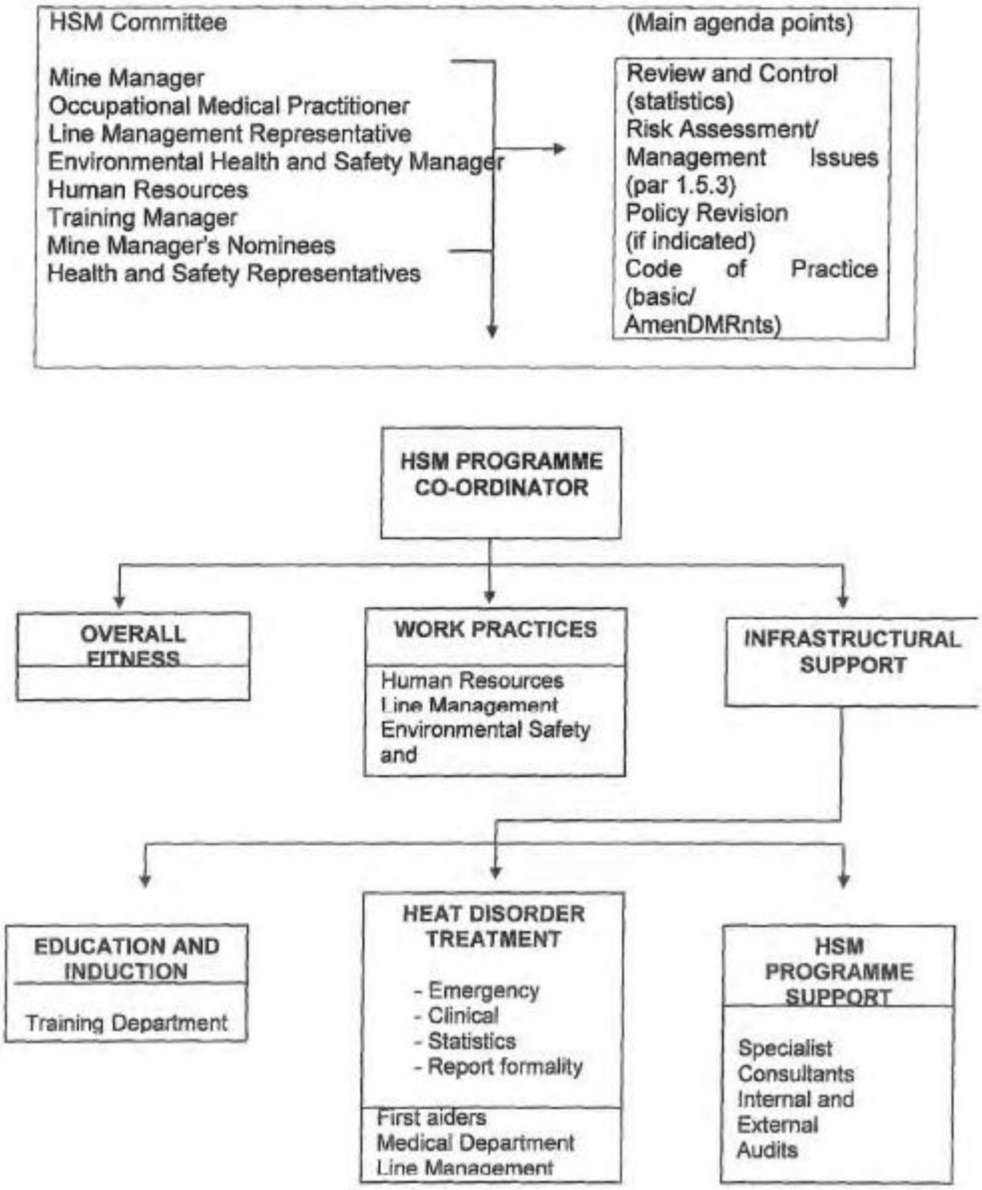
Establishing a structural organisation is seen as an essential first step in the implementation process.

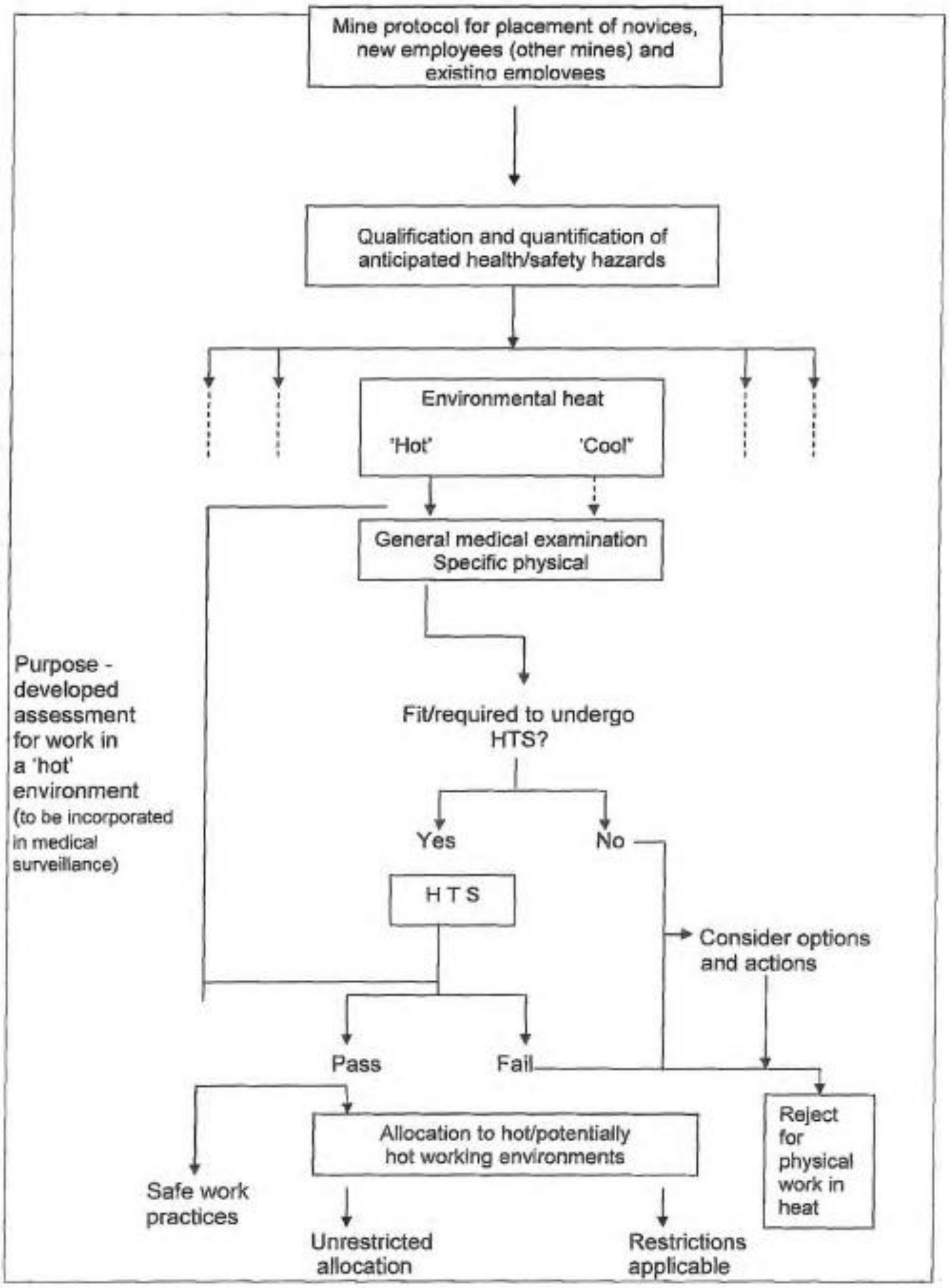
2 Functional Organisation

An overview of the functional organisation of Heat Stress Management is presented in the form of a flow-chart (Figure 1.2). For actual implementation of Heat Stress Management along the lines suggested, it should be clear that the inputs required at various levels become quite specialised. Appropriate disciplines and departments can therefore be identified and their general responsibilities deduced.

Having established a structural organisation, **the second step would be to ensure, as indicated above, that responsibilities are defined, and assigned to appropriate personnel and departments, and that effective inter-departmental communication links be established**. This is one of the key responsibilities of the 'HSM Programme Co-ordinator' listed in Figure 1.1.

OVERALL CONTROL OF HEAT STRESS MANAGEMENT





Annexure 5:
Medical/Physical examinations

(For information only)

Medical/Physical examinations

(Overall fitness for work in hot environments)

'Novice' means an individual with no prior experience of mining as a career.

'Strenuous work' means any form of work in 'hot' environments where the work rate exceeds 160 Wm^{-2}.

1 Introduction

The consequences of high environmental heat loads can be expressed in terms of impaired work capacity, errors of judgement with obvious implications for safety, and the occurrence of heat disorders, especially heat stroke which is often associated with severe and irreversible tissue damage and high mortality rates. It follows that overall fitness to undertake physical work in hot environments is a prerequisite and should conform to certain minimum standards. However, depending on circumstances, different sets of standards may be applied.

Overall fitness for work in hot environments will depend on the outcomes of:

- a purpose-developed general medical examination,
- a specific physical evaluation, and
- an assessment of heat tolerance.

The above outcomes should be incorporated in the medical surveillance programme, as required in terms of section 13 of the Mine Health and Safety Act. As a general guideline, all employees who enter 'hot' environments in the normal course of their duties, irrespective of whether such work consists of daily full-shift exposures or intermittent or periodic exposures, which may be brief (one hour) or extended (full shift), should be screened for heat intolerance.

1.1 General medical examination

The nature of the general medical examination may well include elements specific to a particular occupation and associated hazards. In the present context the following listing applies to environmental heat as a health hazard, most notably where physically demanding work is undertaken.

- **History**
    - Occupational,
    - Medical, especially where treatment is based on medication which is likely to increase susceptibility to heat disorder significantly,
    - Family/social, including alcohol or substance abuse,
    - Outcome of previous HTS tests, and
    - Heat disorders (cramps, exhaustion, stroke),
- **Urinalysis**
    - Origins of haematuria, proteinuria and glycosuria should be established and assessed
- **The examination should exclude**
    - Jaundice;
    - Anaemia;
    - Cyanosis;
    - Clubbing;
    - Oedema;
    - Abnormal lymph nodes; and
    - Febrile disease.
- Uncontrolled hypertension (>160/95) and gross cardiovascular abnormalities require a full investigation. So-called 'functional' murmurs should not be considered a problem. Specialist opinion regarding fitness

for physically demanding work in heat may be required. Hypertension should be controlled.

- The skin should be intact with no infections such as advanced athlete's foot, cellulitis, scabies, etc.
- Respiratory function, as determined by spirometry and chest X-ray, should be normal.
- Ear, nose and throat examination should exclude inflammation or infection (tonsillitis, pharyngitis, chronic suppyrative [sic] otitis media, etc).
- No organomegaly or hernias should be present.
- Gross neurological examination should be normal.
- No other abnormality that may compromise physical work in heat should be present.

Occupational Medical Practitioners should develop knowledge such that difficult decisions in 'grey' areas are taken fairly and professionally, bearing in mind the avoidable dangers of heat disorders.

1.2 Physical evaluation

The physical evaluation should be conducted as part of the medical examination but with special emphasis on features which would rule out physical work or exertion in heat. A specific requirement is to assess an individual's medical and physical fitness to undergo HTS.

1.2.1 Age

Age *per se* does not have a direct bearing on heat tolerance and should not serve as a contraindication for work in heat in isolation of other factors. Heat intolerance does, however, decline with reduced physical work capacity which, in turn, could have cardiovascular origins which do not necessarily become manifest through routine medical examinations. The underlying mechanism is an obligatory age-associated reduction in cutaneous vasodilatation (widening of skin blood vessels) and sweat rate (Yousef, 1987; Nunnely, 1998). A critical age limit of 50 years has been cited (Nunnely, 1998). This view is confirmed by local studies which show a decided increase in heat stroke susceptibility with advancing years (Kielblock, 1992).

As a general recommendation employees of 50 years and above should only be considered for strenuous work in hot environments or placement in work categories where the full-shift physical work demand is regarded as strenuous, provided the complete absence of any other personal risk factor, including a special medical assessment, can be demonstrated. This recommendation also applies to emergency operations, even if only of short duration. As a general reference to categorise work in terms of physical demand, Figures 1 and 2 in Annex 10, should be consulted. Annex 10 is for information only.

1.2.2 General physical appearance

Any apparent physical deformity (eg congenially acquired) or injury (eg amputations or joint malfunction) should be recorded. Where, in the opinion of the Occupational Medical Practitioner, any such deformity or injury precludes the employee from *(a)* undergoing HTS or *(b)* performing his work without undue physical discomfort, this should be stated clearly. The following options exist:

- fit/unfit to undergo HTS,

- fit for work in hot environments but unfit to undergo HTS and, therefore, exempted, and
- totally unfit for any form of physical work.

1.2.3 Body dimensions

In this respect two criteria apply, namely:

- an acceptable body mass to height ratio to rule out both under- and overweight individuals;
- minimum body mass as a criterion of the capacity to cope with externally imposed work demands. Body mass relative to height is often expressed in terms of the Body Mass Index or BMI (Ross et al, 1988); and
- It provides a better predictor of disease risk than weight (mass) alone. (It should not be used to assess competitive athletes or body builders, growing children and/or old and frail elderly individuals.) A high BMI leads to an increased risk to develop certain diseases, eg hypertension, cardiovascular disease, dyslipidaemia, adult-onset diabetes (type II), sleep apnea, osteoarthritis and other conditions. The above examples constitute a condition of co-morbidity, ie any condition associated with obesity (BMI of 30 - 35). Co-morbidity usually worsens as the degree of obesity increases, and often improves if successfully treated.

BMI can be calculated using the equation:

BMI = body mass (kg)/height $(m)^2$

The BMI is then expressed in terms of the following classification, the lower limit being based on the anthropometry of local mine workers (Schoeman et al, 1981):

< 15	: emaciated
15 - 19	: underweight
20 - 25	: normal body fat content
26 - 29	: overweight (warning)
30 - 35	: obese (overt risk factor)
> 35	: exclusion

The BMI should be used in conjunction with the essentially nude body mass to assess the adequacy of body dimensions relevant to physical work in hot environments. A distinction should be made between prospective or new employees ('novices' to mining) and existing employees. Calculated BMI values, for a wide range of body mass and height combinations, appear in Table 1.1 and a protocol for this assessment, in conjunction with a recommended course of action, is given below. A BMI of 30 or more constitutes a definitive risk factor.

TABLE 1.1: Body dimensions as criteria for physical work in hot environments

Employee Status	Criterion/Standard	Interpretation and recommended course of action
Prospective ('novice1')	Body mass <50 kg Body mass 50 - 55 kg BMI 15 - 29 BMI 30 - 35 BMI > 35	Unsuitable (BMI irrelevant): reject Suitable but not for 'strenuous' work2 Suitable Suitable with no medical contra-indications Unsuitable: reject
Existing	Body mass <45 kg Body mass 45 - 50 kg Body mass 45 - 55 kg BMI < 15 BMI 15 - 19 BMI 20 - 29 BMI 30 - 35 BMI >35	Unsuitable (BMI irrelevant): reject Suitable with no medical contra-indications or a history of heat disorders No allocation to 'strenuous' work (>160 $w.m^{-2}$) Unsuitable[3] Suitable with no medical contra-indications or history of heat disorders Suitable Suitable provided no medical contra-indications or history of heat disorders Unsuitable[3]

[1] Novice - see 'Glossary' for definition.

[2] Strenuous work - see 'Glossary' for definition.

[3] 'Unsuitable' implies withdrawal of certificate of fitness unless an acceptable BMI can be achieved within a reasonable time.

TABLE 1.1: Body Mass Index (BMI) as function of body mass and height

BODY MASS INDEX

Mass (kg)

Height (m)	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
2.00	13	13	13	13	14	14	14	14	15	15	15	15	16	16	16	16	17	17	17	17	18	18	18	18
1.98	13	13	13	14	14	14	14	15	15	15	15	16	16	16	16	17	17	17	17	18	18	18	18	19
1.96	13	13	14	14	14	14	15	15	15	15	16	16	16	16	17	17	17	17	18	18	18	18	19	19
1.94	13	14	14	14	14	15	15	15	15	16	16	16	16	17	17	17	18	18	18	18	19	19	19	19
1.92	14	14	14	14	15	15	15	15	16	16	16	17	17	17	17	18	18	18	18	19	19	19	20	20
1.90	14	14	14	15	15	15	16	16	16	16	17	17	17	17	18	18	18	19	19	19	19	20	20	20
1.88	14	14	15	15	15	16	16	16	16	17	17	17	18	18	18	18	19	19	19	20	20	20	20	21
1.86	14	15	15	15	16	16	16	16	17	17	17	18	18	18	18	19	19	19	20	20	20	21	21	21
1.84	15	15	15	16	16	16	17	17	17	17	18	18	18	19	19	19	19	20	20	20	21	21	21	22
1.82	15	15	16	16	16	17	17	17	18	18	18	18	19	19	19	20	20	20	21	21	21	21	22	22
1.80	15	16	16	16	17	17	17	18	18	18	19	19	19	19	20	20	20	21	21	21	22	22	22	23
1.78	16	16	16	17	17	17	18	18	18	19	19	19	20	20	20	21	21	21	21	22	22	22	23	23
1.76	16	16	17	17	17	18	18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24
1.74	17	17	17	18	18	18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24	24
1.72	17	17	18	18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24	24	24	25
1.70	17	18	18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	24	24	24	25	25	25
1.68	18	18	18	19	19	19	20	20	21	21	21	22	22	22	23	23	23	24	24	24	25	25	26	26
1.66	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	24	24	24	25	25	25	26	26	26
1.64	19	19	19	20	20	20	21	21	22	22	22	23	23	23	24	24	25	25	25	26	26	26	27	27
1.62	19	19	20	20	21	21	21	22	22	22	23	23	24	24	24	25	25	26	26	26	27	27	27	28
1.60	20	20	20	21	21	21	22	22	23	23	23	24	24	25	25	25	26	26	27	27	27	28	28	29
1.58	20	20	21	21	22	22	22	23	23	24	24	24	25	25	26	26	26	27	27	28	28	28	29	29
1.56	21	21	21	22	22	23	23	23	24	24	25	25	25	26	26	27	27	28	28	28	29	29	30	30
1.54	21	22	22	22	23	23	24	24	24	25	25	26	26	27	27	27	28	28	29	29	30	30	30	31
1.52	22	22	23	23	23	24	24	25	25	26	26	26	27	27	28	28	29	29	29	30	30	31	31	32
1.50	22	23	23	24	24	24	25	25	26	26	27	27	28	28	28	29	29	30	30	31	31	32	32	32

BODY MASS INDEX

Mass (kg)

Height (m)	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
2.00	19	19	19	19	20	20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24
1.98	19	19	19	20	20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25
1.96	19	20	20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25	25	25
1.94	20	20	20	20	21	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25	25	25	26	26
1.92	20	20	21	21	21	21	22	22	22	23	23	23	23	24	24	24	24	25	25	25	25	26	26	26
1.90	20	21	21	21	22	22	22	22	23	23	23	24	24	24	24	25	25	25	25	26	26	26	27	27
1.88	21	21	22	22	22	22	23	23	23	23	24	24	24	25	25	25	25	26	26	26	27	27	27	27
1.86	21	22	22	22	23	23	23	23	24	24	24	25	25	25	25	26	26	26	27	27	27	27	28	28
1.84	22	22	22	23	23	23	24	24	24	25	25	25	25	26	26	26	27	27	27	27	28	28	28	29
1.82	22	23	23	23	24	24	24	24	25	25	25	26	26	26	27	27	27	27	28	28	28	29	29	29
1.80	23	23	23	24	24	24	25	25	25	26	26	26	27	27	27	27	28	28	28	29	29	29	30	30
1.78	23	24	24	24	25	25	25	26	26	26	27	27	27	27	28	28	28	29	29	29	30	30	30	31
1.76	24	24	25	25	25	26	26	26	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	31
1.74	24	25	25	25	26	26	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	31	32	32
1.72	25	25	26	26	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	31	32	32	32	33
1.70	26	26	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	31	32	32	33	33	33	34
1.68	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	32	32	32	33	33	33	34	34	34
1.66	27	27	28	28	28	29	29	29	30	30	30	31	31	32	32	32	33	33	33	34	34	34	35	35
1.64	28	28	28	29	29	29	30	30	30	31	31	32	32	32	33	33	33	34	34	35	35	35	36	36
1.62	28	29	29	29	30	30	30	31	31	32	32	32	33	33	34	34	34	35	35	35	36	36	37	37
1.60	29	29	30	30	30	31	31	32	32	32	33	33	34	34	34	35	35	36	36	36	37	37	38	38
1.58	30	30	30	31	31	32	32	32	33	33	34	34	34	35	35	36	36	36	37	37	38	38	38	39
1.56	30	31	31	32	32	32	33	33	34	34	35	35	35	36	36	37	37	37	38	38	39	39	39	40
1.54	31	32	32	32	33	33	34	34	35	35	35	36	36	37	37	38	38	38	39	39	40	40	40	41
1.52	32	32	33	33	34	34	35	35	35	36	36	37	37	38	38	39	39	39	40	40	41	41	42	42
1.50	33	33	34	34	35	35	36	36	36	37	37	38	38	39	39	40	40	40	41	41	42	42	43	43

BODY MASS INDEX

Mass (kg)

Height (m)	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
2.00	25	25	25	25	26	26	26	26	27	27	27	27	28	28	28	28	29	29	29	29	30	30	30
1.98	25	25	26	26	26	26	27	27	27	27	28	28	28	28	29	29	29	29	30	30	30	30	31
1.96	26	26	26	26	27	27	27	27	28	28	28	28	29	29	29	29	30	30	30	30	31	31	31
1.94	26	26	27	27	27	27	28	28	28	28	29	29	29	29	30	30	30	31	31	31	31	32	32
1.92	27	27	27	27	28	28	28	28	29	29	29	30	30	30	30	31	31	31	31	32	32	32	33
1.90	27	27	28	28	28	29	29	29	29	30	30	30	30	31	31	31	32	32	32	32	33	33	33
1.88	28	28	28	29	29	29	29	30	30	30	31	31	31	31	32	32	32	33	33	33	33	34	34
1.86	28	29	29	29	29	30	30	30	31	31	31	32	32	32	32	33	33	33	34	34	34	34	35
1.84	29	29	30	30	30	30	31	31	31	32	32	32	32	33	33	33	34	34	34	35	35	35	35
1.82	30	30	30	30	31	31	31	32	32	32	33	33	33	34	34	34	34	35	35	35	36	36	36
1.80	30	31	31	31	31	32	32	32	33	33	33	34	34	34	35	35	35	35	36	36	36	37	37
1.78	31	31	32	32	32	33	33	33	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
1.76	32	32	32	33	33	33	34	34	34	35	35	35	36	36	36	36	37	37	37	38	38	38	39
1.74	32	33	33	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38	38	39	39	39	40
1.72	33	33	34	34	34	35	35	35	36	36	37	37	37	38	38	38	39	39	39	40	40	40	41
1.70	34	34	35	35	35	36	36	36	37	37	37	38	38	38	39	39	39	40	40	40	41	41	42
1.68	35	35	35	36	36	36	37	37	38	38	38	39	39	39	40	40	40	41	41	41	42	42	43
1.66	36	36	36	37	37	37	38	38	38	39	39	40	40	40	41	41	41	42	42	42	43	43	44
1.64	36	37	37	38	38	38	39	39	39	40	40	41	41	41	42	42	42	43	43	44	44	44	45
1.62	37	38	38	38	39	39	40	40	40	41	41	42	42	42	43	43	43	44	44	45	45	45	46
1.60	38	39	39	39	40	40	41	41	41	42	42	43	43	43	44	44	45	45	45	46	46	46	47
1.58	39	40	40	40	41	41	42	42	42	43	43	44	44	44	45	45	46	46	46	47	47	48	48
1.56	40	41	41	42	42	42	43	43	44	44	44	45	45	46	46	46	47	47	48	48	48	49	49
1.54	41	42	42	43	43	43	44	44	45	45	46	46	46	47	47	48	48	48	49	49	50	50	51
1.52	42	43	43	44	44	45	45	45	46	46	47	47	48	48	48	49	49	50	50	51	51	52	52
1.50	44	44	44	45	45	46	46	47	47	48	48	48	49	49	50	50	51	51	52	52	52	53	53

In summary, the above protocol comprises:

- Making a distinction between prospective or new employees (novices) and existing employees,
- Recording both mass (kg) and height (m rounded to the second decimal, eg 1.75), conducting the initial screening using only body mass, ie <50 kg for novices and <45 kg for existing employees signifies rejection or withdrawal of certificates of fitness,
- Extending the initial screening to an assessment based on BMI, and finally
- Flagging screened employees with a body mass of (55 [sic] kg as 'unsuitable' for allocation to strenuous full-shift work in heat.

1.3 Heat as a Health and Safety Hazard: Information Base for Risk Assessment

Heat stroke is widely held to be multifactorial in origin, an observation which is certainly also applicable to the South African mining industry (Kielblock, 1992). However, whereas considerable effort has been devoted in the past to prevent heat disorders, most notably heat stroke, attempts to deal with heat from a safety and productivity point of view have been less focussed. In this respect, the benefits of a systematic reduction in wet-bulb temperature have been amply demonstrated in local gold mining context (Smith, 1984). It remains to point out that the converse also holds true: any escalation in the environmental heat load is likely to be associated with an increase in accident frequency rate and a fall in productivity.

In order to assess risk, and to subsequently manage it, a data base appropriate to the development of proactive strategies is essential. This section, therefore, provides some guidance with particular reference to a personal (employee) risk profile and heat disorder (heat stroke) incident analysis. It is suggested that safety issues be investigated along similar lines and the findings linked to the same data base as proposed here.

1.3.1 Employee risk profile

On the basis of the preceding sections it is quite feasible to develop a 'risk profile' for any employee destined to enter 'hot' working environments in the execution of their duties and responsibilities. This profile consists of the following elements, namely:

- Medical contra-indications, ie a particular condition, treatment or even a medical history likely to lead to a critical job-related reduction in heat tolerance,
- Age ((50 years) [sic] in concert with full-shift exposures to 'strenuous' work in heat,
- Obesity (BMI (30) [sic],
- Heat intolerance, ie a chronic inability to successfully complete HTS,
- Strenuous work *per se*, and
- A history of heat disorders.

Recurring incidents of heat cramps and heat exhaustion should be construed as an inability to develop a satisfactory degree of heat acclimatisation for a particular job, exposure time and environmental heat load. Medical surveillance should be sufficiently sensitive to identify such employees and the Occupational Medical Practitioner should have no hesitation in reclassifying the employee as 'heat intolerant'. However, it follows that a distinction exists between incidents of heat disorders which only affect a small number of employees in a chronic manner, thus reflecting possible inherent heat intolerance, and those linked to poor environmental control. To classify an employee as 'heat intolerant' within the latter context is clearly inappropriate.

The above scenario is not applicable to heat stroke. The reason is that heat stroke is generally associated with extensive multi-organ damage, often of an irreversible kind. As a result heat tolerance is usually severely impaired, irrespective of whether the basic cause is 'inherent heat intolerance' or due to poor environmental control, and persists long after full clinical recovery from the incident (Armstrong et al, 1990; Epstein, 1990; Bricknell, 1996). In fact, heat intolerance has been demonstrated to persist for periods from about three months to as long as five years following heat stroke. There is, therefore, strong evidence to suggest that **heat stroke may well render an employee permanently unfit for physical work in heat.**

In developing an employee risk profile on the basis of the above elements, it is obvious that no hard and fast rules can be set. The estimation of risk will, therefore, remain somewhat imprecise. A threefold approach is recommended, namely:

- a risk profile which features only one of the above elements, especially where it can be controlled or brought under control, should be regarded as 'acceptable',
- the presence of any two factors (elements) should be viewed with concern and should not be condoned unless the situation can be ameliorated, for example through specially-developed safe work practices, and
- a profile containing more than two undesirable elements will constitute an unacceptable risk.

Combinations of risk factors (elements) which should not be condoned under any circumstances are given in Table 1.2.

FIGURE [sic] 1.2: Employee risk profile matrix

Primary risk factor[1]	**Secondary risk factor1**					
	Medical contraindication[2]	**Age >50 plus strenuous work**	**BMI ≥30**	**Heat intolerance**	**Strenuous work**	**History of heat disorder**
Medical contraindication[2]		X	0	0	0	X
Age ≥ 50 plus strenuous work	X		X	X		X
BMI ≥ 30	0	X		X	X	X
Heat intolerance	0	X				X
Strenuous work	0		X	X		X
History of heat disorders	X	X	X	X	X	

[1] See text for full description of respective factors.

[2] Medical contra-indications require a good deal of discretion; for example, insulin-dependent diabetes may well constitute an 'unacceptable' risk even in the absence of all other risk factors. The Occupational Medical Practitioner's discretion and decisions are, therefore, paramount.

[0] The specific combination of risk factors can be condoned if considered on individual merit and taking into consideration specific circumstances.

[x] The combination of risk factors should not be condoned unless under exceptional circumstances.

1.4 Incident Analysis

Incidents of heat stroke have been fairly well investigated in the past and considerable emphasis has fallen on the 'multi-factorial' nature of such incidents. Clearly, therefore, any investigation into the occurrence of heat stroke, including other heat disorders, should be conducted in such a way that the major causal factors are identified. This would enable the development of proper strategies and action plans, as well as providing the basis for regular review. The following framework, presented under specific headings, is proposed.

- General information Mine/shaft/business unit Operation (eg gold) Location/area of work.
- Personal particulars:
  - name/identification or company number;

- country/town of origin;
- total mining experience;
- duration of present contract;
- personal/employee risk profile;
- work category (also rate strenuous/non-strenuous).

• Nature of incident/diagnosis (heat cramps, heat exhaustion/ syncope, heat stroke).

• Temporal information:
  - date;
  - day of the week;
  - time of the day;
  - duration of shift until incident; and
  - number of days in working area (if less than 12, record information on previous area of work).

• Causal factors:
  - nature of work (typical/atypical of normal occupation);
  - environmental heat load (DB, WB, air velocity, radiant temperature, time and date of assessment);
  - 24-hour history* (eating, drinking, well-being, etc);
  - water intake (normally, prior to incident); and
  - water availability.
  - *(*Obtain this history from work or close companions and supervisors).*

• Signs and symptoms:
  - behavioural;
  - subjective complaints;
  - physical signs; and
  - body temperature (oral/rectal; time of first recording).

• Treatment (Emergency/initial treatment):
  - recognition (correct/incorrect);
  - nature of treatment;
  - details of further events and recordings (include formal medical assistance);
  - add clinical/hospital records.

Historical information and trends are of extremely limited value unless the data base enables direct assessments and control virtually on a day-to-day basis. In turn, this will enable the assessment and management of risk, strategy development and, ultimately even, good epidemiology. Reviews should be conducted at regular intervals, say every three months.

ANNEXURE 6
Heat tolerance screening

(For information only)

HEAT TOLERANCE SCREENING

Definitions and acronyms

'HTS' means Heat tolerance screening.

'HTT' means Heat Tolerance Test; ie a one-hour heat tolerance test used for the evaluation of rescue brigadesmen.

1 Introduction

Paragraph 1 considers the objectives, interpretation and protocols associated with HTS. The infrastructural and procedural aspects are dealt with in paragraphs 2, 3 and 4 below.

1.1 Objectives

The primary objective of Heat Tolerance Screening is to identify gross or inherent heat intolerance (ie individuals with an unacceptable risk of developing excessively high levels of hyperthermia during work in heat). Such levels of heat intolerance could be temporary or permanent (inherent) and, in order to make these distinctions, repetitive HTS tests, as detailed in the text, are permitted. The nature of the test is such that it also provides a measure of physical fitness and, as such, serves as a second objective.

HTS should not be confused with or seen as an alternative to the old four-hour Heat Tolerance Test (HTT). With regard to the latter, the purpose was to identify the so-called hyper heat tolerant (HHT) individual whose inherent level of heat tolerance was such that no conventional heat acclimatisation was needed. It should, therefore, be clear that HTS has an entirely different purpose, namely it provides an assessment of risk.

1.2 Interpretation

The outcome of the HTS provides a classification which is primarily directed at making a distinction between 'potentially heat tolerant' and 'inherently/grossly heat intolerant'. Classification into either category will depend on:

- Oral temperature responses, as given below, and
- The absence of any abnormal response during or at the end of the test, eg collapse, vomiting, headache and lack of co-operation.

- **Potentially heat tolerant**

  Any person whose oral temperature does not exceed 37.6 °C ie should be $\leq$.37.6 °C) at the end of the test should be classified as 'potentially heat tolerant'. This implies that that person is fit to undertake physically demanding work in a 'hot' environment and that he will be able to acclimatise successfully with regular exposure.

- **Grossly heat intolerant**

  Individuals with oral temperatures in excess of 37.6 °C (ie should be $\leq$ 37.6 °C) on completion of the test should be considered to be heat intolerant and not be allocated to work in 'hot' areas, unless under carefully specified circumstances (see section 1.3).

  In the event of failure of the HTS, candidates may present themselves once more for retesting but not within a period of two days. With management's discretion, however, and taking into consideration individual merits and medical advice, a second retest is permissible.

Repeated failure of the HTS would normally disqualify a candidate from work in hot areas. However, each case should be dealt with on individual merit. Section 1.3.3 provides some guidance in this regard.

1.3 Eligibility, Frequency of Screening and Outcome Implications Associated with HTS

In terms of a general protocol for the application of HTS, a number of issues can be identified for incorporation into the mine's code of practice. These issues, which therefore require careful consideration, are listed below in conjunction with recommendations and alternatives.

1.3.1 Eligibility

HTS should be seen as one of a number of criteria determining overall fitness for physical or physically demanding work in hot environments. For this reason, all employees who enter hot environments in the normal execution of his duties or responsibilities should ideally be screened. There should be no distinction between employees who are exposed to hot environments on a daily full-shift basis and those who only enter such areas sporadically (once a week or once a month, etc) or for indeterminate periods (eg from a few hours to a full shift).

1.3.2 Frequency of heat tolerance screening

The frequency of HTS will be determined by the outcome of the routine medical and physical assessments, as described in Annexure 5, sections 1.1 and 1.2. Annexure 5 is for information only. There are two possible scenarios:

- Any employee deemed 'fit for physical work in a hot environment' by virtue of the most recent annual assessment, inclusive of successfully passing the HTS test, will be required to repeat HTS at an appropriate interval as determined by the medical discretion of the OMP. Any medical risk factor identified, especially of circulatory, metabolic or physical origin, as well as any incident associated with heat intolerance, should necessitate the OMP to adjust the HTS frequency to a more appropriate interval.
- The consequence of failing the routine annual medical and physical examination falls within the powers of discretion of the Occupational Medical Practitioner. In this respect HTS could, under certain circumstances, provide an additional option. Therefore, where the medical and/or physical status of an employee is suspect, HTS could be conducted on an annual basis as an adjunct to the medical and physical assessments.

In summary, therefore, the frequency of HTS could be relaxed provided the results from annual medical and physical screening examinations fall within acceptable norms.

1.3.3 HTS outcome implications

Any individual who passes the HTS test can be allocated to work in hot environments without any restrictions. The only possible disqualification is a medical history of recurring heat disorders, notably heat exhaustion, or of heat stroke, even if only a single incident.

With regard to failure of HTS, a distinction should be made between new employees or recruits (novices to mining), and existing employees. New employees who fail should be regarded as 'unfit for any form of physical work in a hot environment', irrespective of medical or physical status.

Where existing employees fail HTS, the following protocol is recommended. Firstly, a special medical examination should be considered with the express purpose of ruling out the presence of underlying risk factors contra-indicating physical work in heat, eg a stress electrocardiogram. The medical assessment should also take into consideration the employee's medical history, again with the propensity for heat disorders. Where recurring heat disorders are evident, this should be regarded as a disqualification.

Secondly, all physical parameters (height, age, mass, etc) must fall within accepted norms.

On the basis of favourable outcomes to the above re-assessments, the employee may be allocated to work in hot environments provided that:

- Individualised counselling on the relevant risks and precautions is conducted, acknowledged and formalised,
- The employee accepts that the future occurrence of any heat disorder may render him unfit for any form of work in hot environments,
- The employee is not allocated to 'strenuous' work categories, ie those falling within a work rate range of 160 $W.m^{-2}$; in this regard refer to Annex 7, Figures 1.1 and 1.2 which provide guidance,
- No form of emergency or special operations are undertaken in 'hot' or 'abnormally hot' environments,
- Routine work is only undertaken under 'close supervision' while also observing safe work practices on a permanent basis, as documented in Annex 7, Annex 7 is for information only ,and
- Non-routine work (periodic or intermittent exposure to 'hot' environments) is not carried out unless accompanied by, and under direct instruction of, a specially designated and qualified person; this implies dedicated 'formal supervision'.

Full details of 'formal supervision' and safe work practices are provided in Annex 7. Annexure 7 is for information only.

Infrastructures and Procedure

2 Facilities and Supervision

2.1 Quality control

HTS should be conducted only in climatic chambers with a satisfactory degree of environmental control, and only under the supervision of qualified personnel. The requirements imply a system of quality control consisting of:

- Regular (monthly) internal audits of climatic chamber temperature control and of the accuracy and calibration status of all instrumentation,
- A comprehensive annual audit of supervision proficiency and of the facility in its entirety (records, instrumentation, referrals, reports, etc); this audit should be conducted only by an independent accredited occupational hygienist with applicable and relevant experience, and
- Independent audits also on the basis of unsatisfactory internal audits.

2.2 Supervisors' credentials

Supervisors should be in possession of a certificate issued by a recognised training authority. In the past such certificates were issued by the Chamber of Mines of South Africa but this function was subsequently transferred to the Division of Mining Technology of the CSIR. Presenters of such courses should be registered occupational hygienists with extensive and practical experience of Heat Stress Management and all its facets.

Annual audits conducted by independent assessors should include recommendations on supervisors in need of refresher courses.

2.3 Climatic chamber hygiene

The hot humid conditions that prevail in climatic chambers are conducive to the proliferation of micro-organisms. Since faecal and seral contamination in climatic chambers has been documented, it is imperative that a satisfactory standard of hygiene be maintained in order to protect staff and workers.

Diseases which occur sporadically in the mining industry, such as meningitis, typhoid, gastro-enteritis, tuberculosis, cholera, hepatitis-A and - B as well as numerous others including sexually transmitted diseases, pose a potential threat to the health and well-being of workers and climatic chamber personnel. Vaccines against hepatitis-B and other diseases are available and it is recommended that appropriate measures be taken to safeguard potentially exposed personnel.

3 Precautions during screening

3.1 Disinfectants

It is imperative that a suitable disinfecting agent be used for each of the various applications at the HTS centre. No disinfectant solution should be prepared more than 12 hours before use.

3.2 Hand washing

Before entering the climatic chamber all test centre personnel should wash their hands thoroughly with a disinfectant soap on arrival at the centre and again after visiting toilets. Inside the climatic chamber test centre, personnel should wash their hands thoroughly with a disinfectant soap before and after measuring body temperature.

Open containers of disinfectant soap solution should be available for workers to rinse their hands after visiting urinals. In order to encourage the use of the soap solution, attendants should immediately discard and replace any solution which appears to have become contaminated.

3.3 Footbath

On entering and leaving the climatic chamber each worker should place both feet in a footbath filled with a freshly prepared sodium hypochlorite solution (2 000 ppm) or potassium permanganate solution (1 gram per 10 litres of water).

3.4 Thermometers

Thermometers should be disinfected by total immersion in a container of freshly prepared sodium hypochlorite solution (2 000 ppm) for at least 30 minutes. Once measurements have been recorded, thermometers should be immersed in a sodium hypochlorite solution for at least 30 minutes before reuse.

Where rechecks are necessary, only freshly disinfected thermometers should be used. At no time should a thermometer be reused without having remained in disinfectant solution for at least 30 minutes.

3.5 Stepping boards

Stepping boards should be of a suitable non-porous material. Wooden or hardboard stepping boards are not suitable for use in a climatic chamber. All stepping boards used during a shift should be washed, disinfected and allowed to dry before being returned to storage.

3.6 Shower facilities

To ensure that workers effectively clean and cool themselves after completion of the test, they should shower, washing themselves thoroughly with soap and water. The temperature of the shower water should preferably be controlled at 35.0 ± 5.0 °C by means of a 'master mixer'. After showering each man should be provided with a freshly laundered cotton towel.

3.7 Laundering

Athletic shorts or skirts used during stepping procedures should be disinfected and laundered prior to reuse.

3.8 Disinfection

3.8.1 Climatic chamber

After every test the climatic chamber should be washed out thoroughly with disinfectant and water. Excess water should be removed using 'squeegees'. Finally, a freshly prepared sodium hypochlorite solution (2 000 ppm) is recommended for disinfecting the floor, concrete stepping beams and walls.

It should be noted that sodium hypochlorite may cause corrosion of metal objects, eg urinals and taps. For these applications disinfectant soap should be used.

3.8.2 Restroom

Sodium hypochlorite may cause corrosion of metal objects, eg urinals and taps. For these applications disinfectant soap should be used.

3.9 General maintenance

3.9.1 Condition of floor and walls

Uneven surfaces and cracks should be repaired as soon as possible while the use of wooden components and materials in a climatic chamber should be avoided, as these are ideal places for the growth of infectious organisms.

3.9.2 Ongoing monitoring

The introduction of the vibrio cholera into climatic chambers has been documented. Faecal contamination of the environment, eg via drinking water, floors, air humidifying reservoirs and main sewer lines, may well occur as a result of profuse perspiration flowing across the peri-anal region of carriers undergoing the HTS.

Apart from maintaining strict hygiene during and after climatic room procedures, it is recommended that a formal monitoring programme be implemented.

When substandard conditions exist, appropriate interventions must be applied.

4 General procedure

The procedures to be followed comprise essentially the pre-test period and, subsequently, the HTS itself. The test should ideally be conducted in the forenoon following a light breakfast taken at least one hour before the test is due. However, if from a logistics point of view it would be preferable to conduct the HTS test later in the day, this would be equally acceptable.

4.1 Pre-test procedures

4.1.1 Rest Period

A rest period of 30 minutes should be allowed before HTS commences. The environment should be comfortable for men wearing only shorts (27.0 ± 2.0 °C dry-bulb; <20.0 °C wet-bulb). During this time smoking should be prohibited, and no form of liquid refreshment should be taken during the last 20 minutes before the test. During the rest period supervisors should be alert to detect any apparent signs indicative of alcohol and/or drug abuse, or of illness or sickness.

4.1.2 Induction

In order to foster an understanding on the part of the workers and to elicit their co-operation, every effort should be made to inform them of the reasons and procedures for HTS. In addition, the preventive measures and procedures to be followed during the period of natural acclimatisation, where applicable should be detailed so that workers are fully acquainted with the procedures, as well as factors which may affect their heat tolerance.

4.1.3 Initial body temperature recording

Oral temperatures should be measured only with thermometers checked for accuracy by an accredited institution. This check is carried out against a certified thermometer in a water-bath at temperatures of 37.0 °C and 39.0 °C, respectively.

Oral temperatures are measured upon completion of the rest period. Care should be exercised to ensure that the thermometers are 'shaken down' properly before measurements are made. The thermometer bulb should be placed under the tongue, with the stem protruding from the corner of a closed mouth for at least three minutes before being read. After recording the reading the thermometer should be properly sterilised.

Any individual displaying resting oral temperature of more than 37.0 °C (37.1 °C) should be rejected for HTS. Any individual displaying an oral temperature of more than 37.0 °C should be referred for medical evaluation as a potential fever case. With the approval of the mine medical officer, such individuals can be readmitted for testing at a later date. However, under no circumstances may oral temperatures of 37.1 °C be condoned.

4.2 Test procedure

4.2.1 Environmental conditions

The HTS test should be carried out at a dry-bulb temperature of 29.5 °C and a wet-bulb temperature of 28.0 °C. Environmental temperatures should be measured and recorded at five-minute intervals at various locations in the climatic chamber.

Ideally, the climatic chamber should be operated at the optimum wet-bulb temperature of 28.0 °C, with a maximum permissible range of 27.7 to 28.5 °C. Corrective action should therefore be initiated as soon as the temperature deviates from 28.0 °C wet-bulb, and not only once the permissible range is exceeded. The optimum difference between the dry-bulb and wet-bulb temperatures is 1.5 °C. The dry-bulb/wet-bulb difference should never be less than 1.0 °C or more than 2.0 °C.

The test should be discontinued immediately if any deviations from the above range occur. In such an event, these men could be retested the following day.

In addition to environmental temperatures, the air movement in the climatic chamber must also be controlled within the range of 0.3 to 0.5 $m.s^{-1}$ in all areas of the chamber where men step. This should be confirmed during monthly inspections by the Environmental Control Department on mines. The HTS should not be allowed to commence unless prescribed environmental conditions already exist in the climatic chamber.

4.2.2 Work rate, duration and stepping procedure

An external work rate of approximately 80 W (positive component) should be maintained by a bench-stepping regimen at a fixed step rate of 24 steps per minute and a fixed stepping height of 30.5 cm. The duration of the test is 30 minutes.

The stepping procedure should be performed in the following manner: the upper body should be erect, the arms should swing freely, the same foot must lead in the upward and downward movement of any given step, both feet should complete the full cycle, the upper body may not be supported by hands placed on the thighs, and the period on the beam should equal the period on the floor.

A fully completed step is defined as the movement of the body from the floor up onto the stepping beam, by using both feet, and back to the original position on the floor, again by using both feet.

4.2.3 Assessment of relative heat tolerance

The assessment of relative heat tolerance is based on oral temperature which is recorded at the end of the 30-minute bench-stepping exercise. Thermometers should be issued on an individual basis and sterilised at the conclusion of the assessment.

The thermometer bulb should be placed under the tongue and away from the teeth, with the stem protruding from the corner of the closed mouth for a period of at least three minutes before being read. Supervisors should ensure that mouth breathing is not permitted. In fact, in such cases the supervisors should regard the measurements as invalid and, on this basis, refer the person for a retest.

During the three-minute period men should sit on the stepping beam to minimise post-exertional syncope ('black-out') and to minimise possible injury to themselves should they fall. Supervisors should be alerted to this eventuality.

4.2.4 Related procedures and precautions

Supervisors should also be on the alert for signs of early heat exhaustion, overt fatigue or imminent collapse and should not hesitate to remove from the chamber any such cases which, in their opinion, warrant this action. Further action or treatment would depend on specific circumstances. However, all such cases should be referred for medical examination with a formal report of events surrounding the incident.

Any person who stops stepping, except to regain his stride, or who leaves the climatic chamber before the end of the test, can be re-subjected to the HTS within a period of 24 hours. If a person who is regarded as fit to undergo HTS by virtue of both a medical and physical examination, but is incapable of completing a HTS test on two successive attempts, he should be regarded as unfit for any form of work of a physical nature.

ANNEXURE 7
Work practices: surface, opencast and underground operations

(For information only)

Work practices: surface, opencast and underground operations

1 Rationale for Work Practices

Within the context of Heat Stress Management, no form of heat acclimatisation will have preceded the allocation of employees to 'hot' areas of work. Workers will have been screened only for gross heat intolerance and will be expected to commence duties without the advantage of acclimatisation. Special precautions are, therefore, indicated, the rationale being based on the major causes of heat stroke in mining (Kielblock, 1992). The relevant statistics are, therefore, important to all levels of line management directly responsible for the execution of Heat Stress Management (Table 1.1).

TABLE 1.1: Direct casual factors implicated in development of heat stroke

Factor	Prevalence	
	n	%
Strenuous work[1]	82	85
Atypical[2]	19	20
Lashing	18	19
Drilling	16	17
Transporting	15	15
Pack building	12	12
Winching	2	2
Suspect heat tolerance	50	52
Dehydration	48	50
Alcohol	32	33
No water	13	14
Emetics/Laxatives	3	3
Excessive heat	27	28
Wet-bulb > 32.5 °C	21	22
Dry-bulb > 37 °C	6	6
TOTAL		215

[1] These categories exhibit the highest mean metabolic rates of mining tasks and on average exceed 160 $W.m^{-2}$

[2] A typical work is strenuous work not normally associated with a particular work category.

A review of the occurrence of heat stroke over the past decade identifies 'strenuous work' as the single most important causal factor, followed by suspect heat tolerance, dehydration and excessively hot (dry-bulb >37.0 °C, wet-bulb >32.5 °C) thermal conditions.

Figures 1.1 and 1.2 lists the work rates of a number of surface and underground work categories. Investigations over the past decade or so reveal that the incidence of heat stroke is related mainly to work categories associated with strenuous work (Kielblock 1992). On this basis it could be argued that any work associated with mean metabolic rates in excess of 160 W./m^2 constitutes an unacceptable heat stroke risk. In numerous instances 'strenuous' work not normally associated with a particular job description, and therefore regarded as 'atypical', has been identified as the most critical in terms of heat stroke risk.

'Suspect heat tolerance' refers to instances where the incident could be related to poor health, a history of heat disorders, low work capacity in relation to work demand and, notably, inappropriate exemptions from any form of screening.

Water intake is generally inadequate, either through voluntary restrictions or the non-availability thereof. Moreover, alcohol-induced dehydration has been implicated in more than 30 per cent of heat stroke cases.

Further analysis reveals that excessively hot thermal environments constitute the most serious complication in the incidence of heat stroke fatalities. In fact, where such thermal conditions exist, the mortality rate is virtually doubled. (An excessively hot environment is defined as one where either the dry-bulb exceeds 37.0 °C or the wet-bulb exceeds 32.5 °C.)

The origin of heat stoke is multi-factorial. The main causal factors therefore constitute an interaction of strenuous work, suspect heat tolerance, excessively hot environments and concurrent dehydration. General complacency is the single most important root cause, an observation substantiated by the fact that the relative incidence of the major causal factor totals 215 percentage points (Table 1.1).

On the basis of the above analysis, a basic framework can be derived for work practices in 'hot' environments, irrespective of whether such heat loads are associated with surface, opencast or underground operations. This framework is presented below (Table 1.2).

2 Heat Acclimatisation and its Retention: Implications for HSM Work Practices:

The degree of heat acclimatisation ultimately achieved is a function of metabolic work rate, the environmental heat load, exposure time and exposure time repetitions. During this period, susceptibility to heat disorders is inherently higher and **'formal supervision' is an essential element of the acclimatisation process** in order to ensure that all precautions are in place and observed.

Secondly, under controlled conditions full heat acclimatisation can be achieved within less than a week. Conversely, a substantial and critical loss of heat acclimatisation can take place within a few days' absence from work in hot environments. Therefore, with the introduction of new shift systems or extended surface training, scenarios exist where full heat acclimatisation may remain suboptimal. Under such circumstances, or where the slightest risk of incomplete heat acclimatisation exists, it **follows that recommended work practices should be retained permanently**.

TABLE 1.2: Framework for HSM work practices on the basis of the most important casual factors in the development of heat stroke

CAUSAL FACTOR	WORK PRACTICE
Strenuous work	• Adequate physical work capacity (physical evaluation) • Self-pacing (educational) • Work-rest cycles (administrative and mandatory, if required)
Suspect heat tolerance	• Overall fitness for work in hot environments: ◦ Medical evaluation ◦ Physical evaluation ◦ Screening for heat intolerance

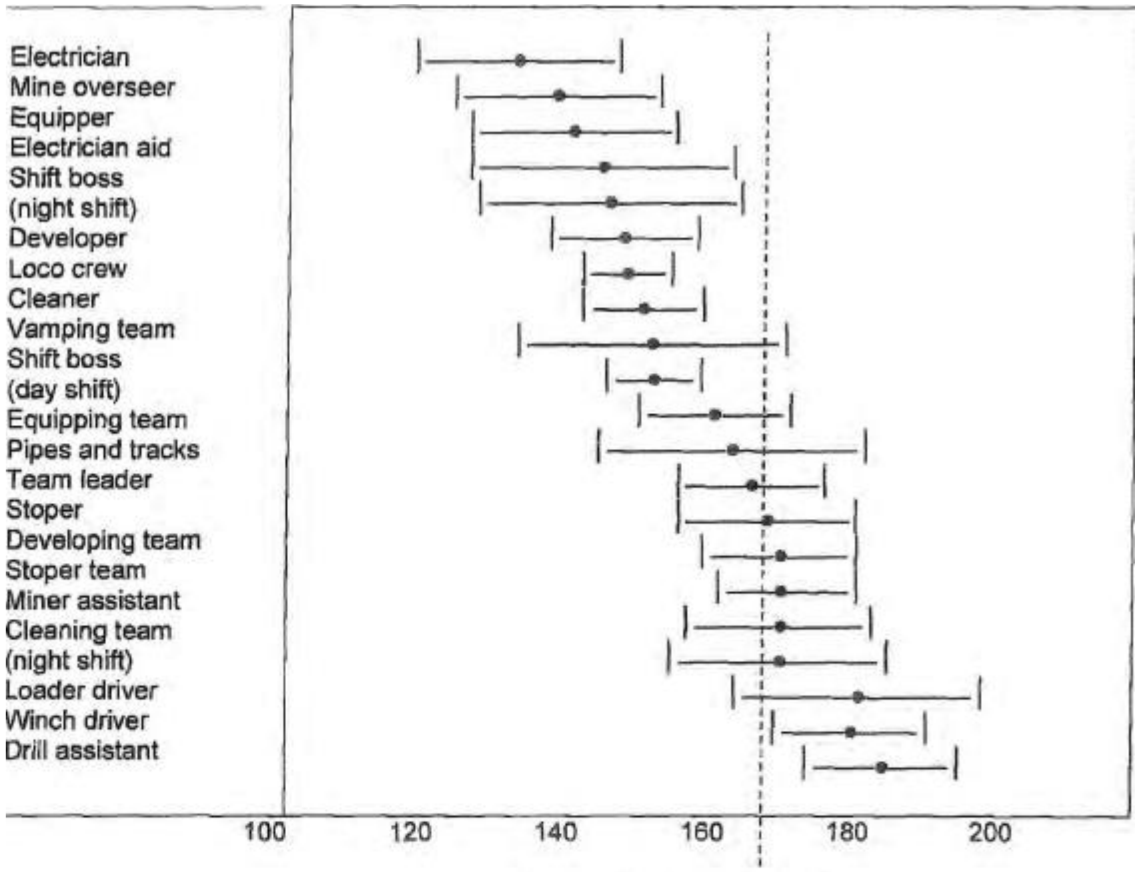
Dehydration • Alcohol-induced • Insufficient fluid replacement	• Education • Provide potable and palatable water at place of work • Introduced water-breaks
Excessively hot environments	• Ongoing monitoring and control • Action plans • Emergency planning

A third perspective is that high levels of inherent or acquired heat tolerance do not provide any unequivocal guarantee against the development of heat disorders, including heat stroke, if basic precautions are not observed. Also, in this respect, therefore, there can be no justification for relaxing work practices simply on the outdated notion that full heat acclimatisation confers immunity against heat disorders: **work practices applicable to the formality of heat acclimatisation are equally applicable once an adequate degree of heat acclimatisation has been achieved.** The only dispensation is that, the need for 'close supervision' could be lessened and even discontinued for routine work, provided a form of informal supervision can be established through good education and awareness retention monitoring, for example through the so-called buddy system, in conjunction with self-care, which is an implicit and explicit requirement under the new Mine Health and Safety Act.

Finally, while employees routinely exposed to work in heat on a day to day basis are likely to develop significant levels of heat acclimatisation, some others will remain unacclimatised by virtue of the intermittent exposures associated with a particular work category. Examples can be drawn from senior management, human resources practitioners, etc. If medically and physically cleared to enter 'hot' environments in the execution of their normal duties and responsibilities, **such employees, irrespective of status or seniority, should only be permitted to do so under close supervision and while adhering fully to mine standards or codes of practice.**

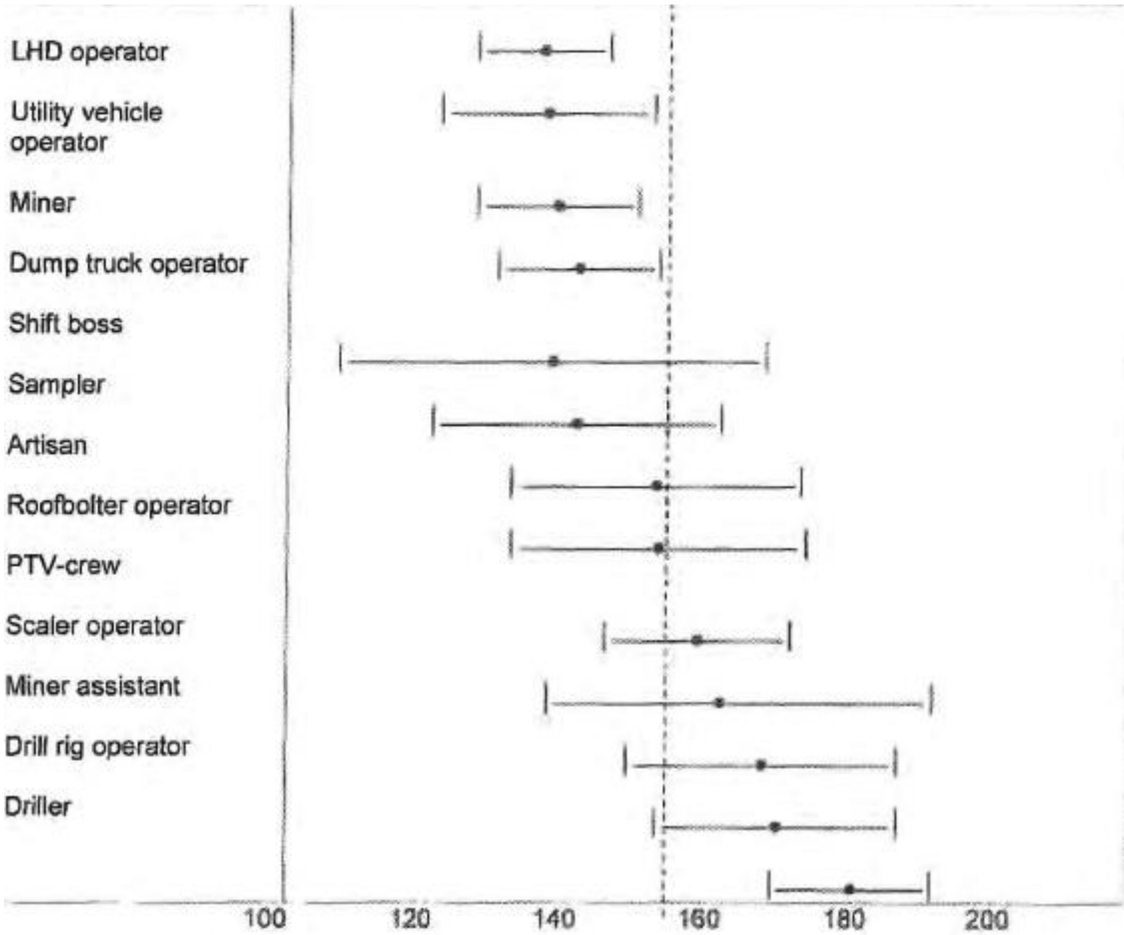
FIGURE 1.1: Metabolic work rates with 95% confidence limits related to conventional mining work categories

WORK CATEGORY



Metabolic rate (W/m²)

Work Category



Metabolic rate (W/m²)

3 Safe Work Practices and Supervision

From sections 1 and 2 it should be clear that two main scenarios exist for the application of safe work practices.

- 'Close supervision' implies supervision taking place under the direction of a specially appointed person whose authority in upholding mine health and safety standards should exceed the dictates of production. It follows that such a person should have qualifications in mining and in health and safety matters, as well as considerable experience. Close supervision applies to:
  - Employees undergoing formal heat acclimatisation, irrespective of the precise circumstances necessitating heat acclimatisation,
  - Any employee of the company who by virtue of his/her job or position only intermittently and irregularly enters 'hot' environments in the routine execution of his duties, and who has been medically and physically cleared to do so, and
  - Visitors or company officials who only enter 'hot' environments on special occasions and who, as a matter of course, have not been cleared either medically or physically to enter such areas.

- 'Informal' supervision is the responsibility of all levels of line management (mine overseer, shiftboss, team leader, etc) and applies only to routines where employees have already achieved a satisfactory degree of heat acclimatisation; more precisely, it excludes all of the contingencies listed under 'close supervision'.

Safe work practices, irrespective of the level of supervision comprise:

- Monitoring work place wet-and dry-bulb temperatures on a basis designed to ensure that safe limits are not exceeded and to detect the development of possible trends; whirling hygrometers, checked in terms of acceptable standards, or any other suitable instrumentation, may be used,
- Checking employees for overt signs of ill health or substance abuse and removing such persons from the place of work for attention appropriate to the situation.
- Ensuring that acceptable work rates are maintained in order to avoid the early onset of fatigue; this would be achieved through work-rest cycles (10 to 15 minutes rest in every hour) where work is of necessity strenuous and ongoing (eg drilling) or by instilling, through constant reminders, a sense of self-pacing,
- Ensuring that fluid replacement beverages (preferably only water or hypotonic fluids) are available at the place of work and that a fluid replacement regimen of at least 2 x 250 - 300 ml per hour is observed.
- The detection of early signs and symptoms of heat disorders and instituting proper remedial action depending on the precise set of signs and symptoms.
- Ensuring that emergency treatment and communication facilities are available and fully functional on a daily basis, and
- Setting into motion purpose-developed emergency action plans in the event of sudden escalations in environmental temperatures.

The above work practices, which should in any event be adopted as standard routine, are especially relevant to employees who return to work after a period of absence, irrespective of duration or reason. In this regard, it should be noted that some industries, eg American nuclear power plants, subscribe to a programme of progressive exposure to achieve heat acclimatisation, for example, the permissible exposure on the first day is limited to 50% of a full shift's exposure, and on successive days, respectively to 75 and 90% (Bernard et al, 1986).

ANNEXURE 8
Absenteeism from routine work in 'hot' environments

(For information only)

1 Absenteeism from Routine Work in 'Hot' Environments

The two categories catering for absenteeism from work in 'hot' environments are:

- Absenteeism associated with any form of vacation leave or the attendance of conferences and training courses, etc, and
- Absenteeism due to illness or injury.

With regard to the former, the general recommendation is that the employee by-passes HTS and resumes normal work under close supervision for the designated period. The only exception is where, following annual leave, the outcome of a routine medical/physical examination necessitates HTS (see Annex 5 'Medical/Physical Examinations', Annex 5 is for information only). The period of absenteeism is immaterial provided the employee does not fall ill during this period of absenteeism. Should this occur, the mine medical officer should be consulted. HTS may be required at any time at the discretion of the mine medical officer, depending on circumstances. Also, formal supervision must be in place to accommodate returning employees.

Absenteeism due to illness, especially febrile disease, makes HTS mandatory before resuming routine work under close supervision. Following physical injury and prolonged inactivity during recovery, HTS should, once again, be mandatory. However, the mine medical officer may exercise his discretion in the event of minor injuries which would not influence overall physical fitness for work in heat.

ANNEXURE 9
Water and nutritional requirements during work in heat

(For information only)

WATER AND NUTRITIONAL REQUIREMENTS DURING WORK IN HEAT

1 Maintenance of hydration: fundamental considerations

Sweat is produced solely to provide water for evaporative heat dissipation. Despite this thermoregulatory benefit, profuse sweating may lead to dehydration and as such constitutes a potential threat to continued normal body function. The reason is plain: sweat production is ultimately dependent on an adequate intake of water.

Dehydration leads to a reduction in the circulating blood volume. Inasmuch as the circulation is charged with heat transfer from the body core to the skin, thus facilitating convective and radiative heat loss, heat dissipation is compromised also as a consequence of inadequate heat transfer. In an effort to maintain an adequate circulation through the skin under these circumstances, the body reduces the flow of blood to non-vital tissues and organs (eg the gut) through constriction of blood vessels (vasoconstriction). Blood volume is reinstated, albeit in a relative sense only.

Compensatory vasoconstriction in response to dehydration commences at water deficits of between 1 and 2 per cent of body mass, ie at water deficits as low as 0.7 litre in a 70 kg man. Since the gut is the primary organ in which compensatory blood vessel constriction occurs, it follows that water absorption will be reduced most drastically. This implies that dehydration may remain largely uncorrected irrespective of the amount of fluid subsequently ingested. It should be stressed in this context that drinking water according to the dictates of thirst is not sufficient to prevent voluntary dehydration, a finding which suggests that the thirst mechanism is not a reliable and sensitive indicator of the state of hydration. Moreover, the alleviation of thirst, and cessation of drinking, does not necessarily reflect rehydration but rather the subjective sensation of stomach fullness.

The psychological effects of dehydration are as dramatic as the physiological ones. Discipline is poor and aggressive attitudes become prominent. Such men are morose and morale is impaired. Fatigue sets in sooner than is normally the case. In short: productivity and safety are in severe jeopardy, as a result of dehydration.

Under conditions designed to simulate moderate work in a mining environment, typical fluid losses as a result of sweating could approach 1 litre within the first hour. It would therefore be advisable to initiate a fluid replacement regimen well in advance of the onset of this critical period. An ideal to strive for seems to be about 500 ml every 20 to 30 minutes. The water should be cool (about 15 °C), palatable and of good quality (potable).

2 Form of Fluid Replacement

The form of fluid replacement is, and remains, a subject of controversy. This is surprising since first principles suggest that the form of replacement should be determined precisely by what is lost, ie sweat.

Sweat is watery fluid which contains considerably less solid matter than the body fluids from which it is derived. It is, therefore, hypotonic with regard to body fluids. Quantitatively the most important constituent is sodium chloride ('salt') which varies in concentration from about 0.1 to 0.3 g per 100 ml of sweat, as opposed to a value of about 0.9 g per 100 ml of body fluid.

The two most prevalent misconceptions are, firstly, that sweat has the same composition as body fluids (ie the same tonicity) and that fluid replacement should, consequently, be achieved by so-called isotonic beverages, and secondly, that the body loses vast amounts of salt during sweating, hence the practice of salt supplementation through tablets and salted drinks. Thus, considering the composition of sweat as outlined above, it should be patently clear that there is no justification for the use of isotonic fluids or salt tablets.

Of further relevance is to point out that, although some form of salt replacement is indicated following prolonged and profuse sweating, pronounced salt depletion is nevertheless unlikely. The reason is that most adults following Western dietary customs consume more than 20 times the requirements of the body on a daily basis. In fact salt supplementation constitutes a physiological hazard: in countries where salt intake is high, a statistical link exists between it and the incidence of hypertension. Even the immediate effect of salt supplementation in tablet form is manifested in overt circulatory strain.

A study conducted on 400 medically screened recruits to the South African mining industry (Kielblock, 1987) revealed that:

(a) Relative to commercially available hypo-, iso-and hypertonic fluid replacement beverages, water is the preferred form and that the benefits are in terms of significantly lower rectal temperatures after four hours' work in heat,

(b) Increased tonicity has a detrimental effect which, ironically, is curbed by a lower voluntary intake but which is aggravated by force-feeding, an observation ascribed to poor gastric emptying.

3 Nutritional requirements for energy replacement

The maintenance of an optimum state of hydration is not the only prerequisite to continued physical effort in hot humid environments. Equally important is the sustained generation of energy, a process achieved by the combustion of the two principal metabolic fuels, namely carbohydrate, in the form of glucose, and fat, in the form of fatty acids.

Considering total body economics, fat has the advantage of being a more compact form of energy; it can also be stored in vast quantities, eg as in obese individuals. In contrast, carbohydrates are poorly stored (about 0.5 to 1.0 per cent of body mass), but have the decided advantage of being able to sustain intense short-term activity. While neither fat nor carbohydrate is inherently inefficient as an energy source, a progressive increase in physical activity is characterised by a concomitant shift from fat to carbohydrate as the predominant source of energy.

Carbohydrate depletion during sustained intense physical effort constitutes a serious limitation to continued activity. This may already become evident within four hours following the commencement of the shift, an event considered to be physiologically deleterious. Impaired work performance is, therefore, attributed to carbohydrate depletion as a result of a man's sporadic eating habits.

Against this background it should be obvious that from a nutritional point of view certain prerequisites exist. These have been enumerated as:

(a) a generous carbohydrate-rich meal at the end of a shift in order to replenish body stores,

(b) a light carbohydrate meal immediately prior to the shift which, although in itself inadequate in the absence of the previous night's meal, is much more tolerable when embarking on any form of physical exertion, and

(c) a mid-shift feed comprising an acceptable tasty fluid meal containing mainly carbohydrate. An added benefit of the latter is that it serves also as an additional form of fluid replacement.

In summary: continued physical work in hot humid underground environments is a function of heat dissipation and the availability of an appropriate metabolic fuel.

ANNEXURE 10
Emergency work in abnormally 'hot' environments - underground

(For information only)

Emergency work in abnormally 'hot' environments - underground

1 Introduction

Where wet-bulb temperatures exceed 32.5 °C, no routine work should be undertaken. Only emergency work, essentially directed at re-establishing an acceptable thermal environment, should be undertaken.

This document is intended to provide a framework for the formulation of guidelines for the protection of employees who, as a result of an emergency of one kind or another, are likely to be exposed to excessively hot environments. Where relevant, some background is given in an effort to provide further guidance. These guidelines are based on the findings of SIMRAC Project GAP 045.

2 Application of this Annexure

Operations normally covered by mines' code of practice dealing with work in conditions conducive to heat stroke are excluded because such work is deemed to be 'routine'. These guidelines apply to emergency (non-routine) work only and embrace all mines, including those generally held to be 'cool' (ie wet-bulb temperature of <27.5 °C with the dry-bulb not exceeding 37.0 °C) and where the prescriptions of regulation 9.2(1) do not apply.

Secondly, many mines have standards in respect of emergency work in hot environments. These standards are mine-specific and the present guidelines should, therefore, be viewed as complementary and not necessarily as superseding existing in-house standards or managerial instructions. However, in absence of any such standards, these guidelines should be interpreted as representing a minimum requirement.

The guidelines presented are based on sound investigation and the data have been subjected to rigorous statistical analysis. The basic approach in establishing tolerance times has been conservative, which permits the degree of flexibility required to translate controlled laboratory simulations into practical application. Therefore, in the interest of practicability and convenience, slight discrepancies exist between the original experimental findings and the recommendations contained in the guidelines.

3 Assessment of the Environment

In the interests of simplicity it is suggested that action levels be based on wet-and dry-bulb temperatures using a whirling hygrometer or any other suitable instrumentation. It is accepted that whirling hygrometers have a number of drawbacks (eg cumbersome to use, fragile, not always easy to read) but at present there are no alternatives which combine easy read-out capabilities, accuracy and mine-worthiness. Sophisticated instruments, also measuring mean radiant temperature and air speed, as well as converting these measurements to various indices, are not required.

The environmental heat load is expressed as the arithmetic mean of the dry-and wet-bulb temperatures, ie an index which has its origins in the Israeli Discomfort Index (DI), but which has been substantially modified to what is now termed the Emergency Heat Stress Index (EHSI).

In calculating the EHSI it is recommended that all fractions of a degree be rounded up. For example, if:

dry-bulb	=	38.2 °C	then	EHSI	= (39 + 35)/2
wet-bulb	=	34,5 °C			= 37 °C

4 Special Precautions

4.1 Supervision

Any operation regarded as 'non-routine' or as an emergency, and complicated by heat, should be undertaken only under direct supervision of line management. The responsible person thus appointed, with whom the responsibility for the implementation of these guidelines and/or the relevant mine standard should be vested, should be assisted in his decisions by the environmental control manager/supervisor, and he should be well versed with respect to the health and safety of employees under his control.

An important element is that of observing recommended precautions, as well as the early detection of the onset of fatigue and heat disorders. Proper instruction is, therefore, indicated during operations.

4.2 Selection of the task force

The task force should consist only of employees who have been screened or tested for heat tolerance or acclimatised to work in heat, by conventional climatic chamber procedures or by natural underground acclimatisation, and who have rested since the previous shift. Apparent signs of alcohol over-indulgence represent a serious contra-indication, as would also apply in the case of incipient illness or where individuals are under medication which would increase susceptibility to premature fatigue or heat disorders. Mine medical officers or qualified medical station personnel should be available to assist in the final selection process.

4.3 Assessment of the task and general awareness

Work rates cannot be prescribed or limited where emergency work has to be undertaken, especially where life is at stake. However, in the assessment of the physical demands likely to be imposed, it would be essential to impress on workers the importance of self-pacing to avoid the onset of severe fatigue. Once this happens it is virtually impossible to recover substantially while still faced with high environmental heat loads. Reinforcing an awareness of the potential hazards associated with a particular task is, therefore, fundamentally important. Induction appropriate to conditions likely to be encountered is, similarly, essential.

A distinction is warranted between, on the one hand, non-routine or emergency work undertaken by qualified mine personnel and on the other hand, operations which by their very nature can only be undertaken by rescue brigadesmen. It is a fallacy to argue that brigadesmen, because of their high selection and training standards, are necessarily superior to general workers when exposed to high environmental heat loads. Brigadesmen operations almost invariably require full dress (overalls), which significantly impede heat dissipation, while the relatively heavy and cumbersome breathing apparatus presents a further burden irrespective of its advantage. Also, with a full mask brigadesmen may have difficulty in observing water breaks and a prior intake is, therefore, advisable. Although these guidelines are not irrelevant to Rescue Brigadesmen operations, they are not intended to govern such operations at present.

4.4 Infrastructure

The key infrastructure and organisational requirements are:

(a) Ensuring drinking water is made available at the place of work and that regular water breaks are observed, eg 350-500 ml of water every 30 minutes,

(b) The availability of emergency body cooling facilities, and

(c) Standby medical staff.

Any employee showing early signs of heat disorders, notably behavioural changes, but also premature fatigue, muscle cramps, nausea, vertigo or more advanced signs associated with heat exhaustion and heat stroke, should be removed to cool areas immediately and treated accordingly.

4.5 Complicating factors

While the emphasis falls on heat in the present context, cognisance should be taken of other aggravating factors, eg carbon monoxide and oxygen deficiency, as well as other gases or toxic fumes. Appropriate gas detection instrumentation should be issued and, in case of very dense smoke, eye protection would be necessary. (It may also be necessary to consider establishing a cache of self-contained self-rescuers). Travelling times could be affected significantly in cases of low visibility or where difficult, or demanding, routes have to be negotiated. Alternate escape routes, where in existence, should, therefore, be identified beforehand.

5 Action levels and permissible exposures

5.1 Action levels

At an EHSI of above 28 °C no emergency work should be undertaken unless by inherently heat tolerant or acclimatised employees. This would apply to mines, or sections of mines where the conditions are not generally conducive to heat stroke. Where conditions are conducive to heat stroke an action level of 30 °C EHSI is proposed for emergency operations, the rationale being to introduce better control to cater for unexpected conditions and to take into account cumulative effects.

The maximum permissible upper limit is set at 45 °C (EHSI units). Experimental subjects are generally incapable of exerting themselves under these conditions and estimates of tolerance times become too unreliable to make further projections because of the lack of statistically meaningful data.

In summary, the recommended action levels are as listed below:

EHSI 28 °C: emergency work to be undertaken only by heat tolerant or heat acclimatised task forces; no time limits are proposed but work should proceed under supervision and with regular water breaks.

EHSI 30 °C: special precautions (see section 4) and tolerance times (see Table 1) are to be observed.

EHSI 45 °C: maximum permissible upper limit, no work should be undertaken unless whole body cooling is feasible.

5.2 Body cooling garments

The benefit conferred by body cooling garments suggests that, at EHSI values of 40 °C and below, tolerance times can be extended by about 30 minutes. This reduces quite sharply above and EHSI of 40 °C and the maximum recommended extended time should not exceed 20-25 minutes.

Although it could be argued that these benefits are not substantial in terms of the investment, the extent of protection may well be crucial from a survival point of view. A further consideration is that the well-being and safety of an entire team could be jeopardised by the premature collapse of any single member.

It is proposed that, where available, body cooling garments be worn in order to provide added protection, especially where conditions cannot be predicted or change unexpectedly. **Mines are advised to confer with the Manager, Occupational Hygiene, CSIR: Mining Technology with regard to choice.**

5.3 Tolerance times

The tolerance times are presented in Table 1 of these guidelines and from a convenience and practical point of view, presented in 10-minute intervals for 'moderate' and 'hard' work, respectively.

A complication arises when temperatures increase because initial estimates of tolerance times have to be reduced to take into account the added heat load. Inasmuch as exposure up to that particular stage, even if of a lower magnitude, cannot be discounted, it is obvious that the new tolerance time has to be adjusted downwards from the limit actually recommended for that EHSI level. The following example illustrates a hypothetical case. A moderate work rate is assumed throughout the entire operation.

At start of operation:		
Dry-bulb temperature	=	32 °C
Wet-bulb temperature	=	28 °C
EHSI	=	(32 + 28)/2
	=	30 °C

The recommended limit for an EHSI level of 30 °C is 230 minutes (Table 1) and this includes travelling time, assuming environmental conditions remain constant.

At point of entry to area of work

Elapsed travelling time	=	20 minutes
Available operational time	=	230 - total travelling time
	=	230 - (20 x 2)
	=	190 minutes

In other words, if the environmental heat load remains constant following entry to the area of work, the available operational time is 190 minutes.

Following entry to the area of work it was established that the environmental heat load had increased:

Dry-bulb temperature	=	38 °C
Wet-bulb temperature	=	34 °C
EHSI	=	(38 + 34)/2
	=	36 °C

The recommended time for an EHSI level of 36 °C is 90 minutes. However, travelling time must be taken into account and an equitable 'penalty' derived. Inasmuch as the respective EHSI levels and corresponding tolerance times constitute equivalent 'doses' (ie identical risks of $<10^{-3}$ to reach rectal temperature of 39.5 °C), the penalty could be expressed in terms of dose.

In the present example travelling time to the area of work amounted to 20 minutes. On the assumption that the return journey would also take 20 minutes under identical conditions, the dose from travelling can be estimated as follows:

Dose	=	Actual exposure/Permissible exposure
	=	Total travelling time/Permissible exposure
	=	40/230
	=	0.1739
	=	17%

This implies that the available dose at the higher EHSI level of 36 °C would have to be penalised by the dose incurred as a result of travelling to and from the area of work. This dose amounts to 17% and, consequently, the available dose amounts to 83% of the total permissible tolerance time, therefore:

Available operational time	=	Permissible tolerance time x O.83
	=	90 x 0.83
	=	74.7
	=	75 minutes

Although the calculation is straightforward, practical problems are likely to be experienced under most emergencies, especially since instrumentation to facilitate rapid calculation is not available at present. To overcome this problem a pocket-sized quick reference chart has been provided. Figures 1 and 2 below give examples of such a reference chart.

FIGURE 1: Emergency work schedules without body cooling garments

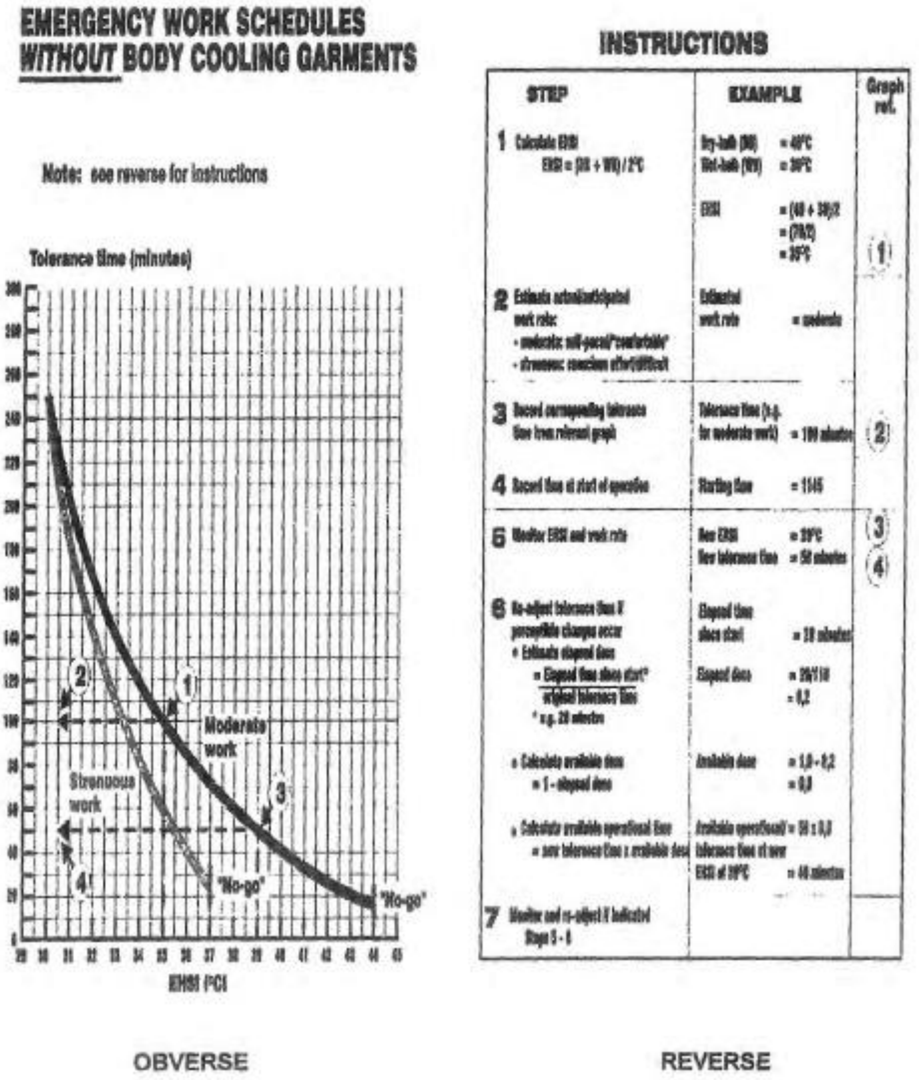
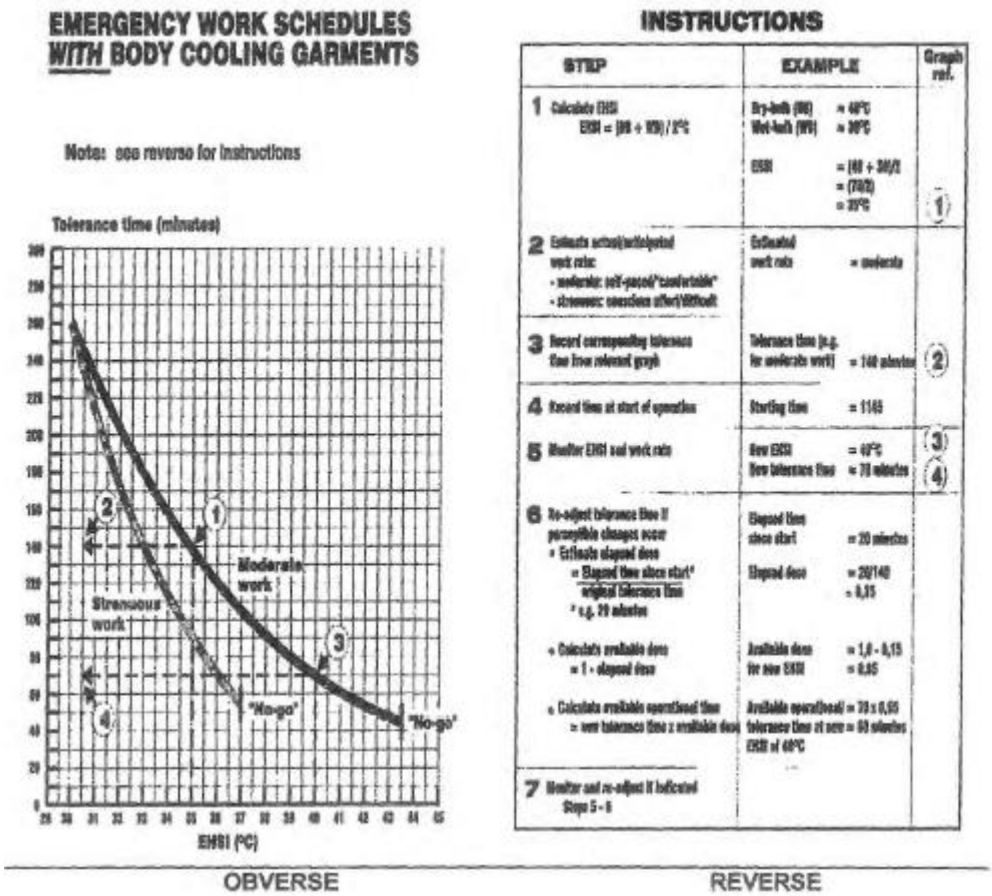


FIGURE 2: Emergency work schedules without the use of body cooling garments: facsimile of quick reference card



It is equally clear that the mental arithmetic associated with the calculation of 'dose' in order to re-assess tolerance time under conditions where thermal conditions deteriorate, would be even more daunting. Consideration should, therefore, be given to 'estimated dose' where convenient fractions are used, eg 25.50 and 75%. Using the above example, the following estimates would be obtained.

Elapsed dose =	40/230	=	20%
Available dose =	200	=	100-20
		=	80%
Available operational time		=	80% of 90 minutes (or 0.8 x 90)
		=	72 minutes

The principle proposed is, therefore, that any convenient fraction (ie single decimal figures) be used when reassessments of tolerance time are indicated.

TABLE 1: Tolerance times for various EHSI levels with and benefit of Body Cooling Garments (BCG)

	TOLERANCE TIME (MINUTES)			
EHSI[1]	**EXPERIMENTALLY DETERMINED[2]**	**RECOMMENDED LIMIT[2] MODERATE**	**STRENUOUS**	**BCG BENEFIT**
28-	-	No limit	No limit	Not applicable
29.9	227	230	230	
30	200	200	180	
31	174	175	140	
32	150	150	110	
33	128	130	85	
34	108	110	60	
35	91	90	40	+30
36	75	70	25	
37				
38	61	60		
39	50	50	No work	
40	40	40		Maximum of 20-25 minutes
41	33	30	Evacuate area	
42	27	30		
43	24	20		
44	22	20		
45	21			

[1] Emergency Heat Stress Index = (dry-bulb + wet-bulb in C)/2

[2] Recommended limits are based on experimentally determined limits but rounded up in the interests of convenience to cater for respectively, 'moderate' (self-paced, ie working at a comfortable rate) and 'strenuous' work (ie where effort is apparent, eg transporting heavy materials without a break, climbing up steeply inclined sections).