DEPARTMENT OF MINERAL RESOURCES AND ENERGY

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MINE HEALTH AND SAFETY ACT, 1996 (ACT NO 29 OF 1996)

GUIDELINE FOR A MANDATORY CODE OF PRACTICE FOR AN OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

I **DAVID MSIZA,** Chief Inspector of Mines, under section 49 (6) of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996) and after consultation with the Council, hereby issues the guideline for an occupational health programme on thermal stress in terms of the Mine Health and Safety Act, as set out in the Schedule.

DAVID MSIZA
CHIEF INSPECTOR OF MINES

SCHEDULE

Guideline for the Compilation of a Mandatory Code of Practice for an Occupational Health Programme on

Thermal Stress

MINE HEALTH AND SAFETY INSPECTORATE

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PART A: THE GUIDELINE

1. FOREWORD

1.1 In an attempt to address matters affecting the health and safety of workers in the South African mining industry, the **MHSC** established a tripartite sub-committee under the auspices of the **MOHAC**. The **MOHAC** found it necessary, in order to address these matters, to draft a guideline for a mandatory **COP** on thermal stress.

1.2 Significant risks to the health of employees in the mining industry exist. In order to protect, monitor and promote the health status of employees, an occupational health programme is required where exposure to such significant risks occurs. The **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 in the South African mining industry.

1.3 Where the risk assessment of employers indicates a need to establish and maintain either a system of occupational hygiene measurements or a system of medical surveillance, or where regulation(s) required either of the systems, 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 minimizing 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 that 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 is that source control through engineering means it represents the primary strategy, irrespective of the hazard in question (refer to Part C, paragraph 7.1). Conversely, personal protection is not a convenient alternative to source control. At best, it merely serves as an interim cost effective expedient.

1.6 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 the risks to health. The first component of any management system is finding out what the situation is, and secondly deciding what to do about it.

2. LEGAL STATUS OF THE GUIDELINE AND COP

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 **CIOM** requires it. These **COPs** must comply with any relevant guidelines issued by the **CIOM** in accordance with section 9(3) of the **MHSA**.

3. THE OBJECTIVES OF THE GUIDELINE

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

3.2. It sets out the two components of an occupational health programme, namely:

3.2.1. Occupational hygiene; and

3.2.2. Occupational medicine.

3.3. Where an employer is required in terms of regulation 9.2(2) of the **MHSA** 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

4.1. **Abnormally hot environment** means any environment where **DB** ≥ 37.0°C, **GT** ≥ 37.0°C and/or **WB** ≥ 32.5°C, and **WBGT index** ≥ 34.

4.2. **Abnormally cold environment** means any environment where **WCET** ≤ -30.0°C.

4.3. **ACGIH** means American Conference of Governmental Industrial Hygienists.

4.4. **BEI** means Biological Exposure Index.

4.5. **BMI** means body mass index.

4.6. **CIOM** means Chief Inspector of Mines.

4.7. **Cold environment** means any environment where **WCET** ≤ 5.0°C but > -30.0°C.

4.8. **COP** means Code of Practice.

4.9. **CSIR** means Council for Scientific and Industrial Research.

4.10. **CSM** means cold stress management.

4.11. **DMRE** means the Department of Mineral Resources and Energy.

4.12. **DB** means dry-bulb temperature.

4.13. **DI** means discomfort index.

4.14. **ECT** means equivalent chill temperature.

4.15. **EHSI** means Emergency Heat Stress Index.

4.16. **GT** means globe temperature (**radiant heat**).

4.17. **Hot environment** means any environment where **DB** ≥ 32.5°C - < 37.0°C, **GT** ≥ 32.5°C - < 37.0°C and **WB** range of ≥ 27.5°C - < 32.5°C and/or the time weighted average **WBGT index**, determined over a period of one hour, ≥ 30 - < 34 in the environment in which an employee works.

4.18. **HSM** means heat stress management.

4.19. **HTS** means heat tolerance screening.

4.20. **HTT** means heat tolerance test.

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

4.22. **MHSC** means Mine Health and Safety Council.

4.23. **MOHAC** means Mining Occupational Health Advisory Committee.

4.24. **OEL** means occupational exposure limit.

4.25. **OEL for thermal stress** means **WB** (°C) 32.5°C, **DB** (°C) 37°C, mean radiant temperature (°C) 37°C, and **WCET** (°C) 4°C.

4.26. **OMP** means Occupational Medical Practitioner.

4.27. **Percentile** means the value of a variable below which a certain percent of observations falls.

4.28. **PPE** means personal protective equipment.

4.29. **Radiant heat** means the electromagnetic transfer of heat energy without direct contact.

4.30. **SIMRAC** means Safety in Mines Research Advisory Committee.

4.31. **Thermal environment** means occupational exposure to hot and **cold environments**.

4.32. **TLV** means Threshold limit value.

4.33. **WB** means wet-bulb temperature.

4.34. **WBGT** means wet-bulb globe temperature.

4.35. **WBGT index** means a standard that offers a useful, first-order index of the environmental contribution to heat stress influenced by air temperature, **radiant heat** and humidity.

4.36. **WCET** means wind chill equivalent temperature.

5. SCOPE

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

a) Heat ≥ 25.0°C **WB** and/or ≥ 32.0°C **DB** and/or ≥ 32.0°C **GT**.

b) Cold < 10°C **ECT**

5.2. This guideline covers a basic occupational health programme for the purpose of measuring occupational exposures to thermal stress, and linking these exposures to employee medical records.

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

5.4. 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.

5.5. The occupational health programme should identify employees with significant exposures and should provide control measures to mitigate the risk. This guideline does not stipulate the control measures, only the hierarchy to be followed to control exposures.

6. MEMBERS OF THE TASK TEAM

6.1. The following members of the MOHAC Task Team have reviewed the document:

STATE	EMPLOYEES	EMPLOYERS
Occupational Hygiene		
B. Novolo	N. Prinsloo	B. Mongoma
C. Kekana	D. Blaauw	S. Kesilwe
		F. Jacobs
Occupational Medicine		
Dr L. Ndelu	S. Nongingi	
M. Hlapane		
D. Mahlaba		
Dr D. Mokoboto		

PART B: AUTHOR'S GUIDE

1. The **COP** must follow the sequence laid out in Part C: Format and content of the **COP** where possible. 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 annexure to the **COP** whether:

   a) The annexure 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 annexure is merely attached as information for consideration in the preparation of the **COP** (i.e. compliance is discretionary).

3. When annexures are used, the numbering should be preceded by the letter allocated to that annexure, and the numbering should start at one again. (e.g. 1, 2, 3, A1, A2, A3, etc.).

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

5. When reference is made in the text to publications or reports, the 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 COP

1. TITLE PAGE

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

1.1.1. Name of mine.

1.1.2. The heading: "*Mandatory Code of Practice for an occupational health programme on thermal stress*".

1.1.3. A statement to the effect that the **COP** was drawn up in accordance with **DMRE** guideline with reference number **DMRE 16/3/2/4-B6** issued by the **CIOM**.

1.1.4. The mine reference number for the **COP**.

1.1.5. The effective date of the **COP** of the mine.

1.1.6. Revision dates of the mine's **COP** (previous if applicable and next revision).

1.1.7. The mine code number.

2. TABLE OF CONTENTS

2.1. The **COP** must have a comprehensive table of contents.

3. STATUS OF COP

3.1. This section must contain statements to the effect that:

3.1.1. The **COP** was drawn up in accordance with the **DMRE** guideline with the reference number **DMRE 16/3/2/4-B6** issued by the **CIOM**.

3.1.2. This is a mandatory **COP** in terms of section 9(2) and (3) of the **MHSA**.

3.1.3. The **COP** may be used in an accident investigation or inquiry to ascertain compliance and to establish whether the **COP** is effective and fit for purpose.

3.1.4. The **COP** supersedes all previous relevant **COPs**.

3.1.5. All managerial instructions, recommended procedures and standards on the relevant topics must comply with the **COP** and must be reviewed to ensure compliance.

4. MEMBERS OF THE 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. The employer must appoint a committee responsible for the drafting of the **COP** after consultation with the health and safety committee in terms of the **MHSA**.

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

5. GENERAL INFORMATION

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

5.1.1. A brief description of the mine and its location.

5.1.2. The commodities produced.

5.1.3. A list of the mining method or combination of methods used at the mine. This section must discuss the degree of mechanisation, taking care to identify the potential sources of thermal stress.

5.1.4. The general ventilation arrangements and/or cooling arrangements.

5.1.5. 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.

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

6. TERMS AND DEFINITIONS

6.1. Any word, phrase or term of which the meaning is not 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.

6.2. The drafting committee should avoid jargon and abbreviations that are not in common use, or those 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 to while at work, and record the significant hazards identified and the risks assessed. The employer must determine how the significant risks identified in the risk assessment process must be dealt with. This should be done with regard to the requirement of section 11(2) and (3) of the **MHSA** that, as far as reasonably practicable, attempts should first be made to:

- Eliminate the risk;
- Thereafter, control the risk at source;
- Thereafter, minimise the risk; and

- Thereafter, insofar as the risk remains, provide **PPE** and 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, manufacturer specifications, approvals, design criteria and performance figures 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, plants or equipment, and material.

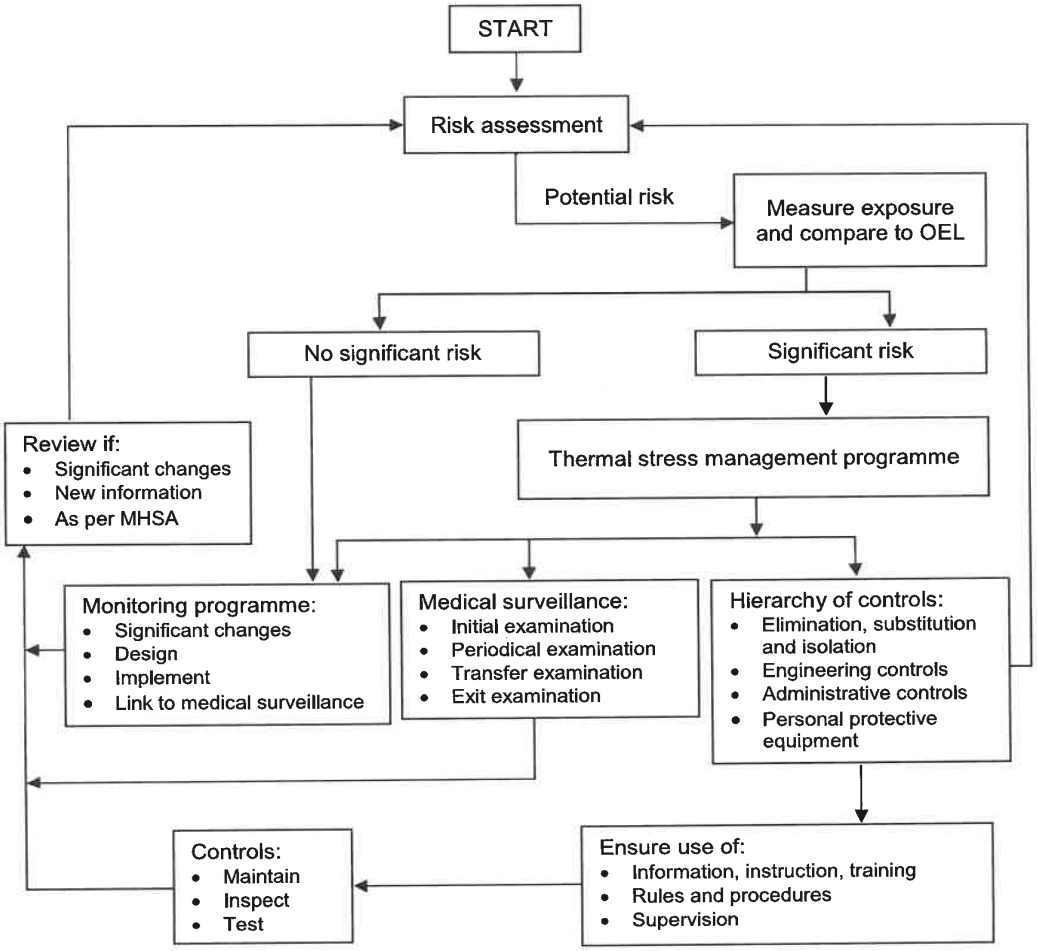
8. KEY ELEMENTS TO BE ADDRESSED IN THE COP

Where the employer's risk assessment indicates a need to establish and maintain a system of occupational hygiene measurements and a system of medical surveillance, or where such systems are required by regulations, the aspects of the occupational health programme and the thermal stress management programme as set out in sections 8.1 and 8.2 below, must be addressed in the **COP**.

These key elements are shown in Figure 1: Occupational health programme below.

The occupational health programme to be implemented on the mine should be summarised in the **COP** in a flow chart similar to Figure 1: Occupational health programme. The occupational health programme has two components i.e. occupational hygiene and occupational medicine.

FIGURE 1: Occupational health programme



8.1. Aspects of an occupational health programme

8.1.1. Risk assessment

8.1.1.1. The **COP** should set out measures to ensure that a qualitative and quantitative risk assessment process is followed, and takes into account all the factors influencing the health of employees. Where the available historical data is not sufficient to enable professional judgement, acceptable risk assessment methodologies should be used.

8.1.1.2. The risk assessment must be described with reference to:

a) The significant sources of thermal stress which would influence the environmental thermal load to which employees may be exposed, and which have been identified, in the activity area, such as:

- Rock temperature due to geothermal gradient.
- Machinery.
- High humidity.
- High **radiant heat** (see Annexure 3: Radiant temperature for information only).
- Auto compression.
- Rate of work (strenuous work).
- Restricted and inclined work areas.
- Ambient temperature.
- Wind velocity.
- Refrigerator rooms, etc.

b) Health effects associated with exposure to thermal stress (high environmental heat loads and radiant temperature).

c) The limits for each relevant parameter of the environmental thermal load on the mine e.g.:

(i) **WB** in °C.

(ii) **DB** in °C.

(iii) Radiant temperature (**GT**) in °C.

(iv) Velocity in metre per second (m/s) i.e. stoping and general ventilation.

(v) Air volume per cubic metre per second per square metre ($m^3/s/m^2$) of the face (development end).

(vi) Indices (**DI**, effective temperature, **WBGT**, etc.).

(vii) **WCET** in °C.

(viii) **WBGT index**.

d) The nature of the key workplace operations and activities that pose the greatest potential for exposure to thermal stress.

e) Occupations and the number of employees exposed to thermal stress.

f) The exposure pattern, i.e. intermittent and continuous.

g) The duration and frequency of employee exposure to heat stress.

h) The actual exposure levels measured compared to the **OEL**.

i) Control measures that are in place e.g. substitution, engineering controls, administrative controls, **PPE** etc.

j) The additional control measures required to be instituted in order to reduce or maintain exposures to below the **OELs**.

k) The frequency of any ongoing monitoring to assess the effectiveness of the controls mentioned above.

NOTE:
- *For the purpose of the risk assessment, the commodity codes, activity codes and occupational codes as set out in Annexure 1 (Mandatory codes list) should be used.*

8.1.1.3. The **COP** must indicate the type(s) of risk assessment to be undertaken for thermal stress monitoring considering the following:

a) Baseline risk assessment.

b) Issue-based risk assessment.

c) Continuous risk assessment.

NOTE:
- *Chapter 3 of the handbook published by the **SIMRAC**, "Handbook on occupational health practice in the South African mining industry", may be consulted and any other methodology to assist in conducting a risk assessment.*

8.1.1.4. Review of risk assessment

The **COP** must address the review of the risk assessment annually (based on the thermal stress monitoring data of the previous cycle) and whenever there is change at the mine that could have an impact on the original assessments, and/or at least in the following instances:

a) Outcomes of medical surveillance programmes indicate the need for it.

b) A **MHSA** section 11(5) investigation indicates the need for it.

c) The introduction of new or revised legislation.

d) The introduction of new mining methods.

e) Process changes are introduced (e.g. in process plants).

f) The introduction of new types of machinery.

g) The modification of current machinery affecting the heat load and operation.

8.1.2. Parameters for the identification of thermal stress risk

The employer must apply the following parameters to identify thermal stress risks.

8.1.2.1. Non-significant risk

a) **WB** < 25.0°C and

b) **DB** < 32.0°C and/or

c) **GT** < 32.0°C and/or

d) **WBGT index** < 25.0°C.

e) **WCET** ≥ 10.0°C should be applied to define a non-significant cold risk.

8.1.2.2. Significant risk

a) **WB** ≥ 25.0°C - < 27.5°C.

b) **DB** ≥ 32.0°C - < 37.0°C.

c) **GT** ≥ 32.0°C - < 37.0°C.

d) **WBGT index** ≥ 25 - < 30 determined over a period of one hour.

e) **WCET** < 10.0°C should be applied to define a significant cold risk.

8.2. Thermal stress management

8.2.1. Non-significant risk

A monitoring programme is not required, but the employer must keep a portfolio of evidence.

8.2.2. Significant risk

The **COP** should put measures in place to ensure that a thermal stress management programme is established and maintained for all workplaces with a significant risk.

The thermal stress management programme should address the following aspects:

a) The thermal stress management structure *(see section 8.2.2.1)*.

b) Risk assessment *(see section 8.2.2.2)*.

c) The determination of **thermal environments** *(see section 8.2.2.3)*.

d) The thermal stress monitoring strategy *(see section 8.2.2.4)*.

e) Quality control *(see section 8.2.2.5)*.

f) Hierarchy of controls *(see section 8.2.2.6)*.

g) **HSM** *(see section 8.2.2.7)*.

h) **CSM** *(see section 8.2.2.8)*.

i) Medical surveillance programmes *(see section 8.2.2.9)*.

j) Fitness to perform work *(see section 8.2.2.10)*.

k) Immediate incident management *(see section 8.2.2.11)*.

l) Reporting and recording *(see section 8.2.2.12)*.

The **COP** must address the following points.

8.2.2.1. Thermal stress management structure

The **COP** must make provisions for the employer to put measures in place for the establishment of a thermal stress management committee whose members are appointed in writing, and have defined roles, responsibilities and authority to manage thermal stress, including but not limited to the following:

a) Employer designated representative as the chairperson.

b) A **MHSA** section 12(1) appointee.

c) An engineer as contemplated in regulation 2.13.1 of the **MHSA** (for the purpose of thermal stress control).

d) **OMP**.

e) Human Resource representative.

f) Human Resource Development representative (education and training).

g) Full-time health and safety representatives.

8.2.2.2. Risk assessment

The outcomes of the risk assessment as in section 8.1.1 above will be utilised as inputs into the thermal stress management programme.

NOTE:
- *Where the available historical data is insufficient to enable a professional judgement regarding the extent of any risk, acceptable methodologies for the identification or the determination of thermal stress should be used.*

8.2.2.3. Determination of **thermal environments**

The employer must identify the **thermal environment** as per the following:

Step 1

The sub-division of the mine into measurement areas e.g.:

- Measurement area 1 = surface.
- Measurement area 2 = underground section A.
- Measurement area 3 = underground section B.
- Measurement area 4 = underground section C etc.

NOTE:
- *Surface operations proceed to step 3.*
- *Underground operations proceed to step 2.*

Step 2

Measurement areas for underground mines should be sub-divided into ventilation districts.

NOTE:
In order for an area to be classified as a ventilation district it:
1. *Must be ventilated independently from other areas.*
2. *Must have independent intake and return airways.*
3. *Does not contaminate other areas.*

Step 3

Measurement areas for surface operations must be sub-divided into activity areas as per the activity area code list found in Annexure 1: Mandatory codes list.

Ventilation districts must be sub-divided into activity areas as per the activity area code list found in Annexure 1: Mandatory codes list.

Step 4

The employer must categorise (as per Table 1: The classification system for heat stress and Table 2: The classification system for cold stress below) the activity areas based on the historical thermal environmental data.

Step 5

Conduct a statistical analysis to ensure that **thermal environments** are correctly classified. The results of the thermal environmental parameters (as per Table 1: The classification system for heat stress and Table 2: The classification system for cold stress below) used, from either historical data or measured data should be compared to the respective **OEL**/standard.

Step 6

Once the thermal environmental parameters (as per Table 1: The classification system for heat stress and Table 2: The classification system for cold stress below) within each activity area have been compared to the respective **OEL**/standard, each activity area can now be categorised into classification bands. For classification purposes, use the 90th **percentile** value for heat stress (the classification for heat stress should be based on the worst measured parameter) and the 10th **percentile** value for cold stress.

NOTE:
*The employer must ensure that in defining any **thermal environment**, the precautions listed below are heeded to:*
- *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.*
- *Seasonal drifts could be crucial and to rely on winter temperatures may lead to an underestimation of the risk and vice versa. Environmental monitoring should consider this.*

NOTE:
- *Using mean values for the purpose of categorisation may underestimate the risk if a significant number of exposed employees have to enter environments close to, or at the upper end of the range of recorded values.*

The classification bands for a **thermal environment** are tabled below and these tables form part of this guideline and must be complied with.

TABLE 1: The classification system for heat stress

CLASSIFI-CATION	TEMPERATURE RANGE (FOR CATEGORISATION)	INTERPRETATION	GENERAL ACTION
A	**WB** ≥ 32.5°C or **DB** ≥ 37.0°C or **GT** ≥ 37.0°C or **WBGT index** ≥ 34	**Abnormally hot environment**	▪ No normal work should be undertaken except work to rectify the condition(s). ▪ Work to rectify the condition(s) must be undertaken only on a basis of risk assessment, supervision and protocols.
B	**WB** ≥ 27.5°C - < 32.5°C and/or **DB** ≥ 32.0°C - < 37.0°C, and/or **GT** ≥ 32.0°C - < 37.0°C and/or **WBGT index** ≥ 30 - < 34	**Hot environment**	▪ **HSM** mandatory.

CLASSIFI-CATION	TEMPERATURE RANGE (FOR CATEGORISATION)	INTERPRETATION	GENERAL ACTION
C	**WB** ≥ 25.0°C - < 27.5°C and/or **DB** ≥ 32.0°C < 37.0°C and/or **GT** ≥ 32.0°C - < 37.0°C and/or **WBGT index** ≥ 25 - < 30	Significant risk	▪ **HSM** mandatory.
D	**WB** < 25.0°C and/or **DB** < 32.0°C and/or **GT** < 32.0°C and/or **WBGT index** < 25	Non-significant risk	▪ No special precautions. ▪ Environmental monitoring must be sufficiently sensitive to detect critical upward drifts in the environmental heat load. ▪ The monitoring programme to satisfy this requirement should be specified.

TABLE 2: The classification system for **cold stress**

CLASSIFI-CATION	TEMPERATURE RANGE (FOR CATEGORISATION)	INTERPRETATION	GENERAL ACTION
A	≤ -30.0°C (≤ minus 30°C)	**Abnormally cold environment**	▪ No normal work should be undertaken except work to rectify the condition(s). ▪ Work to rectify the condition(s) must be undertaken only on a basis of risk assessment, supervision and protocols.
B	≤ 5.0°C but > -30.0°C (≤ minus 30°C)	**Cold environment**	▪ Implement formal **CSM**.
C	> 5°C but < 10.0°C	Significant risk	▪ Implement formal **CSM**.
D	≥ 10.0°C	Non-significant risk	▪ No special precautions. ▪ Monitor **ECT**.

Step 7

Reclassification of **thermal environments** should be considered when any of the following events occurs:

a) Exposure levels change due to controls being initiated, and likewise, when controls deteriorate.

b) Employee complaints are received.

c) Processes are changed (e.g. change in procedures, mining and ventilation layouts, mining methods, plant, equipment or material).

d) Occupational illness related to the **thermal environment** occurs.

e) Change in exposure category occurs.

f) Other events warranting re-evaluation e.g. new regulatory initiatives.

NOTE:
- *The previous cycle for surface operations refers to the data from a similar monitoring period for the previous year.*
- *The previous cycle for underground operations refers to the data from the previous quarter.*

8.2.2.4. Thermal stress monitoring strategy

The employer must implement a thermal stress monitoring strategy and clearly describe the following in the **COP**:

a) Identify internationally or nationally acceptable measurement methodology used for thermal stress monitoring.

b) Describe the acceptable measurement methodology used for thermal stress monitoring.

c) The record keeping system used by the mine to record the thermal stress data.

d) The instrument(s) used to assess thermal stress (heat and cold).

e) The frequency of maintenance and the calibration of measuring instruments.

f) The monitoring period for heat and cold stress must be determined by the risk assessment and the identified thermal stress measurement methodology.

NOTE:
- *Thermal monitoring for heat stress is to be conducted on an annual basis during the warmest period of the year, and cold stress during the coldest period of the year, as determined by the risk assessment.*
- *Care should be exercised to detect trends in 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.*

g) Monitoring frequency

The monitoring frequency must be defined in the **COP** as per Table 3: Heat stress classification and monitoring frequency and Table 4: Cold stress classification and monitoring frequency below or as determined by

the risk assessment, whichever is the higher standard.

TABLE 3: Heat stress classification and monitoring frequency

CLASSIFICATION	TEMPERATURE RANGE (FOR CATEGORISATION)	MONITORING FREQUENCY
A	**WB** ≥ 32.5°C or **DB** ≥ 37.0°C or **GT** ≥ 37.0°C or **WBGT index** ≥ 34	▪ Continuously monitor until the environmental conditions have improved to acceptable limit(s).
B	**WB** ≥ 27.5°C - < 32.5°C and/or **DB** ≥ 32.0°C - < 37.0°C and/or **GT** ≥ 32.0°C - < 37.0°C and/or **WBGT index** ≥ 30 - < 34	▪ Monitoring must be conducted within every 30 days.
C	**WB** ≥ 25.0°C - < 27.5°C and/or **DB** ≥ 32.0°C < 37.0°C and/or **GT** ≥ 32.0°C - < 37.0°C and/or **WBGT index** ≥ 25 - < 30	▪ Monitoring must be conducted within every 45 days.
D	**WB** < 25.0°C and/or **DB** < 32.0°C and/or **GT** < 32.0°C and/or **WBGT index** < 25	▪ As determined by the risk assessment.

TABLE 4: Cold stress classification and monitoring frequency

CLASSIFICATION	ECT RANGE (FOR CATEGORISATION)	MONITORING FREQUENCY
A	≤ -30.0°C (≤ minus 30°C)	▪ Continuously monitor until the environmental conditions improved to acceptable limit(s).
B	≤ 5.0°C - > -30.0°C (≤ minus 30°C)	▪ Monitoring must be conducted within 30 days.
C	> 5.0°C - < 10.0°C	▪ Monitoring must be conducted within 90 days.
D	≥ 10.0°C	▪ As determined by the risk assessment

h) Monitoring programme

In developing the monitoring programme the following should be considered:

(i) Routine monitoring

All working places should be monitored in terms of the most relevant parameter of the prevailing **thermal environment** (e.g. **WB**, **DB** and velocity) that is periodically done as per the monitoring frequency.

(ii) Adjusted monitoring

Where prevailing conditions are closer to the upper limits of the category 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.

8.2.2.5. Quality control

The **COP** must describe a quality control programme taking into account, but not limited to, the following:

a) Maintenance and calibration of instruments used for thermal stress monitoring.

b) Measurement methods to assess thermal stress.

c) **HTS**.

d) Competency of people assessing thermal stress.

e) Reporting on thermal stress conditions and measurements.

8.2.2.6. Hierarchy of controls

The **COP** should address the hierarchy of controls, which are going to be implemented to mitigate the risk of exposure to thermal stress. The following hierarchy of controls should be taken into consideration:

a) Elimination.

b) Substitution and isolation.

c) Engineering controls.

d) Administrative controls.

e) **PPE**.

8.2.2.7. **HSM**

HSM must be implemented by the employer where the risk assessment determines a significant risk. The following aspects must be addressed in the thermal stress **COP** and where applicable, cross-reference to the standard operating procedures of the mine:

a) Medical or physical examinations (see Annexure 6: Medical/physical examinations).

b) **HTS** (see Annexure7: Heat tolerance screening).

c) Work practices for surface, opencast and underground operations (see Annexure 8: Work practices: Surface, opencast and underground operations).

d) Absenteeism from routine work in **hot environments** (see Annexure 9: Absenteeism from routine work in **hot environments**).

e) Water and nutritional requirements during work in heat (see Annexure 10: Water and nutritional requirements during work in heat).

f) Emergency work in **abnormally hot environments** - underground (see Annexure 11: Emergency work in **abnormally hot environments** - underground).

8.2.2.8. **CSM**

The **COP** requires a **CSM** programme to be implemented where the risk assessment determines a significant risk.

The following points must be addressed in the **CSM** programme:

a) Medical or physical examinations.

b) Safe work practices and supervision (strategy for dealing with **cold environments**).

c) Precautions to prevent cold stress e.g. **PPE**.

d) Emergency work.

NOTE:
- *Annexure 4: Cold stress management should be consulted when drawing up the **CSM** programme.*

8.2.2.9. Medical surveillance programme

The **COP** must address the following points:

8.2.2.9.1. The medical surveillance programme as it relates to thermal stress must be described in the **COP** (see Annexure 6: Medical/physical examination).

8.2.2.9.2. The method used to link the thermal stress exposure measurements to the employee's records of medical surveillance as required in terms of section 12(3) of the **MHSA**, must be described in the **COP**.

NOTE:
- *A manual or computerised system could be utilised to link this information.*
- *These systems may have to be customised in accordance with the operations specific needs.*
- *Effective communication between the 12(1) appointee of the **MHSA** and the **OMP** is required to ensure that linking employees' exposure history and medical surveillance information is meaningful.*

8.2.2.9.3. A procedure must be described in the **COP** on how the thermal stress medical surveillance (initial, periodic and exit examinations) will be conducted. The medical surveillance done must exclude the presence of any abnormality that may compromise physical work in **thermal environments**. This must include, but is not limited to, the following:

a) The general medical examination:

(i) History (occupational, medical, family and social) and thermal-related disorders (cramps, exhaustion, stroke and hypothermia) must be obtained.

(ii) Urinalysis must be done to exclude the presence of haematuria, proteinuria and glycosuria.

(iii) The examination must be done to exclude any presence of jaundice, anaemia, cyanosis, clubbing, oedema, abnormal lymph nodes and febrile disease.

(iv) The blood pressure must be checked and if uncontrolled hypertension (>160/95) and gross cardiovascular abnormalities are present, these require a full investigation and obtaining a specialist opinion regarding the fitness for physically demanding work in a **hot environment**.

(v) A skin examination must be done to determine that it is intact with no infections such as advanced athlete's foot, cellulitis, scabies, etc.

(vi) A cardio-respiratory examination including a chest x-ray and spirometry, must be done to exclude any abnormalities.

(vii) Ear, nose and throat examinations must be done to exclude inflammation or infection (tonsillitis, pharyngitis, chronic suppurative otitis media, etc.).

(viii) An abdominal examination must be performed to exclude the presence of organomegaly or hernias.

(ix) A screening neurological examination must be done to exclude

any gross abnormalities.

b) Physical evaluation

The following physical evaluation must be performed to assess the medical and physical fitness of an individual to undergo **HTS** (see Annexure 6: Medical/physical examinations).

(i) Age.

(ii) General physical appearance.

(iii) Body dimensions.

8.2.2.9.4. Methodological standards for test techniques forming part of medical surveillance.

8.2.2.9.5. The methodology used to comply with the legal requirements in respect of medical surveillance for thermal stress as contemplated in section 13(2) of the **MHSA**, must be described in the **COP**.

8.2.2.9.6. The employer must ensure that for routine work, the anticipated work environment takes into cognisance the categories A, B, C and D as referenced in section 8.2.3.3 above, Table 1: The classification system for heat stress and Table 2: The classification system for cold stress, to assist the **OMP** in making an informed decision in terms of fitness to work.

8.2.2.9.7. The **COP** must provide that the employer make the thermal environmental classification available to the **OMP** for medical surveillance.

8.2.2.9.8. Heat (heat cramps, heat exhaustion and heat stroke) and cold disorders (frostbite and hypothermia) can occur and do occur in **thermal environments**. Whenever such incidents occur, immediate and full investigations should take place with the primary purpose being to:

a) Prevent the recurrence of such incidents and by collating such data.

b) Provide input to **HSM** or **CSM** programme reviews (for clinical signs and symptoms of heat-related illnesses refer to Annexure 12: Addendum for the thermal stress guideline on the criteria for heat-related illnesses).

8.2.2.9.9. A procedure where work in **abnormally hot and cold environments** is to be undertaken must be developed. Any adverse consequences, as a result of such exposures, should be entered in the medical surveillance record of employees (see Annexure 11: Emergency work in **abnormally hot environments**).

8.2.2.10. Fitness to perform work

The employer must develop and implement a **HTS** procedure to monitor employees, taking into consideration the following (see Annexure 7: Heat tolerance screening):

a) Fitness of employees to work should be based on the individual's merits. If, however, an employee who has been working in a hot environment for years without any manifestation of heat related illness; fails **HTS**, further assessment should be done to exclude any other medical condition(s) that may render the employee unfit to work in a hot environment. Such an employee may not be declared medical incapacitated based on the failure of **HTS** only, but a holistic approach needs to be undertaken to determine fitness to continue with work in a hot environment. If, however, the same employee is transferred to a hotter environment a risk-based medical surveillance will be conducted.

b) The medical and work history of the employee prior to finalising fitness to work in a hot environment.

c) **HTS** failure does not automatically translate to incapacity or unfitness to work in a **hot environment** unless there is a proven underlying medical condition.

NOTE:

- *While the **BMI** provides a better predictor of disease risk, the **OMP** should use professional discretion in determining employees' fitness to work in **hot environments** especially amongst employees who might be competitive athletes or body builders.*

8.2.2.11. Immediate incident management

Whenever there is an unexplained incident of an employee collapsing whilst working in an **abnormally hot environment**, such incident should be treated as a possible case of heatstroke.

The core body temperature should be taken and there must be rapid cooling of the affected employee as suggested in Annexure 12: Addendum for the thermal stress guideline on the criteria for heat-related illnesses (heat exhaustion and heat stroke).

8.2.2.12. Reporting and recording

The **COP** must address the following:

a) Reporting on a quarterly basis for all classifications, that is A, B and C (refer to Annexure 2: Mandatory occupational hygiene thermal stress reporting forms).

b) A record keeping system, which records the exposure history of each **thermal environment** at the mine and any other thermal stress monitoring records e.g. calibration certificates, sampling sheets, etc. This should be kept and be readily available at the mine, including any reasons for deviation on sample results such as:

(i) Controls not operating effectively.

(ii) Events or factors which influenced the results, e.g. excessive wind speeds, etc.

c) Occupational hygiene measurement records linked to the medical surveillance records, must be kept by the employer.

d) Quarterly re-classification that must be conducted if results are proven and consistent.

e) Any incident of unconsciousness and incapacitation from heatstroke or heat exhaustion must be reported to the **DMRE** as stated in chapter 23 of the **MHSA** regulations.

Historical data is to be maintained as provided for in section 15(2)(a) and (b) of the **MHSA**.

NOTE:

- *For all categories A, B and C, the thermal stress measurement results must be reported within 60 days at the end of each quarter.*
- *For category D, no reporting is required; however, a portfolio of evidence should be kept at the mine.*

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

2.1. 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: Mandatory codes list
(This annexure forms part of the guideline and must be complied with)

1. MAIN COMMODITY CODE LIST

The main commodities produced by the mines.

COMMODITY	CODE	COMMODITY	CODE
Asbestos	AS	Malmesbury Hornfels	MH
Attapulgite	AP	Manganese	MN
Bentonite	BT	Marble	MB
Calcrete	CA	Mercury	HG
Cement	CE	Mica	MC
Chrome	CR	Mineral-pigments	MP
Clay	CY	Montmorillonite	MM
Coal	CL	Nepheline	NP
Cobalt	Co	Nickel	Ni
Copper	CU	Norite	NR
Diamonds	DI	Perlite	PL
Dolerite	DR	Phosphates	PH
Dolomite	DM	Platinum group metals	PT
Dwyka	DK	Prospecting (unspecified minerals)	PR
Emeralds	EM	Pyrophyllite	PY
Feldspar	FD	Quartzite	QZ
Felsite	FT	Quartzite dimension stone	QD
Fireclay	FI	Salt	NA
Flintclay	FY	Sand	SA
Fluorspar	FS	Shale	SH
Fullers-earth	FU	Silica	SI
Gas and condensate (MOSSGAS)	GC	Silicon-metal	SM
Gold	AU	Sillimanite	ST
Granite	GT	Slag	SG
Granite dimension stone	GD	Slate Dimension Stone	SD
Gravel	GV	Soil	SL
Gypsum	GS	Talc	TC
Ilmenite	IL	Tigers-eye	TE
Iron-ore	FE	Tin	SN
Jasper	JP	Titanium	TN
Kaolin	KA	Uranium	UR
Kieselguhr	KG	Vanadium	VA
Lead	PB	Wollastonite	WS
Limestone	LS	Zinc	ZN
Magnesite	MA		

2. ACTIVITY AREA CODE LIST

Alphabetical index of the activity areas.

ACTIVITY AREA	CODE
Assay / laboratory	32
Chemical process	27
Concentrating	24
Conventional mining (coal)	01
Continuous miner (coal)	02
Crushing	20
Development (single shift)	09
Development (multi-blast)	10
Dumps / dump recycling	34
Final products	29
Ground handling (conveyor / loco's)	15
Handgot (coal)	04
Heat process	25
Longwall mining (coal)	03
Milling / pulverising	21
Opencast	07
Raise boring / Dry drilling	12
Raw material	19
Refining	28
Rock mining coal	06
Roving plant	30
Roving surface	31
Roving underground	17
Scraper block caving	14
Screening / grading	22
Separation processes	23
Shaft sinking	11
Shafts and services	16
Smelting	26
Stooping / pillar extraction (coal)	05
Stoping	08
Surface Workshops	33
Trackless Mining	13
Underground workshops	18

NOTE:

- *Where the above broad descriptions do not define an activity area exactly, select the "best fit".*

3. OCCUPATION CODE LIST

Alphabetical index of the occupational codes.

OCCUPATION	CODE
Acclimatisation supervisor	**70301**
Acclimatisation worker	**70302**
Accommodation worker (other accommodation) [n.e.c.]	**80699**
Accommodation worker (residential) [n.e.c.]	**80599**
Accountant [n.e.c.]	**10206**
Accounting / financial management	**10200**
Accounting / financial worker [n.e.c.]	**10299**
Acid plant official	**30402**
Acid plant worker	**30404**
Administration / secretarial management	**10900**
Administrative officer	**10903**
Administrative / financial management (multi-disciplinary)	**10000**
Administrative / financial management [n.e.c.]	**10099**
Administrative / financial / business worker [n.e.c.]	**19999**
Advocate / barrister	**60601**
Agricultural management (multi-disciplinary)	**90000**
Agricultural management [n.e.c.]	**90099**
Agricultural worker [n.e.c.]	**99999**
Air conditioning / refrigeration engineer	**40412**
Air conditioning / refrigeration mechanic	**40413**
Air transport management	**81100**
Air transport officer	**81101**
Air transport worker [n.e.c.]	**81199**
Air and water services team leader/supervisor	**21507**
Air and water services worker	**21508**
Airport controller	**81102**
Amalgamator	**30110**
Ambulance officer	**70803**
Anaesthetist	**70101**
Aptitude tester	**60106**
Aptitude testing supervisor	**60105**
Aqua-jet operator	**21406**
Architect	**50901**
Architectural assistant	**50902**
Architectural management	**50900**
Architectural worker [n.e.c.]	**50999**
Armature winder	**40320**
Assay / chemistry / laboratory worker [n.e.c.]	**50499**
Assay technician	**50403**
Assayer	**50401**
Assistant driller (ocean)	**29909**
Assessor	**10511**
Assopulp worker	**35910**
Attorney / solicitor / conveyancer	**60602**

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Audio visual tester	70303
Audiologist/speech therapist	70322
Audiometrist	70323
Auditing management	10100
Auditing worker [n.e.c.]	10199
Auditor (computer / systems)	10102
Auditor (internal and external)	10101
Auto electrician	40319
Backfill worker	20805
Baker	35020
Banking officer	11114
Banking / investment management	11100
Banking / investment worker [n.e.c.]	11199
Banksman / onsetter	21304
Bargemaster (ocean)	81202
Barber / hairdresser	80803
Barman	80706
Barrister / advocate	60601
Beer maker	35110
Beerhall supervisor	80705
Bell signaller	21305
Beltsman	30205
Bio-medical engineer	70304
Biokineticist	70102
Blacksmith	40422
Blacksmith: apprentice	40424
Blacksmith: chargehand	40421
Blacksmith: foreman	40420
Blacksmith: operative	40423
Blacksmith: worker [n.e.c.]	40425
Blaster (supervisory)	20306
Blaster: opencast / quarry (non-supervisory)	20502
Blaster: surface works (non-supervisory e.g. smelter)	20503
Blaster: underground metal (non-supervisory)	20501
Blasting worker [n.e.c.]	20599
Boiler attendant	40803
Boilermaker: operative (grade 1)	40450
Boilermaker: operative (aide) (grade 2)	40451
Book binder	36015
Bosun (ocean)	81202
Bookkeeper	10208
Box / orepass controller	21404
Brick maker	36710
Bricklayer	40614
Bricklayer: aide	40617
Builder	40615
Building service worker [n.e.c.]	80499
Building services management	80400

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Building worker [n.e.c.]	40618
Building worker: operative	40616
Business analyst (computers)	50503
Business management	10001
Butcher	35010
Buyer / purchaser	10312
Cable joiner	40343
Calcinating worker	30508
Canteen supervisor	80701
Canteen worker	80703
Caretaker / housekeeper	80501
Carpenter	40621
Carpenter and joiner	40622
Carpenter and joiner: apprentice	40623
Carpenter and joiner: chargehand	40620
Carpenter and joiner: foreman	40619
Carpenter: aide	40624
Carpenter: worker [n.e.c.]	40625
Cashier	10209
Caster	30507
Catering management	80700
Cementer (ocean)	21699
Catering worker [n.e.c.]	80799
Cementation driller / injector	21602
Cementation supervisor	21601
Cementation worker [n.e.c.]	21699
Chairlift operator	21307
Chairman (group)	00000
Change house team leader / supervisor	80604
Change house worker	80605
Checker	10395
Chef / cook	80702
Chemical engineer	40701
Chemical engineering management	40700
Chemical engineering worker [n.e.c.]	40799
Chemical process worker [n.e.c.]	30499
Chemist	50402
Chemist technician	50404
Chief executive	00000
Child minder	80802
Chiropodist / podiatrist	70320
Cinema / video operator	60805
Civil engineer	40601
Civil engineering management	40600
Civil engineering technician	40610
Civil engineering worker [n.e.c.]	40699
Civil / building chargehand (other) [n.e.c.]	40651
Civil / building foreman (other) [n.e.c.]	40650

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Civil / building tradesman (other) [n.e.c.]	40652
Cleaner (office) / tea maker	80402
Clerk of works	40611
Clerk (accounts / finance)	10295
Clerk (agriculture) [n.e.c.]	99995
Clerk (air transport)	81195
Clerk (architectural)	50995
Clerk (auditing)	10195
Clerk (banking / investment)	11195
Clerk (catering)	80795
Clerk (club)	80695
Clerk (creative arts)	60995
Clerk (economics)	10795
Clerk (engineering planning)	40195
Clerk (engineering)	49995
Clerk (environmental)	51095
Clerk (estate / township)	80395
Clerk (first aid)	70895
Clerk (general e.g. filing) [n.e.c.]	10995
Clerk (geology)	50195
Clerk (hostel / quarters)	80595
Clerk (industrial engineering)	50795
Clerk (industrial relations)	60295
Clerk (insurance)	10595
Clerk (legal)	60695
Clerk (library)	60795
Clerk (marketing / sales)	10895
Clerk (medical)	79995
Clerk (metallurgical plant)	39995
Clerk (mining planning)	20195
Clerk (mining) [n.e.c.]	29995
Clerk (payroll / timekeeping)	10495
Clerk (personnel)	60195
Clerk (printing)	36095
Clerk (property / mining rights)	10695
Clerk (public relations)	60895
Clerk (rail transport)	81095
Clerk (road transport)	80995
Clerk (rock mechanics)	50395
Clerk (safety / loss control)	50895
Clerk (school)	60495
Clerk (security)	80195
Clerk (sports / recreation)	61095
Clerk (statistics)	50695
Clerk (stores)	10395
Clerk (strategic planning)	00295
Clerk (survey)	50295
Clerk (tax)	11295

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Clerk (training)	**60395**
Clerk (welfare)	**60595**
Clinical assistant	**70202**
Club management	**80600**
Club secretary	**80601**
Club team leader	**80602**
Club worker	**80603**
Coal auger operator	**20604**
Coal cutter operator	**20601**
Coal plough operator	**20605**
Coal preparation worker	**30211**
Coking plant attendant	**30509**
Collator	**36014**
Commissionaire (offices)	**80401**
Commissionaire (residential accommodation)	**80502**
Company secretary (administrative)	**10900**
Compressor attendant	**40804**
Computer operator	**50508**
Computer programmer	**50505**
Concentration / flotation worker [n.e.c.]	**30399**
Consultant (administrative / financial) [n.e.c.]	**19996**
Consultant (agriculture) [n.e.c.]	**99996**
Consultant (engineering) [n.e.c.]	**49996**
Consultant (general management) [n.e.c.]	**09996**
Consultant (humanities) [n.e.c.]	**69996**
Consultant (medical) [n.e.c.]	**79996**
Consultant (metallurgy / beneficiation / manufacturing) [n.e.c.]	**39996**
Consultant (mining production) [n.e.c.]	**29996**
Consultant (scientific / technical) [n.e.c.]	**59996**
Consultant (service occupation) [n.e.c.]	**89996**
Consultant (tax)	**11296**
Consulting engineer (engineering support)	**40000**
Consulting engineer (mining)	**20000**
Consulting metallurgist	**30003**
Continuous miner driver	**20602**
Contractor (outside)	**49902**
Control room operator	**30202**
Conveyancer / attorney / solicitor	**60602**
Conveyer worker [n.e.c.]	**20299**
Conveyer belt attendant	**21202**
Conveyer belt team leader / supervisor	**21201**
Cook / chef	**80702**
Corporate secretary (administration)	**10901**
Cost accountant	**10205**
Cost controller	**10205**
Crane driver	**81301**
Crane driver trainer	**81398**
Creative worker [n.e.c.]	**60999**

OCCUPATION	CODE
Credit controller	10207
Critical path scheduler	20103
Crop worker	90499
Crossing attendant	81009
Crusher attendant	30207
Cupola man	30505
Cutter	49903
Cyanidation team leader / supervisor	30403
Cyanidation worker	30405
Data base administrator	50513
Data base technician	50514
Data capture supervisor	50510
Data capture typist	50511
Day pusher (ocean)	29908
Deck attendant (ocean)	29910
Deck leader (ocean)	20313
Data controller (computers)	50509
Dental assistant	70504
Dental mechanic	70503
Dental specialist (e.g. oral pathologist) [n.e.c.]	70499
Dental surgeon / dentist	70401
Dental therapist	70502
Dental worker [n.e.c.]	70599
Dermatologist	70103
Designer (engineering)	40102
Detective	80104
Developer	20303
Development management (hardware)	50501
Development management (software)	50502
Development team leader / supervisor	20310
Development team worker	20701
Diamond drill team leader / supervisor	50111
Diamond drill worker	50112
Diamond driller	50110
Diecaster	40501
Diesel mechanic	40477
Diesel mechanic: apprentice	40478
Diesel mechanic: chargehand	40476
Diesel mechanic: foreman	40475
Dietician	70305
Diplomatic / political liaison officer	60802
Diver (ocean)	29911
Disinfestation worker	40905
Dog handler	80105
Domestic servant	80801
Dragline operator	21102
Dragline supervisor	21101
Drains cleaner	29906

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Draughting technician	49994
Draughtsperson (architectural)	50994
Draughtsperson (chemical engineering)	40794
Draughtsperson (civil engineering)	40694
Draughtsperson (electrical engineering)	40394
Draughtsperson (geological)	50194
Draughtsperson (mechanical engineering)	40594
Draughtsperson (mining production) [n.e.c.]	29994
Draughtsperson [n.e.c.]	49994
Draughtsperson (survey)	50294
Draughtsperson (technical services)	59994
Drill rig operator (jumbo)	20401
Drill sharpener	40528
Driller: hand percussion / jackhammer	20402
Driller: hand (coal)	20403
Driller: opencast / large diameter	20404
Drilling worker [n.e.c.]	20499
Drillsmith	40527
Driver: ambulance (code 08)	80908
Driver: bulldozer	21103
Driver: forklift	80905
Driver: haul truck (underground and opencast)	21109
Driver: heavy articulated motor vehicle (code 13)	80911
Driver: heavy motor vehicle (e.g. bus / ambulance code 10)	80909
Driver: light motor vehicle /car (code 08)	80907
Driver: mobile industrial / agricultural equipment (code 07)	80906
Driver: motorcycle (code 01-04)	80903
Driver: tractor (code 05)	80904
Driving instructor	80998
Dryerman	30406
Dump team leader / supervisor	30702
Dump worker	30703
Dumpsman	30701
Duplicator	10907
Ear, nose and throat specialist	70104
Economics assistant	10703
Economics management	10700
Economics worker [n.e.c.]	10799
Economist [n.e.c.]	10702
Economy controller	10205
Editor	60901
Educational management	60400
Educational / school worker [n.e.c.]	60499
EEG technician	70306
Electrical chargehand (other) [n.e.c.]	40341
Electrical engineer	40301
Electrical engineering management	40300
Electrical engineering worker [n.e.c.]	40399

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Electrical foreman (other) [n.e.c.]	40340
Electrical technician	40310
Electrical tradesman (other) [n.e.c.]	40342
Electrician	40314
Electrician: aide	40317
Electrician: apprentice	40315
Electrician: chargehand	40313
Electrician: foreman	40312
Electrician: underground section	40316
Electrician: worker [n.e.c.]	40318
Electricity generator worker	40802
Electro mechanic / millwright / minewright	40437
Electronic technician	40311
Employee assistance programme management	60500
Encoder	19910
Energy systems management	40800
Energy systems officer	40805
Energy systems team leader / supervisor	40801
Energy systems worker [n.e.c.]	40899
Engineer [n.e.c.]	40201
Engineering assistant [n.e.c.]	40205
Engineering foreman [n.e.c.]	40004
Engineering inspector	40202
Engineering management (multi-disciplinary)	40001
Engineering management [n.e.c.]	40099
Engineering team leader [n.e.c.]	49901
Engineering technical worker [n.e.c.]	40299
Engineering technician [n.e.c.]	40203
Entertainer	60905
Environmental assistant	51004
Environmental construction supervisor	51007
Environmental construction worker	51008
Environmental engineer	51001
Environmental engineering management	51000
Environmental observer	51005
Environmental officer	51003
Environmental superintendent	51002
Environmental worker [n.e.c.]	51099
Equipper	21504
Estate / township management	80300
Estate / township officer	80301
Estate / township team leader / supervisor	80302
Estate / township worker [n.e.c.]	80399
Estimator / calculator	40104
Executive director [n.e.c.]	00000
Explosives issuer	10317
Facilities management (computers)	50506
Fan attendant	40344

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Farm manager	90001
Filing / records officer	10904
Filter operator / worker	30302
Filter team leader / supervisor	30301
Financial accountant	10204
Financial analyst	10201
Financial economist	10701
Financial engineer	10202
Financial/accounting management	10200
Financial/admin management (multi-disciplinary)	10000
Firefighting/rescue officer	80202
Firefighting/rescue team leader/supervisor	80203
Firefighting/rescue trainer	80298
Firefighting/rescue worker [n.e.c.]	80299
Fireman / stoker	81005
Firemaster	80201
First aid attendant	70802
First aid management / medical station superintendent	70800
First aid team leader / supervisor	70801
First aid trainer	70898
First aid training superintendent	70898
First aid worker [n.e.c.]	70899
Fitter and turner	40428
Fitter and turner: apprentice	40429
Fitter and turner: chargehand	40427
Fitter and turner: foreman	40426
Fitter (including machining): apprentice	40433
Fitter (including machining)	40432
Fitter (including machining): chargehand	40431
Fitter (including machining): foreman	40430
Fitter: operative (grade 1)	40434
Fitter: operative aide (grade 2)	40435
Fitter: worker [n.e.c.]	40436
Forester	90301
Forestry engineer	90300
Forestry worker	90399
Forger	40502
Founder	40505
Furnace worker [n.e.c.]	30599
Game ranger	90501
Ganger / plate / tracklayer (main line)	40656
Garage mechanic: aide	40480
Garage serviceman	40481
Garage worker [n.e.c.]	40482
Garden supervisor / groundsman	90102
Garden worker	90199
General engineering supervisor	40002
General engineering worker [n.e.c.]	49999

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
General management [n.e.c.]	00199
General manager (company)	00102
General manager (mine)	00101
General miner	20305
General practitioner	70201
Geochemist	50103
Geological management	50100
Geological observer / field assistant	50109
Geological worker [n.e.c.]	50199
Geologist	50101
Geology technician	50108
Geophysicist	50102
Grab operator	21401
Grade officer	50408
Graphic artist	60904
Grinderman / pulveriser	30210
Groundsman / garden supervisor	90102
Guest house / quarters management	80500
Guillotine operator	36013
Gynaecologist	70105
Hairdresser / barber	80803
Handyman (maintenance)	40654
Handyman (mining)	21504
Haulage team leader/supervisor	21001
Haulage / underground rail transport worker [n.e.c.]	21099
Health / food inspector	70307
Herdsman / stable hand	90502
Hoist driver	21302
Hoisting worker [n.e.c.]	21399
Horticulturist	90101
Hospital cleaner	79901
Hospital secretary	10902
Hospital superintendent	70002
Hospital worker / orderly	70324
Hostel management	80505
Hostel official	80506
Hostel team leader / supervisor	80507
Housekeeper / caretaker	80501
Humanities management (multi-disciplinary)	60000
Humanities management [n.e.c.]	60099
Humanities worker [n.e.c.]	69999
Hydraulic prop team leader / supervisor	20801
Hydraulic prop worker	20802
Hydraulic technician	40411
Hygiene services worker [n.e.c.]	40999
Induna / tribal representative	60203
Industrial engineer	50701
Industrial engineering management	50700

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Industrial engineering officer	50704
Industrial engineering technician	50702
Industrial engineering worker [n.e.c.]	50799
Industrial physician	70106
Industrial relations assistant	60202
Industrial relations management	60200
Industrial relations practitioner	60201
Industrial relations worker [n.e.c.]	60299
Info services / computer worker [n.e.c.]	50599
Information centre management (computers)	50516
Information services management	50500
Instrument engineer	40321
Instrument mechanician (industrial)	40325
Instrument mechanician apprentice (industrial)	40326
Instrument mechanician chargehand (industrial)	40324
Instrument mechanician foreman (industrial)	40323
Instrument technician	40322
Insurance adviser	10596
Insurance management	10500
Insurance worker [n.e.c.]	10599
Internist / specialist physician	70107
Inventory controller	10315
Irrigation engineer	90400
Issuer (explosives)	10317
Issuer (stores, non-explosive)	10316
Journalist / writer	60902
Junior engineer (civil engineering)	40602
Junior engineer (electrical engineering)	40302
Junior engineer (mechanical engineering)	40402
Junior engineer [n.e.c.]	40207
Kennel worker	90503
Kilnman	30504
Kitchen worker	80703
Laboratory assistant	50406
Laboratory manager/superintendent	50400
Laboratory technician	50405
Labour controller	60103
Ladleman	30506
Lamp room team leader /supervisor	40346
Lamp room worker	40347
Lampsman	40345
Land rehabilitation engineer	90200
Land rehabilitation supervisor	90201
Land rehabilitation worker	90299
Lasher / loader [n.e.c.]	29905
Laundry supervisor	80503
Laundry worker	80504
Leaching worker	30407

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Learner miner	20309
Learner official (assay / chemistry)	50409
Learner official (electrical engineering)	40303
Learner official (engineering) [n.e.c.]	40206
Learner official (geology)	50113
Learner official (mechanical engineering)	40403
Learner official (metallurgy)	30105
Learner official (mining)	20202
Learner operative	40208
Legal assistant	60603
Legal management	60600
Legal worker [n.e.c.]	60699
Librarian	60701
Library assistant	60702
Library management	60700
Library worker [n.e.c.]	60799
Lift operator	21306
Liquor outlet supervisor	80705
Lithographer	36010
Livestock worker [n.e.c.]	90599
Load haul dump driver	21106
Loader driver (rail)	21004
Loader driver (trackless)	21104
Loco driver (main line - SPOORNET)	81003
Loco driver (not main line)	81004
Loco driver (underground)	21002
Loco guard (underground)	21003
Longwall sheerer operator	20603
Magazine master	10317
Magnetometer specialist	50106
Maintenance supervisor	40653
Management accountant	10203
Marketing assistant	10812
Marketing officer	10810
Marketing and sales management	10800
Marketing / sales worker [n.e.c.]	10899
Mason	40626
Mason aide	40627
Masseur / masseuse	70308
Matron / nursing services management	70600
Mechanic (ocean)	40414
Maxillo-facial and oral surgeon	70402
Mechanical charge hand	40521
Mechanical engineer	40401
Mechanical engineering management	40400
Mechanical engineering worker [n.e.c.]	40599
Mechanical foreman (other) [n.e.c.]	40520
Mechanical rockbreaking worker [n.e.c.]	20699

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Mechanical technician	40410
Mechanical tradesman (other) [n.e.c.]	40522
Media technician	60908
Medical advisor	70001
Medical labourer	79901
Medical officer	70201
Medical orthoptist / prosthetist	70309
Medical physicist	70310
Medical specialist [n.e.c.]	70199
Medical station superintendent/first aid management	70800
Medical technician	70311
Medical technologist	70312
Medical worker [n.e.c.]	79999
Medical / health care management (multi-disciplinary)	70000
Medical / health care management [n.e.c.]	70099
Meshing and lacing team leader / supervisor	20803
Meshing and lacing worker	20804
Messenger / postal worker	11010
Metallurgical official [n.e.c.]	30103
Metallurgical worker [n.e.c.]	30199
Metallurgical / plant management	30000
Metallurgical / plant superintendent	30001
Metallurgical / plant supervisor	30002
Metallurgist	30101
Metallurgy technician (extractive)	30102
Microscopist	51006
Milling worker	30208
Millwright / electro mechanic / minewright	40437
Mine construction team leader / supervisor [n.e.c.]	21510
Mine construction worker [n.e.c.]	21599
Mine manager	00101
Mine overseer	20002
Mine planning / valuation engineer	20101
Mine police / security guard	80103
Mine production management [n.e.c.]	20099
Mine production supervisor [n.e.c.]	20399
Mine production worker [n.e.c.]	29999
Mine secretary (administration)	10900
Mine transport worker [n.e.c.]	21499
Miner (general)	20305
Mineralogist	50104
Miner's assistant (cheesa)	20504
Mining engineer [n.e.c.]	20201
Mining technical worker [n.e.c.]	20299
Mining technician [n.e.c.]	20210
Mixed farming worker [n.e.c.]	90699
Model maker	40103
Model maker (survey)	50205

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Money market dealer	11113
Monorail winch operator	21308
Monorope winch operator	21309
Motorman (ocean)	40543
Mortuary attendant	70313
Motor mechanic	40473
Motor mechanic apprentice	40474
Motor mechanic chargehand	40472
Motor mechanic foreman	40471
Motor / diesel mechanic operative	40479
Moulder	40504
Multi task worker (underground production)	20704
Multi task worker (opencast production)	20705
Musician	60905
Network technician (computers)	50515
Neurologist	70108
Night pusher (ocean)	29908
Neurosurgeon	70109
Night shift cleaner	20308
Nurse (charge / senior sister)	70601
Nurse (enrolled / staff)	70603
Nurse (registered all categories) [n.e.c.]	70602
Nursing assistant	70604
Nursing instructor	70698
Nursing services management/matron	70600
Nursing worker [n.e.c.]	70699
Occupational therapist	70314
Occupational health physician	70120
Occupational hygienist	70121
Offshore installation manager (ocean)	00101
Onsetter / banksman	21304
Operations research officer	50703
Operations / network operator (computers)	50507
Ophthalmologist	70110
Optical dispenser	70316
Optician / optometrist	70315
Oral hygienist	70501
Orderly / hospital worker	70324
Orepass / box controller	21404
Orthodontist	70403
Orthopaedic surgeon	70111
Orthoptist	70317
Paediatrician	70113
Painter and decorator / maintenance hand	40637
Painter and decorator (worker) [n.e.c.]	40638
Panel beater	40470
Paper maker	35911
Paper manufacturing management	35900

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Paper tester	35912
Pathologist (medical)	70112
Patternmaker	40503
Paver	40629
Paymaster	10404
Payroll administrator	10402
Payroll controller	10401
Payroll management	10400
Payroll worker [n.e.c.]	10499
PC programmer / product specialist	50517
Performing artist	60905
Periodontist	70404
Personal assistan t /secretary	10905
Personal care worker [n.e.c.]	80899
Personnel assistant / masiza	60102
Personnel management	60100
Personnel officer / practitioner	60101
Personnel worker [n.e.c.]	60199
Pharmaceutical worker [n.e.c.]	70799
Pharmacist	70701
Photographer	60906
Physiologist	70318
Physiotherapist	70319
Pilot (aircraft)	81103
Pipes and tracks team leader / supervisor	21505
Pipes and tracks worker	21506
Pit worker	20703
Planned maintenance foreman	40003
Planning management (engineering)	40100
Planning management (mining)	20100
Planning observer	20104
Planning officer	20102
Planning officer (engineering)	40101
Planning worker (engineering) [n.e.c.]	40199
Planning worker (mining) [n.e.c.]	20199
Plant team leader / supervisor	30204
Plant worker [n.e.c.]	30299
Plant / reduction official	30201
Plasterer	40628
Plastic surgeon	70114
Plater	40448
Plater / boilermaker	40447
Plater / boilermaker apprentice	40449
Plater / boilermaker chargehand	40446
Plater / boilermaker foreman	40445
Plater / boilermaker worker [n.e.c.]	40452
Plater / welder	40455
Plater / welder apprentice	40457

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Plater / welder chargehand	40454
Plater / welder foreman	40453
Plater / welder worker [n.e.c.]	40458
Plate / track layer/ganger (main line)	40656
Play school supervisor	60404
Plumber	40632
Plumber aide	40635
Plumber apprentice	40633
Plumber chargehand	40631
Plumber foreman	40630
Plumber operative	40634
Plumber worker [n.e.c.]	40636
Podiatrist/chiropodist	70320
Pool gang worker	09801
Postal worker / messenger	11010
Power hammer operator	40530
Press operator	40529
Pre-primary school assistant	60405
Printer [n.e.c.]	36011
Printing machine operator	36012
Printing management	36000
Printing supervisor	36001
Printing worker [n.e.c.]	36099
Process controller	30203
Producer / director (creative arts)	60900
Production / section / underground manager	20001
Productivity officer	50705
Project manager (administration / financial) [n.e.c.]	19992
Project manager / officer (agriculture) [n.e.c.]	99992
Project manager / officer (engineering) [n.e.c.]	49992
Project manager / officer (general management) [n.e.c.]	09992
Project manager / officer (humanities) [n.e.c.]	69992
Project manager/officer (medical/health) [n.e.c.]	79992
Project manager/officer (mining) [n.e.c.]	29992
Project manager / officer (reduction / beneficiation / manufacturing)	39992
Project manager / officer (scientific / technical) [n.e.c.]	59992
Project manager / officer (services) [n.e.c.]	89992
Property broker	10601
Property / mining rights management	10600
Property / mining rights officer	10602
Property / mining rights worker [n.e.c.]	10699
Prospector	50107
Prosthetist / Orthotist	70309
Prosthodontist	70405
Psychiatrist	70115
Psychologist (clinical)	60501
Psychologist (industrial)	60104
Public relations assistant	60803

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Public relations management	60800
Public relations officer	60801
Public relations worker [n.e.c.]	60899
Pulveriser / grinderman	30210
Pump team leader / supervisor	40531
Pump worker	40532
Pupil metallurgist	30104
Purchaser / buyer	10312
Purchasing / stores management	10300
Quantity surveyor	40613
Quarryman	20307
Radio / medic (ocean)	79999
Radio mechanician	40327
Radio operator	11012
Radiographer	70321
Radiologist	70116
Rail transport management	81000
Rail transport officer	81001
Rail transport team leader	81002
Rail transport worker [n.e.c.]	81099
Raise / tunnel borer operator	20607
Raise / tunnel borer supervisor	20606
Receiver (stores)	10313
Receptionist/typist/word processor operator	10906
Records / filing officer	10904
Reduction / beneficiation / manufacturing management [n.e.c.]	30099
Reduction / beneficiation / manufacturing worker [n.e.c.]	39999
Reduction / plant official	30201
Reeler	21403
Refiner	30601
Refining worker [n.e.c.]	30699
Refrigeration plant operator	40415
Refrigeration plant team leader / supervisor	40414
Refrigeration / air conditioning engineer	40412
Refrigeration / air conditioning mechanic	40413
Refuse collector	40906
Registrar (medical)	70202
Rescue training service management	80200
Rescue / firefighting officer	80202
Rescue / firefighting team leader/supervisor	80203
Rescue / firefighting trainer	80298
Rescue / firefighting worker [n.e.c.]	80299
Researcher (agriculture) [n.e.c.]	99997
Researcher (engineering) [n.e.c.]	49997
Researcher (general management) [n.e.c.]	09997
Researcher (humanities) [n.e.c.]	69997
Researcher (medical) [n.e.c.]	79997
Researcher (metallurgy / beneficiation / manufacturing) [n.e.c.]	39997

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Researcher (mining production) [n.e.c.]	29997
Researcher (rock mechanics)	50397
Researcher (scientific / technical) [n.e.c.]	59997
Researcher (service occupation) [n.e.c.]	89997
Rigger and ropeman	40508
Rigger and ropeman apprentice	40509
Rigger and ropeman chargehand	40507
Rigger and ropeman foreman	40506
Rigger and ropeman worker [n.e.c.]	40511
Rigger aide	40510
Road builder	40655
Road transport management	80900
Road transport officer	80901
Road transport team leader	80902
Road transport worker [n.e.c.]	80999
Rock breaking worker [n.e.c.]	20799
Rock mechanics engineer	50301
Rock mechanics management	50300
Rock mechanics officer	50302
Rock mechanics worker [n.e.c.]	50399
Rock support worker [n.e.c.]	20899
Roof bolt machine operator	20806
Roof bolt worker	20807
Roughneck (ocean)	29909
Roustabout (ocean)	81201
Rubber reliner	40523
Safety / loss control auditor	50802
Safety / loss control management	50800
Safety / loss control observer assistant	50803
Safety / loss control officer	50801
Safety / loss control worker [n.e.c.]	50899
Sales representative	10811
Salvage yard aide	10319
Salvage and reclamation worker (surface)	10320
Salvage and reclamation worker (underground)	29907
Sample worker	50204
Sampler	50203
Sanitation worker	40904
Saw doctor	40540
Saw sharpener	40542
Sawmill mechanic	40541
Sawyer	35710
School principal	60401
Scientific / technical management (multi-disciplinary)	50000
Scientific / technical management [n.e.c.]	50099
Scientific / technical worker [n.e.c.]	59999
Scraper winch bell operator	20902
Scraper winch driver	20901

OCCUPATION	CODE
Scraping worker [n.e.c.]	20999
Screensman	30209
Sea transport worker [n.e.c.]	81299
Secretarial / administrative worker [n.e.c.]	10999
Secretarial / administration management	10900
Secretary / personal assistant	10905
Section leader	29901
Section / production/underground manager	20001
Securities officer	11112
Security guard / mine police	80103
Security inspector / officer	80101
Security management	80100
Security supervisor (e.g. sergeant)	80102
Security worker [n.e.c.]	80199
Sedimentologist	50105
Seismic network technician	50306
Seismologist	50305
Self-propelled machine driver [n.e.c.]	21107
Service worker [n.e.c.]	89999
Services management (multi-disciplinary)	80000
Services management [n.e.c.]	80099
Sewage plant operator	40903
Shaft foreman	20301
Shaft sinker	21501
Shaft timberman worker	21503
Shaft timberman/timberman	21502
Shakerhand (ocean)	29909
Share transfer officer	11111
Sheetmetal worker	40459
Shift boss	20302
Shot blast operator	40526
Shotcrete worker	20804
Shovel operator	21105
Shunter	81007
Shuttlecar driver	21108
Signaller	81008
Signwriter	40639
Skipman	21303
Slimes dam team leader / supervisor	30704
Slimes dam worker	30705
Slimes dam / dump worker [n.e.c.]	30799
Smelter	30501
Smelter team leader/supervisor	30502
Smelter worker	30503
Social worker	60502
Solicitor/attorney/conveyancer	60602
Sorter	30206
Spannerman / driller's assistant	20405

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Spectrographer	50407
Speech therapist/audiologist	70322
Sports worker [n.e.c.]	61099
Sports / recreation assistant	61002
Sports / recreation management	61000
Sports / recreation officer	61001
Stable hand / herdsman	90502
Stacker operator	21402
Stage worker	21509
Standards officer	10311
Statistical officer	50602
Statistical worker [n.e.c.]	50699
Statistician	50601
Statistics management	50600
Stevedore	81201
Stockbroker	11110
Stoker / fireman	81005
Stone packer	29904
Stope team leader / supervisor	20311
Stope team worker	20702
Stoper	20304
Storekeeper	10314
Stores controller	10310
Stores issuer (non-explosive)	10316
Stores receiver	10313
Stores worker [n.e.c.]	10399
Stores / purchasing management	10300
Strata control observer	50304
Strata control officer	50303
Strategic planning analyst	00201
Strategic planning management	00200
Strategic planning worker [n.e.c.]	00299
Stripper operator	30408
Student (administrative / financial) [n.e.c.]	19993
Student (agriculture) [n.e.c.]	99993
Student (engineering) [n.e.c.]	49993
Student (geology)	50193
Student (humanities) [n.e.c.]	69993
Student (medical)	79993
Student (metallurgy / beneficiation / manufacturing) [n.e.c.]	39993
Student (mining production) [n.e.c.]	29993
Student (scientific / technical) [n.e.c.]	59993
Student (service occupation) [n.e.c.]	89993
Supervisor's assistant (underground)	29902
Supplementary medical worker [n.e.c.]	70399
Surgeon (general)	70117
Survey management	50200
Survey worker [n.e.c.]	50299

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OCCUPATION	CODE
Surveyor (land)	50201
Surveyor (mine)	50202
Sweeper / vamper	29903
Systems accountant	10203
Systems analyst	50504
Systems/network programmer	50512
Tailor	34510
Tea maker / office cleaner	80402
Teacher (nursery education)	60404
Teacher (primary education)	60403
Teacher (secondary education)	60402
Team leader / supervisor (other mining production work)	20312
Technical assistant engineering [n.e.c.]	40204
Technical assistant mining [n.e.c.]	20211
Technical services management	50001
Technical services department (TSD) officer [n.e.c.]	59901
Telecommunications worker [n.e.c.]	11099
Telephonist	11011
Television cameraman	60907
Thoracic surgeon	70118
Timber, pulp and paper worker [n.e.c.]	35999
Timekeeper	10403
Tip team leader / supervisor	21405
Tip worker	21406
Toolmaker	40512
Toolpusher (ocean)	20312
Tour guide	60804
Town planner	40612
Tracer [n.e.c.]	49994
Trackless machine team leader / supervisor	21101
Trackless machine trainer (e.g. dragline)	21198
Trackless machine worker [n.e.c.]	21199
Track/plate layer / ganger (main line)	40656
Train guard	81006
Trainer (administrative / financial) [n.e.c.]	19998
Trainer (agriculture) [n.e.c.]	99998
Trainer (chemical engineering)	40798
Trainer (civil engineering)	40698
Trainer (computers)	50598
Trainer (crane driving)	81398
Trainer (electrical engineering)	40398
Trainer (firefighting / rescue)	80298
Trainer (first aid)	70898
Trainer (general engineering) [n.e.c.]	49998
Trainer (general management) [n.e.c.]	09998
Trainer (humanities) [n.e.c.]	69998
Trainer (mechanical engineering)	40598
Trainer (medical) [n.e.c.]	79998

OCCUPATION	CODE
Trainer (metallurgy / beneficiation / manufacturing) [n.e.c.]	39998
Trainer (mining production) [n.e.c.]	29998
Trainer (nursing)	70698
Trainer (road driving)	80998
Trainer (safety / loss control)	50898
Trainer (scientific / technical) [n.e.c.]	59998
Trainer (security)	80198
Trainer (service occupation) [n.e.c.]	89998
Trainer / instructor [n.e.c.]	60398
Training assistant	60302
Training management	60300
Training officer [n.e.c.]	60301
Training worker [n.e.c.]	60399
Translator	60903
Transport worker [n.e.c.]	81399
Tribal representative/induna	60203
Typist / word processor operator / receptionist	10906
Unclassified occupation (unknown / no specific skill)	09999
Typist / word processor operator / receptionist	10906
Underground / production/section manager	20001
Uranium plant official	30401
Urologist	70119
User support (computers)	50518
Valuator	10510
Waiter / waitress	80704
Water, effluent and sanitation management	40900
Water, effluent and sanitation officer	40907
Water, effluent and sanitation team leader / supervisor	40901
Water treatment operator	40902
Weighbridge attendant	10395
Welder	40456
Welfare assistant	60504
Welfare officer	60503
Welfare worker [n.e.c.]	60599
Winch operator \ driver	40526
Winch transporter team leader	40525
Winch transporter / erector	40524
Winding engine driver (licensed)	21301
Wireline operators (ocean)	20406
Word processor operator / typist / receptionist	10906
Work study observer/assistant	50707
Work study officer	50706
Wrapper	35913
Writer / journalist	60902
Yard supervisor	10318
Yard worker [n.e.c.]	10321

** [n.e.c]. is used to indicate 'not elsewhere classified'*

ANNEXURE 2: Mandatory occupational hygiene thermal stress reporting forms

HEAT STRESS EXPOSURE REPORT FORM 21.9(2)(C)

Main commodity code:						DMRE mine code:	
Sampling/measurement area:	Surface	☐	Underground	☐		Sub-mine code:	
Activity area:	Activity area name:		Activity area code:			Reporting period:	
	Q1	**Q2**	**Q3**	**Q4**		Start:	End:
Heat environment classification: (based on the 90th percentile of the most significant parameter)							

THERMAL: HEAT ENVIRONMENT			Parameter	Number of measurements taken per parameter	Mean dose allocated to medical records (for each parameter)	90th percentile of each parameter (for heat environment classification)	Occupational exposure limit/Standard (for each parameter)	Significant parameter used for classification (tick relevant parameter)
Occupation codes	Occupation descriptions	Number of persons per occupation						
			Wet bulb (WB) ˚C					
			Dry bulb (DB) ˚C					
			Globe (GT) ˚C					
			WBGT index					
COMMENTS ON:								
Reasons for over-exposures								
Corrective measures that will be implemented to prevent/mitigate over-exposure								

COLD STRESS EXPOSURE REPORT FORM 21.9(2)(D)

Main commodity code:				
Sampling/measurement area:	Surface	☐	Underground	☐
Activity area:	Activity area name:		Activity area code:	
	Q1	Q2	Q3	Q4
Cold environmental classification: (based on 10th percentile of the most significant param				

DMRE mine code:	
Sub-mine code:	
Reporting period:	
Start:	End:

THERMAL: COLD ENVIRONMENT							
Occupation codes	Occupation descriptions	Number of persons per occupation	Cold stress parameter	Number of measurements taken	Mean dose allocated to medical records	10th percentile cold environment classification	Occupational exposure limit
			Wind chill equivalent temperature °C				
COMMENTS ON:							
Reasons for over-exposures							
Corrective measures that will be implemented to prevent/mitigate over-exposure							

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ANNEXURE 3: 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 surface of the earth 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.
- 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. WBGT

The **WBGT index** requires knowledge of the natural **WB** (t_{nwb}), the **GT** (t_g), and the **DB** air temperature (t_a). The **WBGT** is calculated for indoor exposure, or for outdoor exposure, with no solar or **radiant heat** source.

For exposure without a **radiant heat** source:

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

For exposure with a **radiant heat** source:

$$\mathbf{WBGT = 0.7t_{nwb} + 0.2t_g + 0.1t_a}$$

CONTINUES ON PAGE 130 OF BOOK 2

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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:

$$\text{Average } \mathbf{WBGT} = \frac{(\mathbf{WBGT}_1) \times (T_1) + (\mathbf{WBGT}_2) \times (T_2) + \ldots + (\mathbf{WBGT}_n) \times (T_n)}{(T_1) + (T_2) + \ldots + (T_n)}$$

In the above equation, $\mathbf{WBGT}_1$, $\mathbf{WBGT}_2$ and $\mathbf{WBGT}_n$ 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 4: Cold stress management
*(For information only, abstract from **ACGIH** booklet)*

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. The 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 a coma and death if not treated quickly. Victims with 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 usually 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 a fall in the deep core temperature of the body. The clinical presentations of victims of hypothermia are shown in Table 1: Progressive clinical presentation of hypothermia below. 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 the 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, and 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 (W/m^2), which is a function of the air temperature and wind velocity upon the exposed body.

A greater insulation value of the protective clothing is required when the wind speed is higher and the temperature in the work area is lower. An **ECT** chart relating the actual dry bulb air temperature and the wind velocity is presented in Table 2: Cooling power of wind on exposed flesh as equivalent temperature below. The **ECT** 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 the 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 will depend on 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 non-reactive 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.

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

CORE TEMPERATURE °C	CLINICAL SIGNS
9	Lowest artificially cooled hypothermia patient to recover.

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

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

	ACTUAL TEMPERATURE (°C)								
ESTIMATED WIND SPEED (in kp/h)	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.

ECT 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 the temperature results in an **ECT** of -32°C. Superficial or deep local tissue freezing will occur at temperatures below -1°C regardless of wind speed.

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

TLVs recommended for properly clothed workers for periods of work at temperatures

below freezing are shown in Table 3: **TLVs** work / warm-up schedule for four-hour shifts.

Special protection for 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 and -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 it 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 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 the clothing of the worker may become wet on the job site, the outer layer of the clothing 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 wet. 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 the 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 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 **ECT** or at a temperature 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 will depend 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 to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the **cold environment**. It 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 the safety and health procedures.

The training programme should include as a minimum, instruction on:

- 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)	Maximum work period	Number of breaks	Maximum work period	Number of breaks	Maximum work period	Number of breaks	Maximum work period	Number of breaks	Maximum work period	Number 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		30 mins	5						
-40 to -42	30 mins	5								
-43 and below										

Notes for TABLE 3:

(i) The schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods of ten minutes in a warm location and with an extended break (e.g. 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 four breaks in a 4-hour period (step 5).

(ii) 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 1 750 W/m^2.

(2) All non-emergency work should have ceased at, or before a wind chill of 2 250 W/m^2.

In general, the warm-up schedule provided above slightly under-compensates for the wind at 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.

(iii) **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 workers 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 **DB** should be measured and recorded at least every four hours.

(c) In indoor workplaces, the wind speed should also be recorded at least every four hours whenever the rate of air movement exceeds 2 m/s.

(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 **ECT** should be obtained from Table 2: Cooling power of wind on exposed flesh as equivalent temperature, in all cases where air movement measurements are required. It should be recorded with the other data whenever the **ECT** is below -7°C.

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

4.2. Medication that may affect thermoregulation

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

- The hypothalamus, which sets normal body temperature.
- Heat perception, leading to behavioural change (heat avoidance).
- Changes in cardiac output or 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 (e.g. ecstasy).
- Antihistamines commonly used for colds and flu.
- Diuretics.
- Beta-blockers.
- Anti-epileptics.
- Anti-spasmodic for stomach cramps.

Workers who are routinely exposed to temperatures below -24°C with wind speeds of less than less than 8,05 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 **HSM** and **CSM** 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 **DB** and air velocity to determine equivalent chill factor.	Implement **CSM**.	Discontinue **CSM**. Monitor **DB** and **WB**.	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 **DB** and air speed for the determination of the wind-chill factor (regulation 9.2(2) of the **MHSA** and refer to **ACGIH**). A system of monitoring, including its derivation, is outlined below.

5.2. Basic considerations

The **ACGIH** interpretation of the **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 one hour.
- < -30°C (**ECT**) : Increasing danger, exposed flesh may freeze in one minute. (final category omitted as being unrealistic for South African conditions)

An air speed of 8km/h (about 2m/s) and above should be regarded as critical in changing the **ECT** from a 'no risk' to a 'risk' category (**ACGIH**). Even at a **DB** of 10°C, an air speed of 16km/h (about 4,5m/s) and above could depress the **ECT** to critical levels. Air speeds on excess of 65km/h have little additional effect.

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

- < 18°C **DB** : '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:
DB as supplied by the weather bureau (confirm relevance and accuracy), or any other direct measurement if more applicable.

5.3.2. **DB** < 18°C (as per weather bureau):
Measure and record **DB** representative of critical workstations (**ACGIH**: < 16°C).

5.3.3. **DB** < 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.

ANNEXURE 5: Heat stress management
(For information only)

1. INTRODUCTION

By definition, **HSM** 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 **HSM** does however suggest the need for instituting some form of central co-ordination, a function that certainly can be delegated.

HSM consists of two essential elements, namely:

- The detection of medical and physical contraindications for work in heat, as well as gross or permanent heat intolerance by means of appropriate screening procedures; and

- The natural progression of heat acclimatization based on safe work practices.

An organizational framework for the control of **HSM** 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 organization is seen as an essential first step in the implementation process.

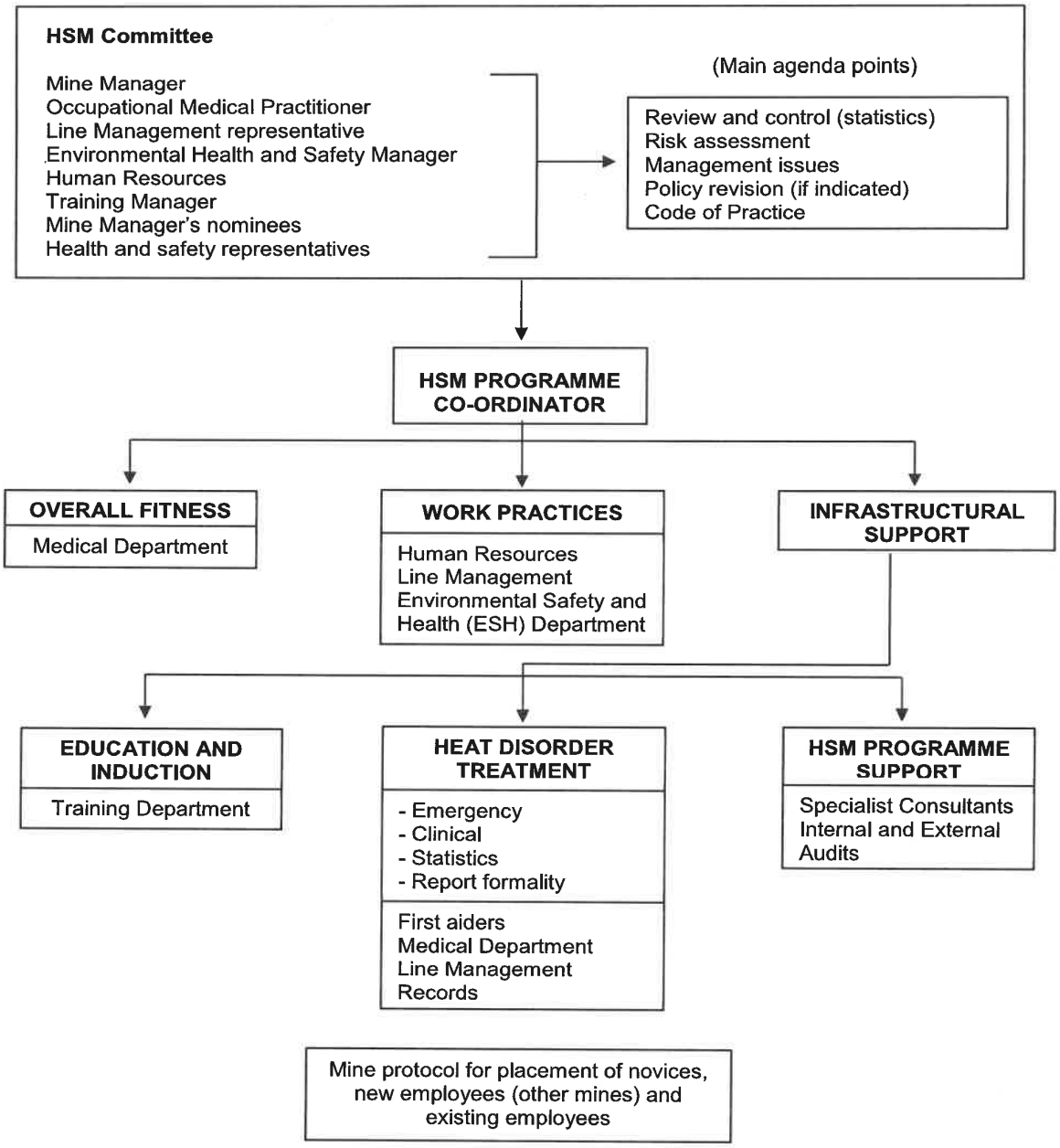
1.1. Functional organisation

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

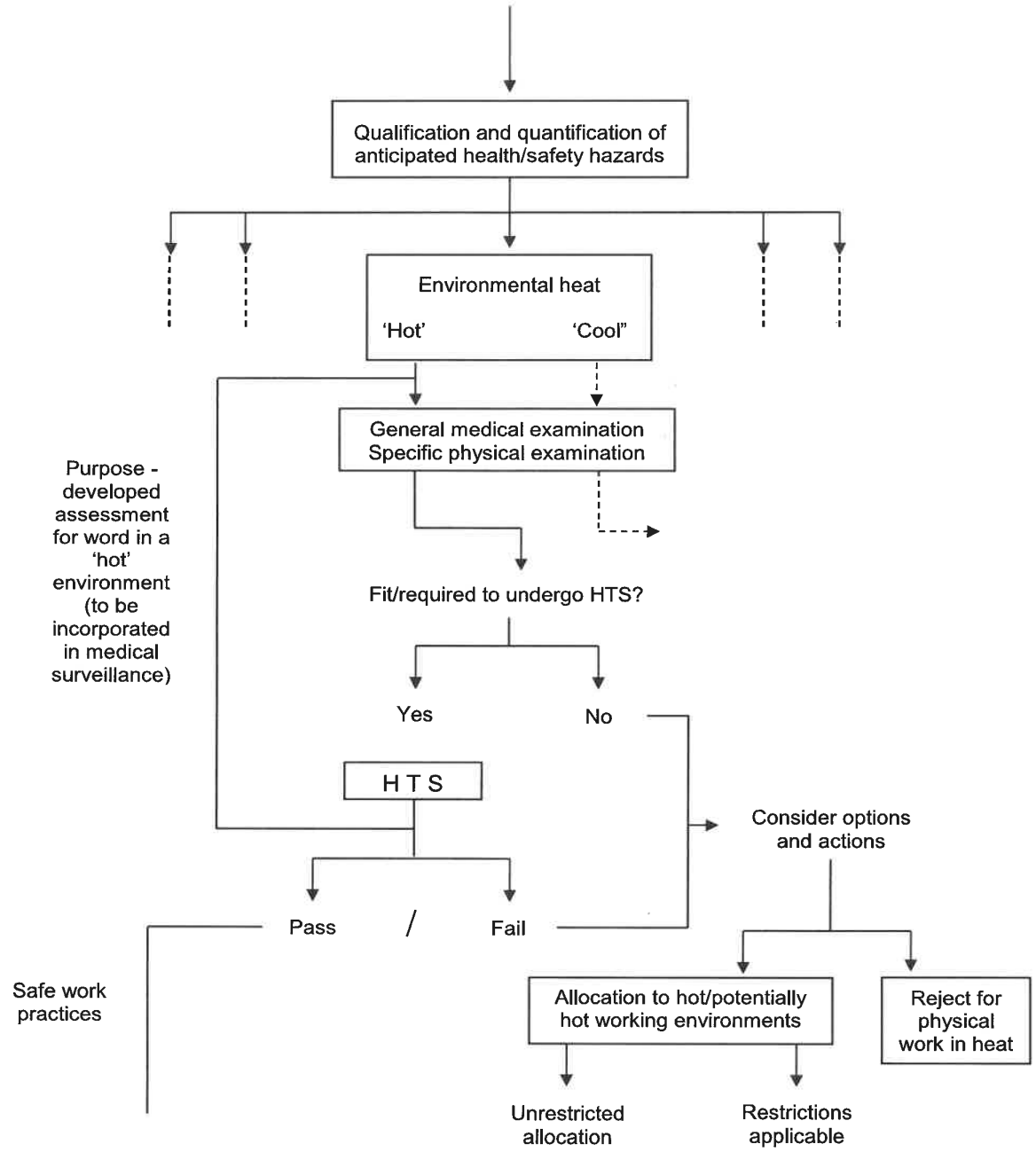
Having established a structural organization, the second step would be to ensure, as indicated above, that responsibilities are defined, and assigned to appropriate personnel and departments, and that effective inter-departmental communication links be established. This is one of the key responsibilities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

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

OVERALL CONTROL OF HSM



OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS



ANNEXURE 6: Medical/physical examinations (overall fitness for work in **hot environments**)
(For information only)

This annexure is an extract from the SIMRAC Project Report GAP 505

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 W/m^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 that 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.
- 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.

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1.1.1 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.
- Heat disorders (cramps, exhaustion, stroke).

1.1.2 Urinalysis

- Origins of haematuria, proteinuria and glycosuria should be established and assessed.

1.1.3 The examination should exclude

- Jaundice.
- Anaemia.
- Cyanosis.
- Clubbing.
- Oedema.
- Abnormal lymph nodes.
- Febrile disease.

1.1.4 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.

1.1.5 The skin should be intact with no infections such as advanced athlete's foot, cellulitis, scabies, etc.

1.1.6 Respiratory function, as determined by spirometry and chest X-ray, should be normal.

1.1.7 Ear, nose and throat examination should exclude inflammation or infection (tonsilitis, pharyngitis, chronic suppurative otitis media, etc.).

1.1.8 No organomegaly or hernias should be present.

1.1.9 Gross neurological examination should be normal.

1.1.10 No other abnormality that may compromise physical work in heat should be present.

OMPs 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

A person's age does not have a direct bearing on heat tolerance and should not serve as a contra-indication to work in **hot environments**. Heat intolerance does however decline with reduced physical work capacity which in turn could have cardiovascular origins, that do not necessarily become manifested through routine medical examination. 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 categorize 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 (e.g. congenitally acquired) or injury (e.g. amputations or joint malfunction) should be recorded. Where, in the opinion of the **OMP**, 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.
- Totally unfit for any form of physical work.

1.2.3 Body dimensions

In this respect, three 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 **BMI** (Ross et al, 1988).
- 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, e.g. hypertension, cardiovascular disease, dyslipidaemia, adult-onset diabetes (type II), sleep apnea, osteoarthritis and other conditions.

The above examples constitute a condition of co-morbidity, i.e. 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:

$$\textbf{BMI} = \text{body mass (kg)} / \text{height (m)}^2$$

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.

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TABLE 1: Body dimensions as criteria for physical work in **hot environments**

EMPLOYEE STATUS	CRITERION/STANDARD	INTERPRETATION AND RECOMMENDED COURSE OF ACTION
Prospective (novice[1])	Body mass <50 kg	Unsuitable (**BMI** irrelevant): reject
	Body mass 50-55 kg	Suitable but not for strenuous work[2]
	BMI 15-29	Suitable
	BMI 30-35	Suitable with no medical contraindications
	BMI >35	Unsuitable: reject
Existing	Body mass <45 kg	Unsuitable (**BMI** irrelevant): reject
	Body mass 45 - 50 kg	Suitable with no medical contraindications or a history of heat disorders
	Body mass 45 - 55 kg	No allocation to strenuous work (>160 W/m^2)
	BMI <15	Unsuitable[3]
	BMI 15-19	Suitable with no medical contraindications or history of heat disorders
	BMI 20-29	Suitable
	BMI 30-35	Suitable provided no medical contraindications or history of heat disorders
	BMI >35	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 2: **BMI** as function of body mass and height

BODY MASS INDEX
Mass (kg)

	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	29	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

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BODY MASS INDEX
Mass (kg)

	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	24	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)

	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, e.g. 1.75), conducting the initial screening using only body mass, i.e. <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**.

- Flagging screened employees with a body mass of (55 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 **WB** have been amply demonstrated in the 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 database 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 database as proposed here.

1.3.1 Employee risk profile

Based on 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 contraindications, i.e. a particular condition, treatment or even a medical history likely to lead to a critical job-related reduction in heat tolerance.

- Age (50 years) with full-shift exposures to strenuous work in heat.

- Obesity (**BMI** 30).

- Heat intolerance, i.e. a chronic inability to complete **HTS** successfully.

- Strenuous work per se.

- 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 acclimatization for a particular job, exposure time and environmental heat load. Medical surveillance should be sufficiently sensitive to identify such employees and the **OMP** 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 based on 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.
- 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 1.2: Employee risk profile matrix

PRIMARY RISK FACTOR[1]	SECONDARY RISK FACTOR[1]					
	Medical contra-indication[2]	Age >50 plus strenuous work	BMI ≥30	Heat intolerance	Strenuous work	History of heat disorders
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 contraindications 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 **OMP'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 (e.g. gold) and 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.

- 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).
- Water availability.

*(*obtain this history from work or close companions and supervisors)*

• Signs and symptoms:

- Behavioural.
- Subjective complaints.
- Physical signs.
- Body temperature (oral or rectal, time of first recording).

• Treatment (emergency or initial treatment)

- Recognition (correct or incorrect).
- Nature of treatment.
- Details of further events and recordings (include formal medical assistance).
- Add clinical or 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 7: Heat tolerance screening
(For information only)

Definitions and acronyms

'HTS' means Heat tolerance screening.

'HTT' means heat tolerance test; i.e. a one-hour **HTT** 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 **HTS** is to identify gross or inherent heat intolerance (i.e. 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 **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 acclimatization was needed. It should, therefore, be clear that **HTS** has an entirely different purpose, namely it provides an assessment of risk.

1.2. Interpretations

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.
- The absence of any abnormal response during or at the end of the test, e.g. collapse, vomiting, headache and lack of co-operation.

1.2.1. Potentially heat tolerant

Any person whose oral temperature does not exceed 37.6°C (i.e. should be ≤.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 will be able to acclimatise successfully with regular exposure.

1.2.2. Grossly heat intolerant

Individuals with oral temperatures in excess of 37.6°C (i.e. should be ≤ 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 the discretion of management, 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 **COP**. 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 their 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 (e.g. from a few hours to a full shift).

1.3.2. Frequency of **HTS**

The frequency of **HTS** will be determined by the outcome of the routine medical and physical assessments, as described in sections 1.1 and 1.2 of Annexure 5: Heat stress management. 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, would be required to repeat the **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 **OMP**. 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, the frequency of **HTS** could be relaxed provided that 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 heat stroke, even if only a single incident.

With regard to failure of the **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 the **HTS**, the following protocol is recommended:

a) 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, e.g. 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.

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

Based on the 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 formalized.
- The employee accepts that the future occurrence of any heat disorder may render him/her unfit for any form of work in **hot environments**.
- The employee is not allocated to strenuous work categories, i.e. those falling within a work rate range of 160 W/m^2. In this regard, refer to tables 1.1 and 1.2 of Annexure 8: Work practices: Surface, opencast and underground operations to 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 Annexure 8: Surface, opencast and underground operations for information only.

- 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, which implies dedicated formal supervision.

Full details of formal supervision and safe work practices are provided in Annexure 8: Surface, opencast and underground operations.

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.

- Independent audits also based on unsatisfactory internal audits.

2.2. Supervisors' credentials

Supervisors should be in possession of a certificate issued by a recognized training authority. In the past these certificates were issued by the Minerals Council 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 **HSM** 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 parts per million) or potassium permanganate solution (1g per 10ℓ of water).

3.4. Thermometers

Thermometers should be disinfected by total immersion in a container of freshly prepared sodium hypochlorite solution (2 000 parts per million) 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 re-use.

Where re-checks are necessary, only freshly disinfected thermometers should be used. At no time should a thermometer be re-used without having remained in a 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°C ± 5.0°C by means of a master mixer. After showering, each employee 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 re-use.

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 000parts per million) is recommended for disinfecting the floor, concrete stepping beams and walls.

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

3.8.2. Restroom

Sodium hypochlorite may cause corrosion of metal objects, e.g. urinals and taps. For these applications disinfectant soap should be used in rest rooms.

3.9. General maintenance

3.9.1. Condition of floor and walls

Uneven surfaces and cracks should be repaired as soon as possible. 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, e.g. 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 of 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°C ± 2.0°C **DB**; < 20.0°C **WB**). 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 acclimatization, 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 sterilized.

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 re-admitted 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 **DB** of 29.5°C and a **WB** 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 **WB** of 28.0°C, with a maximum permissible range of 27.7°C to 28.5°C. Corrective action should therefore be initiated as soon as the temperature deviates from 28.0°C **WB**, and not only once the permissible range is exceeded. The optimum difference between the **DB** and **WB** is 1.5°C. The **DB/WB** 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 employees 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 employees step. This should be confirmed during monthly inspections by the environmental control departments 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 80W (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.
- 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 temperatures, which is recorded at the end of the 30-minute bench-stepping exercise. Thermometers should

be issued on an individual basis, and sterilized at the conclusion of the assessment.

The thermometer bulb should be placed under the tongue, 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 employees should sit on the stepping beam to minimize post-exertional syncope ('black-out') and to minimize 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.

OCCUPATIONAL HEALTH PROGRAMME ON THERMAL STRESS

ANNEXURE 8: Work practices: Surface, opencast and underground operations
(For information only)

1. RATIONALE FOR WORK PRACTICES

Within the context of **HSM**, no form of heat acclimatization 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 acclimatization. Special precautions are indicated with the rationale 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 **HSM** (Table 1.1).

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

FACTOR	PREVALANCE	
	n	%
Strenuous work[1]	82	85
▪ Atypical[2]	19	20
▪ Lashing	19	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
▪ WB > 32.5°C	21	22
▪ dB > 37.0°C	6	6
TOTAL		**215**

[1] These categories exhibit the highest mean metabolic rates of mining tasks and on average exceed 160 160 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 (**DB** >37.0°C, **WB** >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, through either voluntary restrictions or the non-availability thereof. Moreover, alcohol-induced dehydration has been implicated in more than 30% 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 **DB** exceeds 37.0°C or the **WB** 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 in Table 1.2 below.

2. HEAT ACCLIMATISATION AND ITS RETENTION: IMPLICATIONS FOR HSM WORK PRACTICES

The degree of heat acclimatization 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 acclimatization process in order to ensure that all precautions are in place and observed.

Secondly, under controlled conditions full heat acclimatization can be achieved within less than a week. Conversely, a substantial and critical loss of heat acclimatization 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 acclimatization may remain suboptimal. Under such circumstances, or where the slightest risk of incomplete heat acclimatization exists, it follows that recommended work practices should be retained permanently.

TABLE 1.2: Framework for HSM work practices based on 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. In addition, there can be no justification for relaxing work practices simply on the outdated notion that full heat acclimatization confers immunity against heat disorders. Work practices applicable to the formality of heat acclimatization are equally applicable once an adequate degree of heat acclimatization has been achieved.

The only dispensation is that the need for close supervision could be lessened and even discontinued for routine work. Informal supervision can be established through good education and awareness retention monitoring, for example through the so-called buddy system and self-care, which is a requirement under the **MHSA**.

Finally, while employees routinely exposed to work in heat on a day-to-day basis, are likely to develop significant levels of heat acclimatization, some will remain unacclimatized 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 their status or seniority, should only be permitted to do so under close supervision and while adhering fully to mine standards or **COPs**.

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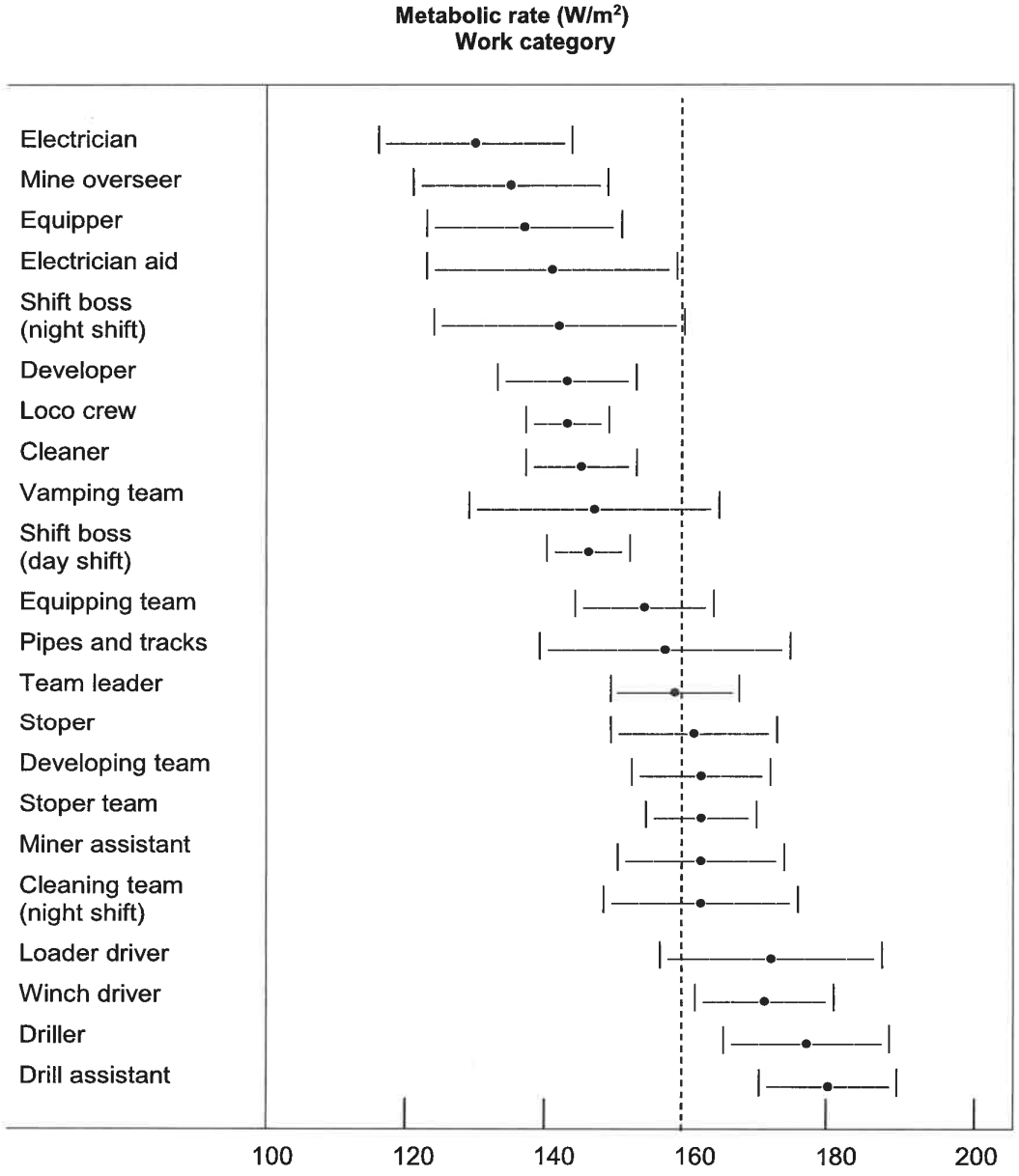
FIGURE 1.1: Metabolic work rates with 95% confidence limits related to conventional mining work categories



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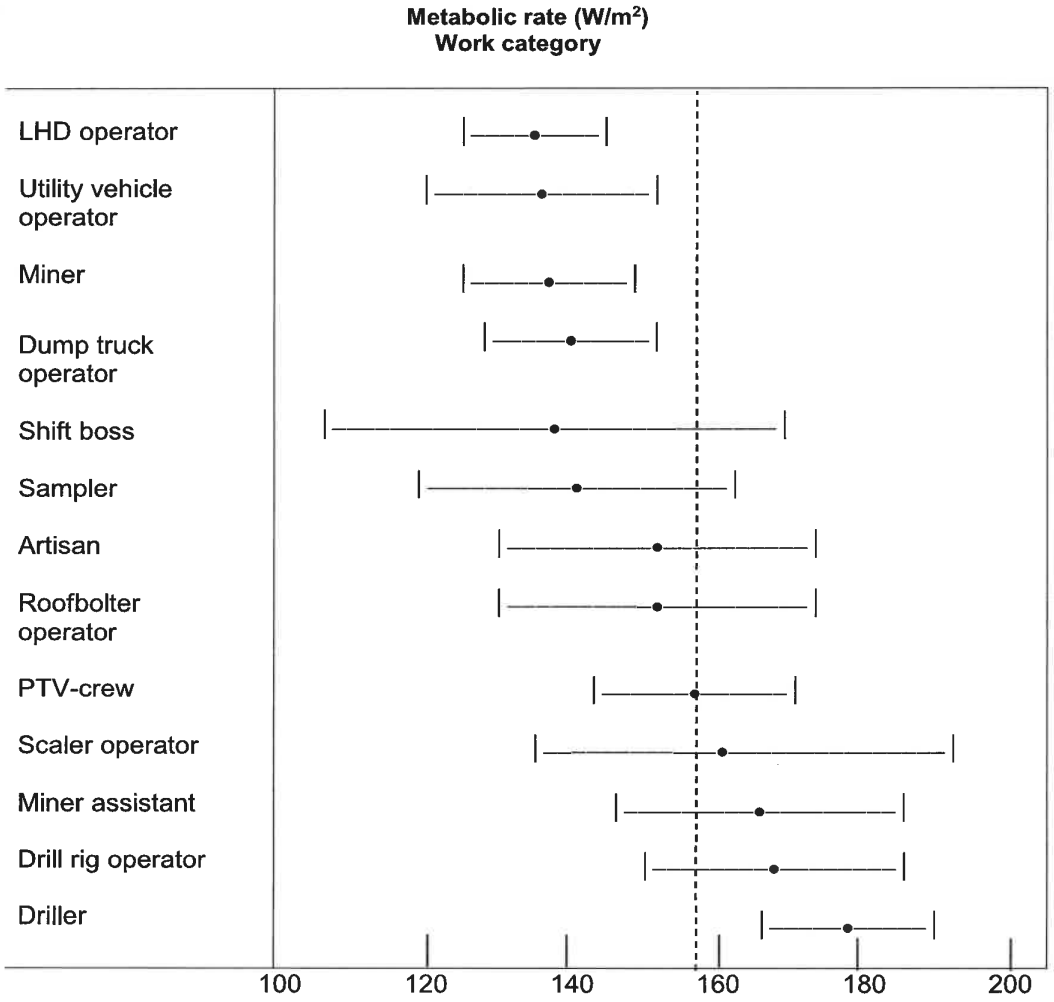


3. SAFE WORK PRACTICES AND SUPERVISION

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 acclimatization, irrespective of the precise circumstances necessitating heat acclimatization.

  - 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/her duties, and who has been medically and physically cleared to do so.

- 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 acclimatization, 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 **WB** and **DB** 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 for 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 (e.g. 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 two x 250-300ml 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.

- 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, e.g. American nuclear power plants, subscribe to a programme of progressive exposure to achieve heat acclimatization. For example, the permissible exposure on the first day is limited to 50% of a full shift exposure, and on successive days, respectively to 75% and 90% (Bernard et al, 1986).

ANNEXURE 9: Absenteeism from routine work in **hot environments**
(For information only)

1. 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.

    - Absenteeism due to illness or injury.

With regard to the former, the general recommendation is that the employee bypasses **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 Annexure 6: Medical/physical examination). 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. In addition, 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 the overall physical fitness for work in heat.

ANNEXURE 10: Water and nutritional requirements during work in heat
(For information only)

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 because 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 (e.g. 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% of body mass, i.e. at water deficits as low as 0.7ℓ in a 70kg 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 that 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, because of dehydration.

Under conditions designed to simulate moderate work in a mining environment, typical fluid losses because of sweating could approach 1ℓ 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 500ml 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, i.e. sweat.

Sweat is watery fluid that 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 g 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:

1) Sweat has the same composition as body fluids (i.e. the same tonicity) and fluid replacement should consequently be achieved by so-called isotonic beverages.

2) 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 and it can be stored in vast quantities e.g. as in obese individuals. In contrast, carbohydrates are poorly stored (about 0.5% to 1.0% of body mass), but have the decided advantage of being able to sustain intense short-term activity. While neither fat nor carbohydrates are 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 physiologically deleterious. Impaired work performance is therefore attributed to carbohydrate depletion as a result of a 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.

(c) A mid-shift feed comprising an acceptable tasty fluid meal containing mainly carbohydrate. An added benefit of the latter is that it also serves 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 11: Emergency work in **abnormally hot environments** - underground
(For information only)

1. INTRODUCTION

Where **WB** exceed 32.5°C, no routine work should be undertaken and only emergency work, essentially directed at re-establishing an acceptable **thermal environment**, should be undertaken.

This annexure is intended to provide a framework for the formulation of guidelines for the protection of employees who, because 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 and is based on the findings of **SIMRAC** project GAP 045.

2. APPLICATION OF THIS ANNEXURE

Operations normally covered by mines' **COP** dealing with work in conditions conducive to heat stroke are excluded because such work is deemed 'routine' work. These guidelines apply to emergency (non-routine) work only and embrace all mines, including those generally held to be 'cool' (i.e. **WB** of < 27.5°C with the **DB** not exceeding 37.0°C) and where the prescriptions of regulation 9.2(1) of the **MHSA** 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 the 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 a degree of flexibility required to translate controlled laboratory simulations into the practical application. Therefore, in the interest of practicability and convenience, slight discrepancies exist between the original experimental findings and the recommendations contained in the guideline.

3. ASSESSMENT OF THE ENVIRONMENT

In the interests of simplicity, it is suggested that action levels be based on **WB** and **DB** using a whirling hygrometer or any other suitable instrumentation. It is accepted that whirling hygrometers have a number of drawbacks (e.g. cumbersome to use, fragile or not always easy to read) but at present there are no alternatives which combine easy read-out capabilities, accuracy and mine-worthiness. Sophisticated instruments, 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 **DB** and **WB**, i.e. an index which has its origins in the Israeli **DI**, but which has been substantially

modified to what is now termed the **EHSI**.

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

DB = 38.2°C
WB = 34.5°C
then
EHSI = (39 + 35)/2
= 37.0°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 the direct supervision of line management. The responsible person 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/her decisions by the environmental control manager or supervisor. He/she should be well versed with respect to the health and safety of employees under his/her 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. This 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 non-routine or emergency work undertaken by qualified mine personnel on the one hand and operations which by their very nature can only be undertaken by rescue brigadesmen on the other hand. 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. In addition, with a full mask, brigadesmen may have difficulty in observing water breaks and a prior intake is, therefore, advisable. Although these guidelines are relevant to rescue brigadesmen operations, they are not intended to govern such operations at present.

4.4. Infrastucture

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, e.g. 350 -500 ml of water every 30 minutes.

(b) The availability of emergency body cooling facilities.

(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, e.g. 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 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 where conditions change unexpectedly. Mines are advised to confer with the Manager: Occupational Hygiene at the CSIR: Mining Technology with regard to choice.

5.3. Tolerance times

The tolerance times are presented in Table 1: Tolerance times for various **EHSI** levels and benefit of body cooling garments 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:

DB	=	32.0°C
WB	=	28.0°C
EHSI	=	(32 + 28)/2
	=	30.0°C

The recommended limit for an **EHSI** level of 30°C is 230 minutes (Table 1: Tolerance times for various **EHSI** levels and benefit of body cooling garments) 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 the 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:

DB	=	38.0°C
WB	=	34.0°C
EHSI	=	(38 + 34)/2
	=	36.0°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' (i.e. 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:

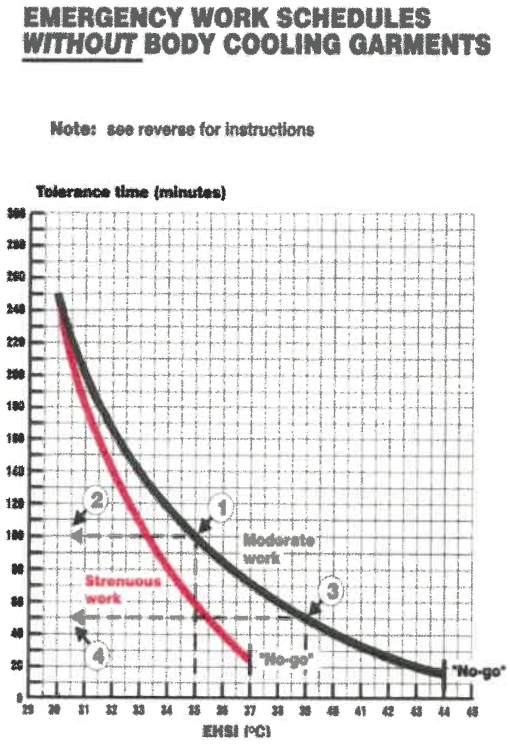
Dose	=	Actual exposure / permissible exposure
	=	Total travelling time / permissible exposure
	=	40 / 230
	=	0.1739
	=	17%

This implies that the available dose at the higher **EHSI** level of 36.0˚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:

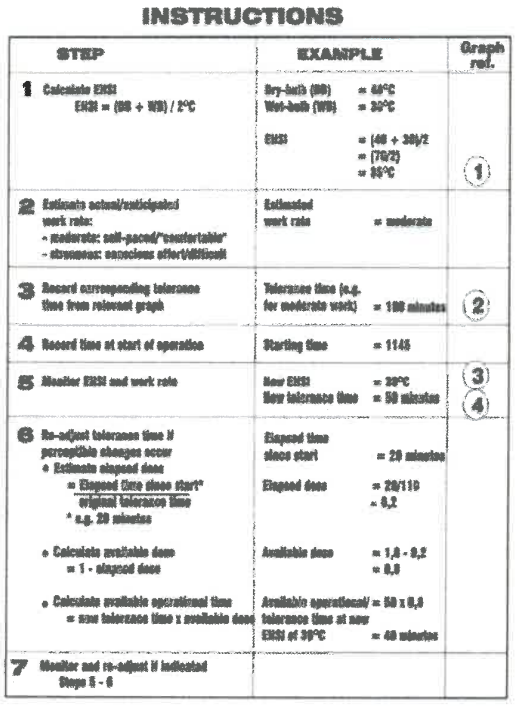
Available operational time = Permissible tolerance time x 0.83
= 90 x 0.83
= 74.7
= 75 minutes

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. Figure 1: Emergency work schedules without body cooling garments and Figure 2: Emergency work schedules without the use of body cooling garments (facsimile of quick reference card) below give examples of such a reference chart.

FIGURE 1: Emergency work schedules without body cooling garments



OBVERSE



REVERSE

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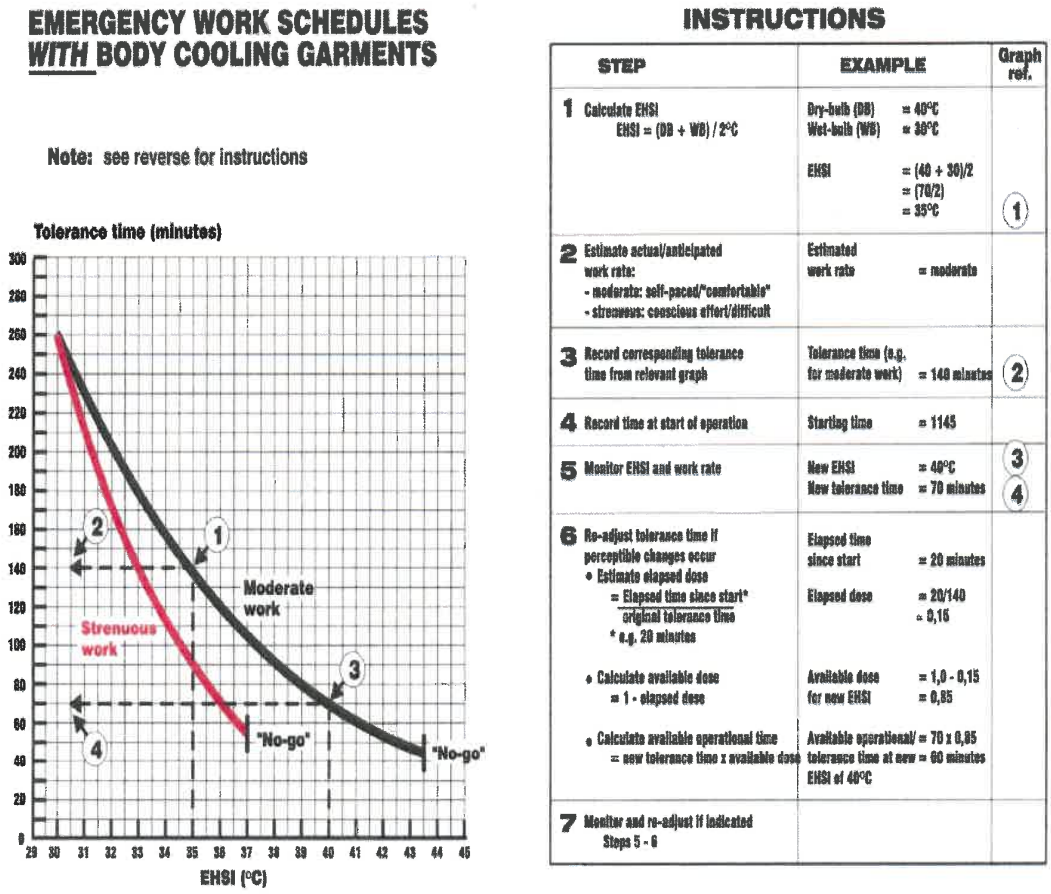
FIGURE 2: Emergency work schedules without the use of body cooling garments (facsimile of quick reference card)



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 the 'estimated dose' where convenient fractions are used e.g. 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 (i.e. single decimal figures) be used when reassessments of tolerance time are indicated.

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TABLE 1: Tolerance times for various **EHSI** levels and benefit of body cooling garments

EHSI[1]	TOLERANCE TIME (MINUTES)			
	EXPERIMENTALLY DETERMINED[2]	RECOMMENDED LIMIT[2]		BODY COOLING GARMENTS BENEFIT
		MODERATE	STRENUOUS	
28-29,9	-	No limit	No limit	Not applicable
30	227	230	230	
31	200	200	180	
32	174	175	140	
33	150	150	110	
34	128	130	85	
35	108	110	60	+30
36	91	90	40	
37	75	70	25	
38	61	60	No work	
39	50	50		
40	40	40	Evacuate area	Maximum of 20-25 minutes
41	33	30		
42	27	30		
43	24	20		
44	22	20		
45	21			

[1] **EHSI** = (**DB** + **WB** 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, i.e. working at a comfortable rate) and "strenuous" work (i.e. where effort is apparent, e.g. transporting heavy materials without a break, climbing up steeply inclined sections).

ANNEXURE 12: Addendum for the thermal stress guideline on the criteria for heat-related illnesses (heat exhaustion and heat stroke)

1. OVERVIEW

1.1. Heats stroke is the most severe disorder and can result in death if not detected at an early stage. It is caused by a rapid increase in one's core temperature in excess of 40°C from exposure to a hot and humid environment. Heat stroke is accompanied by serious clinical syndromes that damage multiple organ systems. Heat stroke is a medical emergency and rapidly cooling the affected worker is imperative.
Source: Expert consensus on standardized diagnosis and treatment for heat stroke (online).

1.2. Heat exhaustion is often considered a precursor to the more serious heat stroke. This disorder has been encountered frequently in experimental assessment of heat tolerance. Usually, it is accompanied by a slightly elevated core body temperature (38°C - 39°C, or 100.4°F - 102.2°F).

Source: Criteria for a recommended standard occupational exposure to heat and hot environments, Department of Health and Human Services, Centres for Disease Control and Prevention, National Institute for Occupational Safety and Health (online).

2. CLINICAL SIGNS AND SYMPTOMS OF HEAT-RELATED ILLNESSES

WHAT TO LOOK FOR	WHAT TO DO
HEAT STROKE	
High body temperature (39°C or higher): ▪ Hot, red, dry or damp skin. ▪ Fast, strong pulse. ▪ Headache. ▪ Dizziness. ▪ Nausea. ▪ Confusion. ▪ Losing consciousness (passing out).	Heat stroke is a medical emergency: ▪ Move the person to a cooler place. ▪ Help lower the person's temperature with cool cloths or a cool bath. ▪ Do not give the person anything to drink. ▪
HEAT EXHAUSTION	
Heavy sweating: ▪ Cold, pale, and clammy skin. ▪ Fast, weak pulse. ▪ Nausea or vomiting. ▪ Muscle cramps. ▪ Tiredness or weakness. ▪ Dizziness. ▪ Headache. ▪ Fainting (passing out).	▪ Move to a cool place. ▪ Loosen your clothes. ▪ Put cool, wet clothes on your body or take a cool bath. ▪ Sip water. **Get medical help right away if:** ▪ You are throwing up. ▪ Your symptoms get worse. ▪ Your symptoms last longer than one hour.
HEAT CRAMPS	
Heavy sweating during intense exercise. Muscle pain or spasms.	▪ Stop physical activity and move to a cool place. ▪ Drink water or a sports drink. ▪ Wait for cramps to go away before you do any more physical activity.

WHAT TO LOOK FOR	WHAT TO DO
	Get medical help right away if: ▪ Cramps last longer than one hour. ▪ You are on a low-sodium diet. ▪ You have heart problems. ▪
SUNBURN	
Painful, red and warm skin. Blisters on the skin.	▪ Stay out of the sun until your sunburn heals. ▪ Put cool cloths on sunburned areas or take a cool bath. ▪ Put moisturizing lotion on sunburned areas. ▪ Do not break blisters.
HEAT RASH	
Red clusters of small blisters that look like pimples on the skin (usually on the neck, chest, groin, or in elbow creases).	▪ Stay in a cool, dry place. ▪ Keep the rash dry. ▪ Use powder (like baby powder) to soothe the rash.

Source: https://www.cdc.gov/disasters/extremeheat/pdf/Heat_Related_Illness.pdf

3. ASSESSMENT OF CORE BODY TEMPERATURE

Usually heat exhaustion may manifest as sweaty and clammy extremities and heat stroke may manifest as hot or warm limbs. The actual body temperature needs to be measured at the core.

Usually the thermometer is placed within the mouth, in the groin folds, armpits or rectum to detect the core temperature. A temperature of 40°C (104°F) or above is often a major sign of heat stroke.

Heat stroke however can be diagnosed at lower temperatures and these temperatures are not always indicative of heat stroke as athletes may reach them during physical exercise.

Source: Diagnosis and treatment of heat stroke (online)

4. DIAGNOSIS OF HEAT STROKE

4.1. Laboratory tests can confirm the diagnosis, rule out other causes for the symptoms and assess organ damage. These tests include:

- Routine blood work.
- Infection indications.
- Blood biochemistry: electrolytes, renal function, liver function and rhabdomyolysis.
- Coagulation.

- Arterial blood gas.
- Routine urine testing and urine biochemistry.
- Routine fecal testing.
- Muscle function tests (rhabdomyolysis).

4.2. Other tests

- Electrocardiogram.
- Chest X-ray.
- Cranial Computerized Tomography (CT) examination.
- Cranial Magnetic Resonance Imaging (MRI) examination.

5. TREATMENT OF HEAT EXHAUSTION AND HEAT STROKE

Those with heat exhaustion and heat stroke need the following therapy approaches:

- The person needs to be taken to a cool place. Preferably a room with air conditioning or at the most somewhere in the shade.
- If the person is conscious, he or she should have something cold to drink i.e. water or a rehydration drink such as a sports drink.
- Drinks containing alcohol and caffeine should be avoided as it leads to further dehydration.
- In patients with heat exhaustion, the symptoms decrease within an hour or so, and leave no long-term effects.
- The persons clothing should be loosened and excess clothing should be removed.
- There should be adequate ventilation and airflow to allow further cooling. Fanning often helps.
- The person's skin should be cooled by using cool but not cold water (15-18°C). This could be done with a cool shower or bath, or by applying a wet flannel cloths or a facecloth to the skin.
- They may be immersed in cool but not cold water. This last step is best performed under medical supervision as the person may respond with a sudden change in blood pressure especially among those who have heart disease or the elderly.
- Gently massage the skin to ensure blood circulation.

- In case of fits or seizures, move the person away from objects that may cause injury. Nothing should be forced into the mouth of the patient.
- When the person vomits or is unconscious, they should be placed on their side to avoid choking. In these cases, emergency departments must be notified immediately.
- Those who are vulnerable to heat stroke and its complications (i.e. children below the age of two years, the elderly, or debilitated and long-term ill persons with diabetes, kidney and heart disease) need to be moved to a hospital for better monitoring and care.
- In the hospital will administer fluids and electrolytes as necessary while closely monitoring breathing, airways and the maintenance of blood circulation of the person.
- Apply ice packs to the patient's neck, armpits and groin to cool at a rate of around 0.1°C per minute. Ice-bath immersion has been shown to be the most effective cooling method.
- Cooling is slowed or stopped, once the body temperature is < 38.5°C to avoid overcooling. Iced gastric lavage and peritoneal lavage is attempted in severe cases.
- Medication such as Benzodiazepines and muscle relaxants are given to control shivering and fits.
- A urinary catheter is inserted to measure the exact urine output.
- Complications such as respiratory distress, encephalopathy (brain disorder), rhabdomyolysis, kidney or liver damage is managed according to the severity and the symptoms.

Source: Diagnosis and treatment of heat stroke (online)

6. EPIDEMIOLOGICAL CHARACTERISTICS OF HEAT STROKE

The heat index is a numerical value obtained by a mathematical operation using temperature and humidity levels. The heat index positively correlates with the rate of onset for heat stroke. When the heat index is > 41, the heat stroke onset rate increases. When the heat index is > 54, heat stroke is extremely likely to occur (Figure 1).

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FIGURE 1: Heat index correlation with temperature and humidity

Temperature (°C) \ Relative humidity (%)	40	45	50	55	60	65	70	75	80	85	90	95	100
43.3	58												
42.2	54	58											
41.1	51	54	58										
40.0	48	51	55	58									
38.9	46	48	51	54	58								
37.8	43	46	48	51	53	58							
36.7	41	43	45	47	51	53	57						
35.6	38	40	42	44	47	49	52	56					
34.4	36	38	39	41	43	46	48	51	54	57			
33.3	34	36	37	38	41	42	44	47	49	52	55		
32.2	33	34	35	36	38	39	41	43	45	47	50	53	56
31.1	31	32	33	34	35	37	38	39	41	43	45	47	49
30.0	29	31	31	32	33	34	35	36	38	39	41	42	44
28.9	28	29	29	30	31	32	33	34	35	36	37	38	39
27.8	27	28	28	29	29	29	30	31	32	32	33	34	35
26.7	27	27	27	27	28	28	28	28	29	29	30	30	

In extreme danger, with highly prone to HS

In danger, the incidence of HS increases

Source: Expert consensus on standardized diagnosis and treatment for heat stroke (online)

ANNEXURE 13: Reference documents
(For information only)

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