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Ergonomics of the thermal environment — Medical supervision of individuals exposed to extreme hot or cold environments

Ergonomie des ambiances thermiques — Surveillance médicale des personnes exposées à la chaleur ou au froid extrêmes

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12894 was prepared by Technical Committee ISO/TC 159, *Ergomomics*, Subcommittee SC 5, *Ergonomics of the physical environment*.

Annexes A to F of this International Standard are for information only.

Introduction

This International Standard is one of a group of standards which specify methods for measuring and evaluating hot, moderate and cold thermal environments. International Standards or Technical Reports, which describe the evaluation of hot and cold thermal environments, give advice on the acceptability of these environments for human exposure, taking account of the activity level and the effects of clothing worn. That advice is given on the basis that the individuals concerned are healthy, that is, without any medical factor which might predispose them to ill effects from the thermal environment. Furthermore, biological variability prevents the accurate prediction of the response of any particular individual to climatic extremes. For these reasons, it is necessary to provide appropriate medical supervision for individuals who are to be exposed to extreme thermal environments. This International Standard describes a method to determine the degree of medical supervision relevant to different types of exposure, in order to limit the risk of any individual suffering from ill health.

Ergonomics of the thermal environment — Medical supervision of individuals exposed to extreme hot or cold environments

1 Scope

This International Standard provides advice to those concerned with the safety of human exposures to extreme hot or cold thermal environments. Extreme thermal environments are those which result in a high rate of heat gain or loss by the body. A precise definition of such environments cannot easily be given, as the change in body heat storage depends on clothing and activity as well as the parameters of the climatic environment. As a guide, the boundaries of extreme environments might be considered to be as follows: for hot environments, a wet bulb globe temperature of 25 °C; for cold environments an air temperature of 0 °C or below.

Extreme environments can only be tolerated for limited periods of time before a risk of ill health results. Control measures are necessary to ensure the safety of those so exposed, one of which is the provision of appropriate medical supervision prior to and during exposures.

This International Standard is intended to assist those with responsibility for such exposures to reach decisions about the appropriate level of medical supervision in different situations. This International Standard should be read and used in the context of other relevant guidance and legislation.

This guidance is applicable to laboratory and occupational exposures to extreme environments. In either case an assessment should be made of the expected thermal stress on the individual, but the detailed arrangements for medical supervision will differ. Control of occupational exposures must also satisfy national health and safety legislation.

The laboratory or climatic chamber studies for which this International Standard will be relevant include those in which people may be exposed to high or low ambient conditions or local heating or cooling. Studies may, for example, investigate physiological or psychophysical responses to the environment or the benefit of clothing or other protective equipment. Scientific investigations and demonstrations for teaching purposes are included in the scope. In some countries, such studies are subject to specific legislation and, in all cases, experimental exposures should be conducted in the context of accepted ethical criteria as detailed in relevant national and international statements (see informative annex A and the bibliography).

Extremes of environment may be only one component of the total physiological stress imposed in a study. In such cases, appropriate advice must also be obtained with regard to any medical supervision required prior to exposure to the other stressors involved, for example whole body vibration.

In some cases, ergonomic investigations are conducted in the field, for example, to document the physiological stress of particular occupations. If the overall stress of the task is increased as a result of the proposed study, this International Standard will be relevant.

This International Standard does not apply to the use of hypo or hyper thermia in the course of medical investigation or treatment.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to

investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 9886, *Evaluation of thermal strain by physiological measurements.*

ISO 13731, *Ergonomics of the thermal environment — Vocabulary and symbols.*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
independent medical officer
qualified medical practitioner identified in a study protocol as responsible for the arrangements for medical fitness assessment and health monitoring in support of a study to which this International Standard applies and who is not the principal investigator

3.2
experimenter
the member of the investigation team who is in overall control of a particular experimental session

3.3
medical fitness assessment
procedure by which the state of past and present health of an individual is reviewed to identify any possible medical predisposition to harm from exposure to extreme thermal environments

3.4
health monitoring
process in which the acute effects on the individual resulting from exposure to an extreme thermal environment are observed and interpreted by someone with appropriate training, utilizing physiological monitoring and clinical observation

NOTE The purpose is to detect any indications that an individual may no longer be adequately tolerating the exposure conditions, and therefore to prevent any serious ill health arising, if necessary by removal of the individual from the exposure.

3.5
occupational physician
qualified medical practitioner who has received appropriate training and who is responsible for the supervision of the health at work of employees in one or more enterprise

3.6
principal investigator
where more than one person is responsible for the design of a study a principal investigator should be nominated and he or she will normally be responsible for obtaining ethical approval for a study and for ensuring that adequate arrangements are made for medical supervision of the experimental subjects

NOTE In the case of multicentre studies with a centrally agreed protocol, the person organizing the study, i.e. the promoter, may be responsible for seeking ethical approval.

4 Principles of medical supervision of individuals

4.1 General

The use of the relevant International Standards, given in clause 2, for the assessment of the thermal environment, will allow exposures to be controlled in such a way that the risk of illness arising is minimized. Where body core temperature is maintained in the band 36,0 °C to 38,0 °C then serious general health effects, resulting from

changes in body heat storage, are unlikely, although not entirely unknown. Core temperature is defined in ISO 13731 and described in ISO 9886. In this International Standard, where reference is made to values of core temperature, it is intended that these will have been obtained from valid measurement sites, such as those described in ISO 9886.

If core temperature departs from the range previously specified, there is a progressively increasing risk of acute ill health, specifically heat stroke (heat hyperpyrexia) or profound hypothermia, either of which can be life threatening. Disorders resulting from changes in body heat storage are not, however, the only types of ill health that can arise in extreme thermal environments. For example, in the cold, asthmatic attacks may occur, (particularly in association with exercise), angina may be precipitated, and rhinitis, coughs and nose bleeds have all been reported. Also peripheral cooling can result in frostbite. In the heat, blood flow redistribution can result in episodes of low blood pressure and the risk of collapse before significant heat gain has occurred.

The main illnesses which can arise from changes in body heat storage in hot or cold environments are summarized in informative annex B. This also gives information on the other health effects which can occur in hot and cold conditions.

ISO 9886 and ISO 13731 apply only to healthy subjects in whom the normal physiological control of body temperature is unimpaired. Also, they are unable to take account of the variability of responses between different individuals, although some large differences, such as those between acclimatized and unaclimatized individuals, are considered. For these reasons, it will be important, in the circumstances described below, to include a system of medical supervision of the exposed individuals in risk management. Such supervision may entail both medical fitness assessment prior to exposure and health monitoring during exposure.

4.2 Ergonomic investigations

4.2.1 Introduction

Ergonomic investigations may be conducted in the laboratory or in the field. In either case, the protection of the individuals participating in the studies must be a major consideration.

4.2.2 Laboratory studies

4.2.2.1 General

Studies should be conducted according to accepted ethical guidelines, for example, as contained in the “Helsinki Declaration” (see [8] in the bibliography). The study protocol should be approved by a local research ethics committee. The Principal Investigator and each Experimenter should be aware of their duties towards the subjects both in the design and conduct of the investigations. They should ensure that only individuals who have given their consent participate in the studies and that subjects are free to withdraw from participation during the course of an investigation if they so wish. The application of these principles is described in annex A.

The protocol should describe any arrangements for medical fitness assessment or health monitoring and identify an independent medical officer responsible for the implementation of these arrangements. The medical officer may advise on any likely risks to the subjects and on the level of fitness assessment and monitoring appropriate to the intended study. The medical officer may delegate specific duties to appropriately qualified individuals, for example, health monitoring during exposures may best be done by experienced laboratory staff with appropriate training in first aid and basic resuscitation techniques. The medical officer will act as the final arbiter in questions of fitness of particular individuals to participate in a study.

The medical officer should have practical experience of observing the effects of thermal stress on people, as well as a sound theoretical knowledge of these effects. This may be obtained by cooperation with a research team, or in the course of formal training in applied physiology or related disciplines.

4.2.2.2 Medical fitness assessment

Medical fitness assessment should take place prior to exposure to extreme hot or cold environments. This should take account of the intended exposure conditions and is centred on the individual. It is intended to determine

whether there are any reasons to consider that the person may be susceptible to ill effects from the planned environmental exposure.

Assessment may be by questionnaire and medical examination and advice is given in informative annexes C and D on when these options may be appropriate. If physiological measurement is to be used during exposure, either to support health monitoring or to collect information, then simple initial health checks may also be required, see informative annex E.

A questionnaire should always be completed and the option for a medical examination should be followed in every case where there is any doubt about the fitness of an individual. Examination allows an assessment of the psychological suitability of an individual which cannot be judged from responses to a questionnaire.

Where assessment is by questionnaire and this does not reveal any medical factor which may predispose an individual to ill effects, he or she may be accepted as a subject. Where results suggest a possible predisposition, an individual should only be accepted on the advice of a medical officer who may ask to examine the individual or to obtain an opinion from a relevant specialist.

4.2.2.3 Health monitoring

Assessment of the anticipated physiological strain, coupled with appropriate medical fitness assessment will, in most situations, provide adequate safeguards against the risk of illness occurring from exposure to hot or cold conditions. In the more extreme conditions, to which this International Standard applies, and particularly in exposures to heat, the onset of ill health and the occurrence of symptoms may be rapid and some form of health monitoring is likely to be required to detect these changes and allow an early intervention. An example might be where the prediction of physiological strain is not practicable due to the type of clothing to be worn.

The level of health monitoring required will depend on the detailed circumstances of exposure. The minimum possible is the observation of the subjects by someone with experience of the effects of heat or cold on the body. In many cases, the measurement of physiological parameters will form part of the experimental protocol and the data collected will be used in the results of the study. If not already required for this reason, monitoring of core and skin temperatures, heart rate and, in some cases, blood pressure is likely to be required as these factors may be limiting. Upper limits for withdrawal of subjects from exposure should be decided as part of the experimental protocol.

In most cases, it will be adequate for the monitoring to be done by a trained non-medical person and to have access to the opinion of a medical officer but, in more severe conditions, it will be prudent for the medical officer, or another appropriately trained person (such as an emergency medical technician or paramedic), to be available to attend promptly to a casualty if required. Whether or not a medical officer is available to assist in monitoring and treatment, it will be necessary to have arrangements in place for the rapid removal of a casualty to a hospital with emergency facilities. More detailed advice on the appropriate level of monitoring is given in informative annexes C and D.

During any prolonged series of experiments in which behavioural changes could occur in the subjects, there should be arrangements in place to allow the experimenter and the independent medical officer to obtain the advice of a psychologist.

4.2.3 Field investigations

Ergonomic investigations made in the field should conform to the same ethical guidelines provided for laboratory-based studies. Where volunteers who are not normally employed in the work task act as subjects, the requirements for medical fitness assessment and health monitoring are as described in 4.2.2.2 and 4.2.2.3.

Where workers regularly employed in the task under investigation are the subject of study, the requirements for medical supervision should be agreed with the occupational physician responsible for the health of the workers. The requirements will be based on those described in 4.3, taking account of the effect of the study on normal work practices and of the views of workers and their representatives.

4.2.4 Practical implementation of medical supervision

Advice on the practical requirements of medical supervision in the laboratory, or during field studies with volunteers not normally exposed to the conditions, can be found in informative annex E.

4.3 Occupational exposure

4.3.1 General

Medical supervision of workers who may be exposed to very hot or cold conditions at work should form part of their normal occupational health care and should take account of national health and safety legislation. Work environments are generally less predictable than those used in laboratory investigations and some jobs may require high rates of energy expenditure and the use of protective clothing. In these circumstances, endogenous heat production contributes significantly to the resulting heat strain.

A risk assessment should be undertaken for all occupational exposures to extreme thermal environments. This should allow an evaluation of the likely physiological strain of the task to be made, before the work actually begins. Also, it should allow the available means of reducing this physiological strain to be identified. Work tasks should not be designed in a way which permits unacceptable physiological strain to occur, for example, no work should be planned in which the risk assessment shows that there is a significant potential for general hypothermia to occur. However, where outdoor work takes place, it will not always be possible to entirely eliminate such risks, for example, during fishing, forestry or agriculture in cold temperate or sub-arctic climates, or during construction work in tropical latitudes.

Work which carries a risk of heat strain must be carefully controlled. Heat strain may however be expected to occur in some emergency situations, such as rescue work in mines. The level of fitness assessment and health monitoring should be matched to the circumstances of exposure and general guidance is given in annex F.

4.3.2 Medical fitness assessment

This will be determined by the occupational physician responsible for the workforce in the context of relevant national legislation and guidance. All the components of the job should be taken into account and this may include the need to respond to emergency situations. Direct health monitoring will often be impractical in work tasks, therefore adequate fitness assessment with proper control of exposure will form the basis for the prevention of ill health from exposure to heat or cold at work.

4.3.3 Health monitoring

After appropriate medical fitness assessments have been completed, health monitoring may still be required in some occupational situations where exposure is extreme. Further advice is contained in informative annex F. Information on any acute ill health which occurs during exposures should be reported back to the occupational physician with responsibility for the workers.

Annex A
(informative)

General principles underlying ergonomic investigations in which volunteer subjects may experience discomfort

A.1 General principles

In this annex the general principles relating to the ethics of experimentation on human subjects are described. Reference should also be made to relevant national codes or regulations or other international guidance. (See the bibliography).

Within the field of ergonomics, it is of legitimate interest to study the boundaries of environmental conditions which individuals can safely tolerate and also the effects of such environmental conditions on the performance of mental and physical tasks. Such studies are usually best conducted in the laboratory, in which exposure can be carefully controlled and responses closely monitored. These studies are often conducted with volunteers with no previous experience of the environmental stresses to be studied, or the measurement techniques to be used. Such studies are considered to be ethically acceptable if they comply with certain general principles.

There must be a genuine expectation of increased scientific knowledge on completion of the study. In the case of teaching demonstrations using standard procedures, the benefit is in the increased knowledge and experience of the students concerned. The level of benefit in terms of increased knowledge should outweigh the discomfort experienced by the subjects. Thus it will not normally be acceptable to submit volunteers to great discomfort, unless the information to be obtained is considered to be of high practical or theoretical value.

The study must be planned using current knowledge of the problem being investigated and the methodology proposed must be suitable to obtain the required information. This should not be extended to obtain information which may be only “of interest”, in other words, all the data collected should be directly relevant to the object of the experiment.

No serious risk to the health or personal safety of the subjects should be foreseeable. Although studies should be designed so as to minimize such risks, individuals will vary in their tolerance to the environmental conditions and the resulting discomfort. They should be free to withdraw from the study if they so wish, at any time and without the need to give any explanation.

The investigator must have access to adequate facilities to conduct the experiment successfully and to provide for the welfare of the subjects. This will include suitable changing rooms and areas where instrumentation can be applied in privacy as well as areas for subjects to rest and recover after an experiment.

The protocol for the investigation should be submitted to a research ethics committee for approval, and due account taken of any comments made by the committee. The protocol should include an assessment of the severity of the environmental exposure on the subjects, information on any potential risks to health, and details of the arrangements proposed for fitness assessment and health monitoring of the subjects, where this is appropriate. The protocol should also include information about the arrangements which have been made for financial compensation of a subject in the event that any injury or harm to health occurs. It is recommended that laboratories have appropriate insurance to cover this eventuality.

Volunteer subjects should give their written consent to participate in the study. Consent is only valid if it is both true and informed. For consent to be true, there should be no factor which might unfairly influence the decision of the individual to participate, either in the relationship between the investigator and the potential subject, or in the remuneration which may be offered. A suggested form of written consent is given in A.2. Particular care should be taken to ensure that no pressure to participate is exerted on individuals in a subordinate position to the investigator, such as students or junior members of staff.

For consent to be informed, the investigator should explain to the potential subject the purpose of the investigation, the methodology to be used, the level of discomfort to be expected and any foreseeable risks. Such explanations should be available to the potential subject in writing. Also, it must be made clear to volunteers that they are free to withdraw their consent at any time, including during the course of an experimental session.

Individuals who take part in studies also have responsibilities towards the investigators. They should comply with the instructions given to them, particularly in relation to behaviours to avoid prior to attending for experimental sessions, for example, not smoking or not consuming alcohol or caffeine. Participation in more than one experimental investigation at the same time may invalidate the results of one or both of the studies and may present a risk to the individuals themselves. Subjects should not attempt to participate in more than one study at the same time, and must not do so without obtaining the approval of the investigators in both studies.

A.2 Example of a consent form for a volunteer subject in an ergonomic investigation involving exposure to heat or cold

IN CONFIDENCE

Name ..... Age ..... years Sex: Male/Female

Normal medical adviser. Name .....

Address .....

.....

1. I am willing to participate as an experimental subject in the study of

   .....

   to be conducted by .....

   at .....

2. I have received an explanation of the nature and purpose of this study and of any risks to my health which are foreseen.

3. I agree to provide accurate information about my health and to be medically examined if this is considered necessary. I agree that my normal medical adviser can provide information about my medical history to the authorized medical adviser to the study (independent medical officer). I understand that all information about my health will be treated in confidence.

4. I agree to cooperate fully with the investigators and not knowingly to do anything which might invalidate the results.

5. During the course of the investigation to which I am now giving my consent, I will not participate as a subject in any other study, without first informing the investigators and obtaining their approval, which may be withheld.

6. I understand that I am free to withdraw my consent to participate in the study at any time without the need to give an explanation for my decision.

Signed ..... Date .....

Statement by investigator

In connection with the study described above, I have explained to ..... the nature and purpose of the study and the foreseeable risks from participation in the study. I have explained that the decision to volunteer does not affect the right to compensation in the event of illness or injury.

Signed ..... Date .....

Annex B
(informative)

Medical effects of exposure to hot and cold

B.1 General

This annex provides an introduction to the subject which should be supplemented by reference to standard textbooks of physiology, medicine and first aid. These notes are provided for information only and on their own do not provide a sufficient basis on which to plan the treatment of casualties suffering from the effects of exposure to extreme heat or cold.

B.2 Heat disorders and their immediate treatment

B.2.1 General

The main disorders arising from exposure to heat are usually classified into the categories described in B.2.2 to B.2.7. These categories probably represent a continuum of effect of increasing severity and, if early signs are not detected and treated, individuals will be at risk of more serious illness. The essential treatment of heat disorders, other than a simple faint, is to reduce the body core temperature. Any episode of altered consciousness level in an individual exposed to heat should be taken as a sign of heat hyperpyrexia even if the body core temperature is not found to be significantly elevated.

Other disorders which may arise due to heat are heat hyperventilation, heat oedema, heat cramps and prickly heat. An individual who has suffered a heat disorder should be medically assessed prior to any further heat exposure.

In heat exposures where health monitoring is required, adequate facilities to treat heat disorders should be available. This will include a couch or bed on which to let a person rest, a strong electric fan, a source of tepid water and sheets and sponges. A bath or shower may also be desirable.

Equipment should be available to allow a clinical examination and for a doctor, nurse or other competent person (emergency medical technician/paramedic) to be able to monitor the casualty's pulse, blood pressure and rate and depth of respiration. A high-reading metal-stemmed thermometer should be available to measure rectal temperature if core temperature is not otherwise monitored. There is no advantage in having equipment available for advanced resuscitation, for example, by laryngeal intubation unless the medical officer concerned is competent in the use of these techniques.

With heat casualties, the priority for treatment is to lower the body core temperature and, if necessary, transfer the person to hospital. This must be considered in any case where the person shows no sign of rapid recovery, either of consciousness level and clinical condition, or to a lower body core temperature. Body cooling can be continued during transfer of the casualty to a medical facility.

B.2.2 Heat hyperpyrexia (“heat stroke”)

This potentially fatal condition occurs when body core temperature is raised above a value of approximately 41 °C, although the clinical condition is not precisely linked to recorded core temperature. Its onset may be sudden, being indicated by collapse of the individual who will often, but not invariably, have a hot, red, dry skin. The consciousness level is likely to be impaired and the pulse is rapid and weak. The condition results from a failure of the body's thermoregulatory mechanism to match the body's cooling requirements and if the individual is not removed from the heat, and actively cooled, brain damage or death can arise from the elevated tissue temperatures.

First aid: This is a medical emergency. Remove the casualty from the heat and remove the clothing. Take measures to cool the casualty. If unconscious, lie him in the three-quarters prone (“recovery”) position and cover with a wet sheet, blowing air over the body with a fan. Tepid sponging can also be used. If conscious, use a tepid bath or shower, massaging the skin to stimulate the circulation. Medical, or paramedical, assistance should be summoned but the priority is to cool the casualty. Immediate medical treatment may include the administration of large volumes of intravenous fluids. Ice, or very cold water, is not normally recommended to be used for cooling as superficial vasoconstriction can prevent loss of heat from the skin surface.

B.2.3 Heat exhaustion

This results from a combination of thermal and cardiovascular strain. The individual becomes tired and stumbling, with poor control and coordination, and is irritable. The pulse is rapid and may be bounding or weak. The peripheries are pale and moist and respiration is shallow and rapid. Dehydration or, less commonly, salt deficiency may contribute to the onset of heat exhaustion, which may, in turn, predispose to the onset of heat hyperpyrexia or to other accidents. If, during heat exposure, sweat losses are replaced with very large quantities of water, it is possible to lower the sodium concentration in the blood. This may result in a reduction in the peripheral circulation.

First aid: Remove the person from the heat, loosen clothing and allow to recover in a cool place. This can be assisted by fanning or tepid sponging. Oral fluids can be given if conscious, with added salt if excessive ingestion of water alone can have contributed to the collapse. In more severe cases, immediate medical treatment will include the administration of intravenous fluids as for heat hyperpyrexia and probably transfer to hospital.

B.2.4 Heat syncope

This is a simple faint as a result of reduced effective circulating blood volume and may occur at core temperatures below 38 °C. It is more likely to occur in the unaclimatized during early exposure to heat, before the cardiovascular system has had time to adapt. It can be serious if the body is held upright, for example due to work in confined spaces, in which case brain damage or death may result.

First aid: Allow the person to lie down to recover.

B.2.5 Heat hyperventilation, tetany

This can arise as a result of hyperventilation in the heat, especially where respiratory protective equipment is being worn. It is a consequence of respiratory alkalosis due to the increased loss of carbon dioxide. It is not serious if recognized and treated, but can be very distressing for the individual affected, and can result in unconsciousness, vomiting or convulsions, and contribute to further heat illness.

First aid: The condition is readily treated by asking the person to rebreathe into a small bag held over the nose and mouth until the symptoms improve, usually in a period of minutes.

B.2.6 Other effects

Health effects arising from heat exposure include cardiovascular effects, heat oedema, heat cramps and prickly heat.

The normal cardiovascular response to heat exposure is a tachycardia. Blood pressure is initially maintained but may fall if fluid is lost to the circulation either through venous pooling, sweating or loss to the interstitial space. Heat exposure places a large strain on the heart, which may be compromised in the presence of ischaemic, or other cardiac disease.

Heat oedema may manifest as transient ankle swelling during acclimatization to heat.

Heat cramps may cause painful muscle spasm in the presence of salt deficiency but is rare in occurrence. It can be treated by putting the muscle group on stretch and massaging it. If a weak (0,1 % to 0,2 %) saline solution is available then drinking this is likely to relieve symptoms in 10 min to 15 min.

Prickly heat is the name given to a fine, superficial skin rash associated with excessive sweating and which most frequently arises in covered areas of skin. If suspected, the individual should be referred for a medical opinion.

B.2.7 Burns

Burns can result from contact with hot surfaces in the environment. Information on the temperature of surfaces which may cause a burn on skin contact for a period of 1 s is contained in EN 563 ([7] in the bibliography). The immediate first aid treatment for a burn is to reduce the tissue temperature by immersion in cold water if this is practical. The ideal temperature for the water is 15 °C but water at temperatures between 8 °C and 25 °C is effective. Ice or iced water should not be used. Thereafter, the burn can be dressed with clean linen or plastic “cling” film and the casualty transferred to a hospital.

B.3 Hypothermia and cold injury and their immediate treatment

B.3.1 General

Subclauses B.3.2 to B.3.5 cover the effects of general hypothermia and local cold injury. Hypothermia resulting from immersion in cold water is not discussed.

B.3.2 Hypothermia

This is the result of a progressive fall of body core temperature in conditions where clothing insulation is inadequate. It is defined as a body core temperature below 35 °C.

Core temperatures of 32 °C to 35 °C can be considered to represent mild hypothermia but are dangerous because if fatigued, gait and coordination may be affected, and this may compromise. The ability to reach a warmer environment. Shivering may also be present. Below 32 °C symptoms become more severe and consciousness can be lost at core temperatures below 30 °C. This dangerous level of temperature should never be reached in controlled laboratory or occupational settings.

First aid: Cooling below a core temperature of 35 °C should not normally occur in the course of ergonomic investigations. In indoor work places (e.g. cold stores), work-rest regimes should be such as to prevent cooling to hypothermic temperatures. The greatest risk of hypothermia occurs in outdoor occupations where there is a risk of clothing insulation becoming wet and where high air velocities may be encountered.

For the moderate cooling which may occur in controlled laboratory or industrial settings, it will generally be adequate to have access to a warm place in which individuals may recover. In a laboratory, access to a warm bath should also be available. A warm shower is less satisfactory.

For mild hypothermia occurring outdoors, the casualty should be moved to shelter, any damp clothing removed and dry insulation provided, for example, in the form of a sleeping bag, or fresh dry clothes, to allow a natural recovery of core temperature. In severe hypothermia, there is a risk of cardiac arrythmias and treatment is limited to preventing further heat loss and arranging evacuation of the casualty.

B.3.3 Frostnip/frostbite

This may occur on contact with cold surfaces or exposure of naked skin to cold winds. Frostnip is seen as a white spot on the exposed tissues. If not rewarmed it may progress to frostbite, in which the appearance is of an area of marbled white frozen tissue which is cold and firm to touch and anaesthetic.

First aid: Frostnip and early frostbite can be treated by applying body heat, e.g. from a warm hand to the affected area. In controlled exposures, no more serious injury should arise.

B.3.4 Non-freezing cold injury

This condition presents as numbness during exposure and painful swelling of the affected part on rewarming. It is unlikely to occur in controlled occupational exposures due to the long period required for its onset. It may arise, however, after comparatively short periods of immersion of a part in cold water.

First aid: Injury to a small area, e.g. one finger, may not require any treatment other than painkillers. If large areas are affected, e.g. both feet, treatment is by slow rewarming.

B.3.5 Chilblain

This is a superficial, mild form of non-freezing cold injury presenting as an area of dark blue/purple discoloration of the skin.

First aid: This requires no treatment other than possibly pain killers.

B.4 Other general health effects arising in cold conditions

B.4.1 Cardiovascular

The normal physiological response to cold exposure is a bradycardia and rise in blood pressure. This may be dangerous in individuals with pre-existing hypertension. Cold air inhalation may precipitate angina pectoris in some people who suffer this condition.

Vasoconstriction, which also occurs in the cold, may compromise the blood supply of peripheral tissues in the presence of coexisting vascular disease. Raynaud's phenomenon, whether idiopathic or acquired, for example, through the use of hand-held vibrating tools, may be triggered by cold exposure.

B.4.2 Respiratory

Cold air inhalation may precipitate an asthmatic episode. This is particularly likely to occur in association with exercise levels which are moderate or high. Asthmatics may know whether or not their disease is provoked by cold exposure or exercise.

Cold air inhalation can also provoke coughs, rhinitis and nose bleeds.

A chronic obstructive pulmonary disease (esquimo lung) has been reported in the residents of sub-arctic regions, but it is not known whether this condition is solely attributable to cold air inhalation.

B.4.3 Other effects

Cold exposure will increase the metabolic rate and can induce a diuresis. There is some evidence that chronic exposure to cold conditions may be associated with an increase in arthritic and musculoskeletal disorders.

Annex C
(informative)

Medical supervision of individuals exposed to extreme hot environments in the laboratory

C.1 General

The recommendations given in this annex provide a **minimum** level of medical supervision

C.2 Medical fitness assessment

Such assessment should be considered before any individual is exposed to hot conditions unless the individual has been previously assessed, has a certificate of fitness which remains in date and has had no heat related, or other, ill health following the date of the previous assessment.

Assessment may be made by the completion of a health questionnaire with or without a subsequent medical examination. A suitable questionnaire for assessment prior to exposure to hot conditions is given in clause C.7. The questionnaire should be administered to the subject by someone with appropriate knowledge, who could be a member of the investigation team. The resting heart rate and blood pressure should be recorded in all cases.

Where possible, it is always preferable to supplement the questionnaire examination with a medical examination and this should be done in all cases where there is a positive response to any item on the questionnaire. Particular attention should be given to the heart and lungs.

An examination is recommended where the subject is over the age of 30, where the work rate is high (greater then 40 % of maximal capacity), where rapid rise in core temperature may arise (due, for example, to high radiant heat or humidity), where protective clothing is to be worn, and where other stressors such as noise, vibration or sleep loss are present in the study protocol.

C.3 Medical examination

C.3.1 General

Where medical examination is indicated, a thorough clinical assessment should be made with particular attention to the factors which may predispose to heat illness which are as follows:

C.3.2 Obesity

If body weight is significantly in excess of that deemed normal for height, as indicated, for example, by the Body Mass Index (weight, in kilograms, divided by the square of height in metres), exposure may be inadvisable.

C.3.3 Lack of physical fitness

Some of the physiological changes associated with high fitness are similar to those of heat acclimatization. The fit person has an advantage. Body temperature rise during exercise is proportional to the percentage of aerobic capacity used. For a given work load the less fit person is at a disadvantage.

C.3.4 Age

Habitual activity level and physical fitness tend to decline from middle age. In men, thermoregulatory responses have been shown to diminish from the sixth decade. Cardiovascular disease also becomes more common from middle age (in men, age 40; in women, age 50).

C.3.5 Gender

Differences in thermal tolerance between the sexes arise mainly from different habitual levels of exercise.

C.3.6 Pregnancy

Although sauna bathing for short periods of time is considered safe in pregnancy, it is not recommended that women who are known to be pregnant be exposed to extreme heat in laboratory situations.

C.3.7 A past history of heat illness

This may indicate a reduced tolerance to thermal stress. Any factors which may have contributed to the previous episode should be enquired about, as well as the person's subsequent response to thermal stress. If two or more episodes have occurred then the person may be genuinely intolerant to heat.

C.3.8 Drug or alcohol abuse

Alcohol consumption, either in a single episode or chronically, has been associated with episodes of heat stroke, and may also impair general health. Acute alcohol and drug abuse may impair thermal tolerance either by direct effects on thermoregulatory mechanisms or by inducing inappropriate behaviour.

C.3.9 Pre-existing disease

This requires careful evaluation, particularly where it affects the cardiovascular system, the skin or sweating mechanism or the respiratory system, or where there is any disorder, for example of the gastro-intestinal system or renal system which is likely to affect fluid or electrolyte balance. A history of syncopal attacks, epilepsy or mental illness may render an individual unfit for exposure to hot conditions.

C.3.10 Medication

Many drugs administered therapeutically have the potential to impair normal thermoregulation, especially drugs which have anticholinergic activity, for example antihistamines, trycyclic antidepressants and anti-psychotics. Many drugs which act on the central nervous system also impair thermoregulation, for example barbiturates, benzodiazepines, anti-psychotics, tricyclic antidepressants and monoamine oxidase inhibitors. All anti-hypertensive drugs can precipitate episodes of low blood pressure and diuretics may promote dehydration.

C.3.11 Investigations

Special tests such as electrocardiography or lung function testing should be undertaken at the discretion of the medical officer. A 12-lead electrocardiogram is likely to be required in any case where there is a suggestion of ischaemic heart disease. Objective tests of aerobic capacity or skinfold thickness may provide useful information.

C.4 State of Hydration

The state of hydration is an important determinant of the physiological response to heat strain. Those who are to be exposed to heat should be aware of this, and of the need to maintain good hydration, including the ingestion of fluids shortly before exposure to elevated temperature. The amount of fluid drunk prior to entry to the heat is likely to be controlled by the researchers. If fluids are to be restricted as part of the experimental procedure, this will increase the resulting physiological strain.

C.5 Temporary unfitness

Many factors have been identified which have been considered to contribute to the development of heat hyperpyrexia. In general, any factor which may reduce the general state of health or well-being may predispose to heat illness, for example, any infection, dehydration or loss of sleep. Some of these factors, such as sleep loss, may be added stressors in an experimental protocol.

An individual who reports feeling unwell for any reason prior to exposure to heat should not be exposed. Special care should also be taken after an absence of more than two weeks from hot conditions, in individuals previously acclimatized.

C.6 Health Monitoring

Some form of monitoring of subjects will be necessary in all exposures considered to be extreme. This will be related to the expected body heat storage during the exposure. Recommended limits for body heat storage are given in ISO 7933, although these are not specifically intended for application in laboratory studies.

A rise in body core temperature rise can be used as a surrogate for heat storage and can be measured during experiments and used as a guide to the level of health monitoring required. Where core temperature is expected to rise to, but not above 38,5 °C, then monitoring by a trained lay observer, experimenter or first aider will be adequate. If experiments are planned in which the core temperature is expected to rise above this level, this should be supplemented by the advice of a medical officer. The medical officer, or other trained personnel, such as an emergency medical technician/paramedic should, if possible, be available to attend the laboratory and assist in administering first aid, if required.

Where body core temperature is expected to rise above 38,0 °C, then it will be normal to monitor core temperatures, skin temperatures and heart rate at frequent intervals during the exposure.

This advice, based on rise in core temperature, is most suited to situations where there is a moderate energy expenditure and a moderate to high thermal stress. In other circumstances, for example, where heating is purely passive and, in particular, where subjects are sitting or standing, then peripheral blood pooling may result in circulatory embarrassment. Blood pressure should be monitored regularly to detect this possibility.

Other situations which require particular care are where naive subjects, not previously experienced in hot conditions, are exposed (due to the uncertain psychological response), and where a rapid rise in core temperature may be expected (regardless of the absolute level reached, i.e. even below 38 °C core temperature). Care should be taken when personal protective equipment of any sort, but especially respiratory protective equipment, is worn.

C.7 Medical fitness assessment questionnaire prior to hot exposure

IN CONFIDENCE

This questionnaire should be completed prior to exposure to hot conditions. It is recommended that it is administered by someone with appropriate knowledge, for example, a nurse or trained laboratory scientist.

Please circle the appropriate responses

Name ..... Date...../...../.....

Age ..... years Sex: Male/Female

Present occupation .....

1. Have you ever experienced episodes of fits or faints, or loss of consciousness (apart from concussion)? Yes/No

2. Do you suffer from diabetes mellitus or any general medical condition, for example, affecting the bowel or kidneys? Yes/No

3. Do you suffer from any disease of the heart or blood vessels, including high blood pressure? Yes/No

4. Do you suffer from any chest disease, e.g. asthma? Yes/No

5. Have you been treated for any serious mental ill health, or do you suffer from anxiety or depression? Yes/No

6. Do you suffer from any disease of the skin? If yes, please specify Yes/No

   .....

7. Have you had any treatment which reduces your ability to sweat, e.g. sympathectomy? Yes/No

   If yes, please specify .....

8. Are you currently taking any medication? Yes/No

   If yes, please specify .....

   .....

9. Have you ever had any illness due to the heat e.g. faints or collapse? If yes, please state what happened and describe the circumstances Yes/No

   .....

   .....

   .....

   .....

   Where you treated in hospital for this? Yes/No

   Has this, or anything similar, ever happened again? Yes/No

10. If female, is it possible that you are now pregnant? Yes/No

NOTE If the reply to any question from 2-10 is yes, refer to the medical officer for advice. Note that prescribed or self-administered medication may impair normal physiological responses to the heat.

11. How often do you undertake exercise which leaves you out of breath?

never/occasional/regular/daily

12. How often do you drink alcohol?

never/occasional/regular/daily

13. Please give any other relevant comments here;

.....

.....

.....

.....

.....

BRIEF EXAMINATION DETAILS

1. Height ..... cm

2. Weight ..... kg

3. Assessment of height and weight:
   e.g. Body Mass Index (weight in kg/height in m^2) .....
   % greater or less than recommended weight for height .....

4. Resting heart rate ..... bpm
   sitting/lying (record posture)

5. Resting blood pressure ..... /..... mmHg
   sitting/lying (record posture)

Annex D
(informative)

Medical supervision of individuals exposed to cold environments in the laboratory

D.1 General

The recommendations given in this annex provide a **minimum** level of medical supervision

D.2 Medical fitness assessment

The general principles follow those given in clause C.2 for hot conditions. Assessment should be undertaken for all exposures unless there is satisfactory evidence of recent previous assessment.

In all cases, a questionnaire such as that given in clause D.6 should be administered. The resting heart rate and blood pressure should be measured.

It is always preferable that the questionnaire should be supplemented by a medical examination, paying particular attention to the peripheral circulation. An examination is recommended where the subject is over the age of 30.

D.3 Medical examination

D.3.1 General

Where a medical examination is performed, a thorough clinical assessment should be made with particular attention to the factors which may predispose to illness due to cold which are described in D.3.2 to D.3.11.

D.3.2 Cardiovascular disease

Cold exposure causes physiological effects which may be harmful to those with cardiovascular disease. These include the induction of bradycardia and hypertension. Cold air inhalation may precipitate attacks of angina pectoris. Individuals suffering from ischaemic heart disease and/or hypertension are at risk in extreme cold. Vasoconstriction of peripheral tissues is the normal response to cold exposure. This may be problematic in the presence of peripheral vascular disease. Raynaud's phenomenon may be triggered in susceptible individuals and repeated exposures may be unwise.

D.3.3 Respiratory disease

Cold air inhalation may precipitate an asthmatic episode. This is particularly likely to occur in association with exercise levels which are moderate or high. Asthmatics may know whether or not their disease is provoked by cold exposure or exercise.

Cold air inhalation can also provoke coughs, rhinitis and nose bleeds and care should be taken with individuals already suffering from these conditions.

D.3.4 Metabolic disorders

Normal thermoregulation in the cold will be impaired in the presence of untreated thyroid disease and may be impaired in diabetes mellitus. Care should be taken with individuals who suffer from these, or other, metabolic disorders.

D.3.5 Musculoskeletal disorders and arthritis

Cooling reduces the power which muscles are able to generate and may impair joint movement in the presence of arthritis.

D.3.6 Past history of cold illness

A history of local cold injury may predispose an individual to a subsequent attack at the same site, or another site. A past history of general hypothermia need not indicate a predisposition to this condition.

D.3.7 Pregnancy

There is epidemiological evidence to suggest that women who work in the cold during pregnancy have an elevated risk of miscarriage. It is not recommended that pregnant women should participate in studies of extreme cold environments.

D.3.8 Drugs and alcohol

Alcohol consumption, either in a single bout, or chronically, has been associated with episodes of hypothermia, and may also impair general health. Acute alcohol and drug abuse may impair thermal tolerance either by direct effects on thermoregulatory mechanisms or by inducing inappropriate behaviour.

D.3.9 Psychological factors

The perception of cold on the skin of the face and on the peripheries may be unpleasant. This, coupled with concern about possible cold injury may be a cause of anxiety, particularly for individuals unfamiliar with such exposures.

D.3.10 Medications

Many prescribed drugs and alcohol may impair thermoregulation in the cold. These include antidepressants, tranquilizers, anti-psychotics, hypnotics, drugs of abuse, hypoglycaemics, anti-thyroid drugs, sympathetic and ganglion-blocking agents, vasodilators and calcium antagonists. Tobacco and snuff use will impair peripheral circulation and narcotic drugs also increase the risks in cold environments.

D.3.11 Investigations

Special tests such as electrocardiography or lung-function testing should be undertaken at the discretion of the medical officer. A 12-lead electrocardiogram is likely to be required in any case where there is a suggestion of ischaemic heart disease. Objective tests of aerobic capacity or skinfold thickness may provide useful information.

D.4 Temporary unfitness

Repeated exposures to cold do not produce physiological acclimatization to cold in the way that repeated exposures to hot conditions results in acclimatization to heat. There is, therefore, not the same loss of physiological tolerance if a series of cold exposures is interrupted by a period of absence, as is likely to occur with absence during a series of hot exposures. Some habituation to cold conditions may be lost as a result of such an interruption, but this is unlikely to affect physiological tolerance of the conditions. If absence has occurred as a result of illness then it is important to consider whether medical fitness for continuing exposure will have been affected by the condition, or its treatment. It is unwise for individuals suffering from upper respiratory tract, gastro-intestinal, or other infections to participate in exposures to extreme cold.

D.5 Health Monitoring

The onset of hypothermia can be insidious with changes in mental function and general performance which are not apparent to the affected individual. Even moderate hypothermia is a major physiological stress and so should be prevented during all exposures.

In conditions where general body cooling may arise, observation by a friend or experimenter is important to detect such changes. Such observation is particularly necessary if there is also any risk of exposed flesh freezing so that faces, forehead, nose, cheeks and ear lobes can be checked for any signs of frostnip or frostbite. In the event of this occurring, action should be taken immediately according to a previously agreed protocol.

Non-freezing cold injury may occur if the peripheral skin temperature falls to values which are a few degrees above 0 °C, and remains at these levels for some time. Measurement of finger and toe temperatures will be necessary where such peripheral cooling may occur.

All those exposed to conditions where there is a risk of general or local body cooling should be familiar with the signs and symptoms of such illness. The risk of frostbite from contact of the unprotected skin with cold surfaces or liquids should be understood and protected against.

Where body core temperature may be expected to fall below 36,0 °C appropriate means of rewarming should be available and a medical officer available to give advice (contactable by phone). If body core temperature is likely to fall below 35,0 °C then it would be beneficial if a medical officer or other trained personnel, such as an emergency medical technician/paramedic, were available to attend a casualty.

D.6 Medical fitness assessment questionnaire prior to cold exposure

IN CONFIDENCE

This questionnaire should be completed prior to exposure to cold conditions. It is recommended that it is administered by someone with appropriate knowledge, for example, a nurse or trained laboratory scientist.

Please circle the appropriate response.

Name ..... Date...../...../.....

Age ..... years Sex: Male/Female

Present occupation .....

1. Have you ever experienced episodes of fits or faints, or loss of consciousness (apart from concussion)? Yes/No

2. Do you suffer from thyroid or other general medical disease, for example, diabetes mellitus? Yes/No

3. Do you suffer from any disease of the heart or blood vessels, including high blood pressure? Yes/No

4. Do you suffer from Raynaud's phenomenon, or other peripheral vascular disease? Yes/No

5. Do you suffer from any chest disease, e.g. asthma or chronic bronchitis? Yes/No

6. Have you been treated for any serious mental ill health, or do you suffer from anxiety or depression? Yes/No

7. Do you suffer from any disease of the skin? If yes, please specify Yes/No

   .....

8. Do you suffer from any rheumatism or diseases of the joints? Yes/No

9. Do you currently take any medication? Yes/No

   If yes, please specify .....

   .....

10. Have you ever experienced any general or local allergic reaction to cold? Yes/No

    If yes, please specify .....

    .....

    .....

11. Have you ever suffered from any freezing or non-freezing cold injury? Yes/No

    If yes, please specify .....

    .....

    .....

12. Have you ever suffered an episode of low body temperature requiring medical treatment? Yes/No

    If yes, please specify .....

    .....

    .....

13. If female, is it possible that you are now pregnant? Yes/No

NOTE If the reply to any question from 2-13 is yes, refer to the medical officer for advice. Note that prescribed or self-administered medication may impair physiological responses to the cold.

14. Do you smoke cigarettes or other tobacco? Yes/No

    If yes, please specify .....

15. How often do you drink alcohol?

    never/occasional/regular/daily

16. How often do you undertake exercise which leaves you out of breath?

    never/occasional/regular/daily

17. Please give any other relevant comments here.

    .....

    .....

    .....

    .....

BRIEF EXAMINATION DETAILS

1. Height ..... cm

2. Weight ..... kg

3. Assessment of height and weight:
   e.g. Body Mass Index (weight in kg/height in m^2) .....
   % greater or less than recommended weight for height .....

4. Resting heart rate ..... bpm
   sitting/lying (record posture)

5. Resting blood pressure ..... /..... mmHg
   sitting/lying (record posture)

Annex E
(informative)

Practical requirements of medical supervision in the laboratory, or during field studies with volunteers not normally exposed

E.1 General

In preparing for appropriate medical supervision, the points described in E.2 and E.3 should be considered.

E.2 Medical fitness assessment

a) A copy of the experimental protocol and an assessment of the severity of expected stress on the subjects must be supplied to the independent medical officer.

b) Adequate facilities, comprising a room with a couch and hot running water should be made available to the medical officer for the conduct of medical examinations.

c) Arrangements must be made for the confidential storage of personal medical information. Clinical details must only be held and seen by a medical officer.

d) Following medical examination, fitness to participate in a study should be certified in writing by the medical officer. The period of validity of the certificate should be stated.

e) Where any significant abnormality is detected in the course of such examinations then, with the individual's consent, this should be notified to his or her normal medical adviser.

f) Where experimental observers will also be exposed to environmental extremes in the course of an investigation, they should also have their fitness assessed for their own and their subjects' protection.

g) The form of medical checks which are relevant to instrumentation which may be used for physiological monitoring are as follows:

   — internal abdominal temperature — past history of bowel disease or surgery;

   — rectal temperature — history of anal disease, e.g. fissure;

   — aural or tympanic temperature — examination of aural canal and tympanic membrane;

   — oesophageal temperature — history of nasal disease or injury, disorder of the mouth, throat, pharynx or hypopharynx;

   — peripheral skin temperature — examination for active skin disease and question regarding any allergy to adhesive tape;

   — aural and oesophageal probes should be inserted by individuals with appropriate training.

E.3 Health monitoring

a) The experimenter, and any other person monitoring the subjects, must have access to data on the environmental conditions in the laboratory or chamber at all times when subjects are exposed, and there should be a facility to allow vocal communication with the subjects.

b) Individuals exposed to extreme environments should be briefed on the symptoms they may experience as a result of the environmental stress and on the action they should take if such symptoms occur.

c) Withdrawal criteria should be set in the experimental protocol and, once approved, not exceeded.

d) There should be adequate access to an exposure chamber to allow a subject who has collapsed to be easily removed, and there should be adequate staff available to allow assistance to be given to an indisposed subject without the supervision of other exposed subjects being compromised.

e) Subjects should not normally leave the laboratory until they have fully recovered from any adverse effects of exposure. A record should be kept of the conditions to which subjects have been exposed.

f) Appropriate facilities for the initial resuscitation of any individual affected by the environmental conditions must be available.

NOTE See also informative annex B

g) Arrangements should be in place for the rapid removal of any casualty to a hospital with emergency treatment facilities.

Annex F
(informative)

Occupational exposures to extreme heat and cold

F.1 General

The recommendations given in this annex provide a **minimum** level of medical supervision

F.2 General

All activity which might entail any risks to the worker should be evaluated by means of a formal risk assessment, the purpose of which is to identify ways in which exposure to those risks may be avoided or reduced. This applies to the full range of hazards which may be met in occupational activity and not only to those arising from the thermal environment. Wherever possible, all work activities should be planned in a way which avoids extreme exposures to hot or cold environments.

The planning and organization of work must take account of national health and safety legislation. Detailed arrangements for medical supervision of workers should be subject to consultation with workers and their representatives.

F.3 Hot exposures

The desirable aim for exposures in hot conditions is to arrange that body core temperature does not exceed a value of 38,0 °C, the upper level considered acceptable from physiological monitoring in ISO 9866. In those circumstances for which the use of ISO 7243 is appropriate, its correct use will achieve this result.

There will always be a small number of occupational activities where this condition cannot be achieved due to the combined effects of activity level, clothing worn and environmental conditions. For the purposes of this International Standard, these situations may be considered in the three categories of regular exposures, exceptional exposures and emergencies.

All such exposures must be properly planned and account taken of the other hazards to which the workers will be exposed, for example contact with hot surfaces. Appropriate measures to control the exposure, usually by limiting the duration, will need to be put in place.

Regular exposures are those with which managers and workers may be engaged on an almost routine basis. They include work in protective clothing which limits heat loss in moderately elevated or high ambient temperatures: for example, spraying preservatives in the roof space of buildings or stripping insulation from hot pipe-work. Also included would be very hard physical work in moderate ambient conditions or training activities for emergency exposures.

Exceptional exposures are those which occur only on an infrequent basis and where there is not day to day practice in their management. These may occur at relatively short notice. Examples of such exposures are planned maintenance around structures in electricity-generating stations or furnaces, or very brief interventions to rectify damage during hot production processes.

Emergency exposures cover most of the work of fire and rescue authorities including rescue services in mines. Here there is an imperative to save human life, but not at the risk of the emergency workers themselves. Prior training and proper control at an incident can limit the effects on emergency personnel even although it is not possible to prepare for specific emergencies in advance.

F.3.1 Medical fitness assessment

Detailed arrangements for the medical assessment of workers is the responsibility of the occupational physician or occupational health service with oversight of that group of workers. All workers who may be exposed to extreme heat gain would benefit from a medical fitness assessment prior to such exposures taking place.

It is suggested that the form of that assessment should include a questionnaire, as given in clause C.7 and a clinical examination. The latter is proposed as standard practice for the following reasons:

— collapse of the worker will have an effect on the activity and safety of others;

— occupational exposures are harder to monitor than those in laboratories;

— heat may be only one of the hazards to which the worker is exposed;

— there will be a full age range in the working population.

It is not proposed that formal tests of heat tolerance are adopted, although a past history of heat illness in an individual may indicate heat intolerance and must be given careful consideration.

Workers who are accepted as fit for work in extreme hot conditions should have their fitness reviewed on a regular basis. This is particularly important for those who are not regularly exposed to hot conditions. The frequency of repeat assessments will be specified in national codes or regulations, for example, in Germany, Berufsgenossenschaftliche Grundsatz G30.

F.3.2 Health monitoring

Opportunities for health monitoring during exposure to heat are often limited. In most cases, however, it is possible for workers to keep a visual check on their colleagues and to observe for signs of heat exhaustion or abnormal behaviour. Understanding the effects of heat illness and training in what to look for should form part of the management of such activities. This should be supplemented by advice on preventive measures, such as maintenance of adequate hydration.

Where new exposures are started on a routine basis, consideration should be given to arranging for an individual with appropriate training (doctor or first aider, occupational health nurse, emergency medical technician or paramedic) to observe the workers and to confirm that clinical harm does not result. Workers may be monitored using the methods described in ISO 9886 or by means of their subjective responses and clinical signs. Monitoring body temperatures in occupational settings is often difficult, although portable electronic devices are now available which can make records of heart rate on a continuous basis, as well as displaying the current value, and personal heat-stress monitors are under development.

Once a pattern of responses has been established for a particular task then the need for close monitoring will diminish, although care should be taken when new workers start or where there is any change in the nature of the exposure, or gaps in continuing experience.

With exceptional exposures, there may be a greater degree of uncertainty about the responses which may occur and there is likely to be a greater degree of inexperience for the individuals exposed. In such circumstances, the provision of a trained individual to observe the work (as previously described) will be an appropriate safeguard.

The status of the individuals who are monitoring the workers should be agreed before the work takes place. For example, whether they have the authority to stop the task or to withdraw individuals from the exposure. This may be important where the worker's behaviour or decision making can be affected by the heat. Only in rare circumstances should it be necessary for a medical officer to be actually present, although in all cases arrangements for first aid and for further treatment of possible casualties must be in place. This may include the facility to obtain advice from a medical officer and to transfer a casualty to hospital.

Emergency exposures provide the least opportunity for monitoring the condition of the workers involved. Emergency workers will not be exposed on their own and a “buddy” system of monitoring will be normal. Personal alarm devices based on physiological responses are a possible development. However, proper organizational control of exposures will remain essential.

Monitoring of workers exposed to heat may have to extend beyond the period of actual exposure to ensure that adequate recovery takes place before individuals leave the worksite, or are considered fit for a subsequent re-exposure to heat.

F.4 Cold exposures

F.4.1 Indoors

The majority of indoor occupational exposures to cold take place in the course of food preparation or storage. Many food preparation exposures take place in the moderately cold range where discomfort is the main problem, although long-term health effects have also been suggested. Extreme exposures to cold at work take place in the course of cold-storage work. There are few, if any, situations where exposures which are not of this regular pattern, i.e. exceptional or emergency exposures, are likely to take place.

F.4.1.1 Medical fitness assessment

For regular exposures to extreme cold, workers should have the benefit of a medical fitness assessment. It is suggested that the format for this assessment should be based on the advice given in informative annex D for laboratory exposures, with a questionnaire assessment supplemented by a medical examination. The frequency of repeat assessments will be specified in national codes or regulations, for example, in Germany, Berufsgenossen-schaftliche Grundsatz G 21.

F.4.1.2 Health monitoring

Workers should use a buddy system to monitor their own and others' behaviour and signs of ill health. Occupational exposures to extreme cold should be managed in such a way that the risk of significant hypothermia is minimal. In most cases, there will be no need for trained first aiders or an occupational health nurse to provide further objective assessment of the workers' condition.

F.4.2 Outdoors

The potential for extreme cooling can arise both in temperate and polar regions as a result of the effects of wind chill, precipitation and low ambient temperatures. In temperate zones, people who may be affected include farmers, linesmen, maintenance workers on road and rail networks and emergency personnel, along with workers on offshore installations and sea-going fishermen. In polar regions, these and other workers may be affected. This type of exposure may be thought of as "regular", but with the potential for "exceptional" exposures where climatic conditions change or accidents occur. Emergency exposures include the need to locate and rescue people who have become lost or whose transport has become disabled in remote areas.

F.4.2.1 Medical fitness assessment

It is suggested that all outdoor workers who may be exposed to extreme cold would benefit from a fitness assessment. The details are at the discretion of the occupational physician with responsibility for the workers but may follow the advice given in informative annex D. It is likely that a medical examination will also form part of this assessment.

F.4.2.2 Health monitoring

The provision of formal health monitoring is not usually practical in such work environments. Working alone in cold environments is hardly ever suitable and people should operate a buddy system to observe for early signs of cold injury, see informative annex B. People who work in cold environments, especially in sparsely populated areas should be trained in first aid for illness and accident and in appropriate survival techniques. Work organization should minimize the risk of ill health and first-aid equipment should be available. A reliable system of communications will facilitate the early provision of assistance in the event of an accident or an emergency, such as a transport breakdown.

F.5 Long-term health effects

Those who are occupationally exposed to extreme heat or cold may experience these conditions on a regular basis throughout a working lifetime. Chronic effects from exposure to heat and cold are not universally agreed upon. It has been suggested that general stress reactions may follow continued heat exposure, as well as there being an increased risk of kidney stones. (Heat intolerance can follow an episode of acute heat illness.) It has been suggested that some arthritic and musculoskeletal disorders may be more common in those regularly exposed to cold, and a range of symptoms, including those from the gastrointestinal tract, rheumatism and bronchitis have been reported in workers exposed to moderate cold.

Long-term health surveillance may be appropriate for workers chronically exposed to extreme heat or cold. As a minimum, this could consist of a record of the exposures to which people have been subject, with the facility for individuals to notify any experience of ill health which they consider may be attributable to these exposures.

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