Virginia Defense Force
Pamphlet 385–4

Safety

Thermal Injuries

Headquarters
Virginia Defense Force
5001 Waller Road
Richmond, VA 23230-2915
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Headquarters
Virginia Defense Force
George Washington Division
Richmond, VA
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Safety

THERMAL INJURIES

Summary. This document is an adaptation of several DoD publications relating to hot and cold thermal injuries, for use by the units of the Virginia Defense Force (VDF). This pamphlet provides guidance to commanders and other personnel in the detection, identification, prevention, and first aid treatment of environmental thermal injuries.

Applicability. This pamphlet applies to units of the VDF. During mobilization for state active duty, procedures in this publication can be modified to support policy changes as necessary.

Suggested Improvements. Users are invited to send comments and suggested improvements directly to Headquarters, Virginia Defense Force, George Washington Division, Division Safety Office, 5001 Waller Road, Richmond, Virginia 23230-2915.

Distribution. Distribution is intended for all VDF units down to, and including, company-level.

JOHN D. TAYLOR
Major General, Virginia Defense Force

Contents (Listed by paragraph and page number)

Chapter 1

INTRODUCTION

1–1. Introduction
Virginia Defense Force Pamphlet (VDFP) 385-1 focuses on identifying and reducing the risk of illness and injury through appropriate surveillance, prevention and control programs and measures. This pamphlet supports the VDF in the area of thermal protection of personnel by providing background information and direction to Commanders, supervisors and individuals on the measurement and prevention of thermal injury to VDF personnel.

1–2. Purpose.
The purpose of this VDFP is to provide guidance in the prevention and treatment of thermal injury in VDF personnel.

1–3. Historical Perspective
History has demonstrated the difficulties in hostile thermal environments. The thermal stresses upon, and subsequent thermal strain experienced by, personnel can have a detrimental effect upon mission success by degrading both individual and, ultimately, collective performance.

1–4. Basic Heat Exchange Principles
Thermal injury is caused by either a rise or fall in the body's core temperature. Control of human body temperature can be simplified by the following heat balance equation:

Heat Storage = Heat Gained – Heat Loss

1–4–1. Heat Gain and Loss
Heat may be gained from that generated by exercise, the surrounding environment and equipment. Heat loss is mainly through sweating although a small amount is lost through conduction and convection. Excess heat gain over heat loss may result in the storage of heat in the body and vice versa. The result of which is a rise or fall in the body core temperature with the associated potential for injury.

1–4–2. Fatigue Relation to Heat Storage
Moreover, when individuals are wearing protective clothing assemblies, personal fatigue and time to exhaustion are inversely related to the initial level of core body temperature and are directly related to the rate of heat storage.

1–4–3. Risk of Error
Individual and collective risk of error exists in thermal environmental extremes.

1–5. Definitions

1–5–1. Heat Illness
Traditional heat illness has been divided into heat exhaustion and heatstroke. In practice the division is difficult to define, thus, for the purpose of this VDFP the term 'heat illness' is all embracing and applies to an individual who becomes incapacitated as the result of a rise in core body temperature.

1–5–2. Cold Injury
Cold environments pose a threat to the individual if they exceed the capacity of the body's thermo-regulatory response mechanisms. The main hazards are hypothermia associated with a fall in the body's core temperature and/or tissue damage that falls under the broad headings of freezing cold injury (FCI) and non-freezing cold injury (NFCI). For the purposes of this VDFP the term 'cold

injury' is all embracing and applies to an individual who becomes incapacitated as the result of a drop in core body temperature, FCI, or NFCI.

Chapter 2

GENERAL HEALTH SUPPORT, PREVENTIVE MEASURES AND RISK FACTORS

2–1. Training, Exercise and Operations

During training, exercises and operations, Commanders must take into account general health support measures in hostile thermal environments that complement specific temperature observations, comprising:

(1) Provision and management of appropriate work and rest cycles.
(2) Training and information to all assigned personnel in the recognition of the signs and symptoms and prevention of heat illnesses and cold injury.
(3) Provision of appropriate fluid replacement in both hot and cold environments.
(4) The associated implications of operating in a hot or cold environment while wearing personal protective equipment (PPE).
(5) Where the tempo of operations permits, the importance of acclimatization measures.

2–2. Preventive Measures

The key to the prevention of thermal injury is an awareness of thermal risk factors by Commanders, supervisors and individuals at all levels. Any task involving physical exertion in a hot or cold climate and subsequent exposure to high or low ambient temperature should be considered a high-risk activity. When there is a thermal casualty risk, it is the Commander's duty to ensure that resources are available to undertake an appropriate risk assessment. A combination of administrative and physical methods of risk management provides greater protection to a workforce than single measures alone.

2–3. Acclimatization to Heat

The process of acclimatization is characterized by a series of physiological adjustments that occur when an individual is exposed to a hot climate. Adaptation typically occurs during the first 10 to 14 days of heat exposure and the largest change occurs at days 3 to 5. An individual is considered acclimatized if he or she has undertaken regular exercise for longer than 10 days in the same environmental conditions as the proposed activity. **However, for the purpose of risk management, no VDF personnel should be considered as acclimatized for state active duty (SAD) as activation is usually less than 10 days in duration.**

2–4. Individual Risk Factors for Heat Injury

There is a wide variation in human tolerance to heat stress. Nevertheless, it is possible to identify factors that can cause particular individuals to become heat casualties. The following personal factors must be considered when assessing individual heat injury risk:

(1) Obesity.
(2) Lack of physical fitness and/or lack of sleep.
(3) Recent alcohol intake.
(4) Concurrent mild illness (e.g., diarrhea, viral illness, fever, etc.).
(5) Dehydration.
(6) Medications or illegal drugs.
(7) Prior history of heat illness / injury.
(8) Some metabolic diseases.

2–5. Individual Risk Factors for Cold Injury

Systematic review of accidental cold injury has identified the following individual risk factors in a cold environment and must be considered:

(1) Alcohol.
(2) Psychotropic medication.
(3) Insufficient clothing.
(4) Wetness from either the environment or sweat.
(5) Lean body mass.
(6) Physical exhaustion.

(7) Concomitant illness.

2–6. Environmental Assessment and Determination of Thermal Injury Risk

The risk of thermal injury can be determined by an assessment of the thermal stress placed upon personnel as a function of the air temperature, wind speed and humidity. Measurement indices of these environmental parameters fall into 3 categories, according to their derivation and comprise:

(1) Indices that measure physical heat exchange but ignore the human physiological response to thermal stress. Examples include the index of thermal stress and the heat stress index.
(2) Indices based upon empirical observations from physiological experiments including the WBGT Index, the wet-dry index and the predicted 4 hour sweat rate.
(3) Indices based upon the subjective responses of individuals exposed to different thermal environments, such as the effective temperature index and the corrected effective temperature. In sum, this group attempts to provide a measure of thermal comfort rather than thermal stress.
(4) The VDFP utilizes those indices that can be easily applied, measured and interpreted when conducting either deployed or home location operations; namely the WBGT Index and the WCT Index.

Chapter 3

THERMAL INDICES

3–1. The WBGT Index

Detailed analysis of the influence of the environment on thermal stress requires a knowledge of the following 4 basic parameters; air temperature, mean radiant temperature, air speed and absolute humidity. The WBGT index combines the measurement of two derived parameters, natural wet bulb temperature (Tnwb) and the black globe temperature (Tbg) and, in some situations, the measurement of the basic parameter, air temperature (Tdb). The WBGT index can be determined using either the field apparatus described in the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) handbook, the portable handheld WBGT kit (NSN 6665-00-159-2218) or a suitable commercially available apparatus. The WBGT formulae are as follows:

(1) WBGT = 0.7 Tnwb + 0.2 Tbg + 0.1 Tdb °F (outdoors).
(2) WBGT = 0.7 Tnwb + 0.3 Tbg °F (absent solar load or indoors).
(Where Tnwb = natural wet bulb, Tbg = black globe and Tdb = dry bulb temperatures.)
3) Thermal stress indices that account for the thermal environment provide further guidance to Commanders against which they can judge the risk of injury to their subordinates against the mission requirements. Therefore, the measurement of the WBGT index must closely relate to the training or working conditions.
(4) The data collected by trained personnel is to be compared to reference values shown at Table A2.1. and Table A2.2. of Attachment 2 and, when necessary, used to implement administrative and personnel procedures to directly reduce thermal strain and subsequent thermal stress at the workplace.
(5) When the forecast outside temperature reaches 85°F as a daily high, WBGT measurements are to be taken a minimum of 4 times, evenly spaced, during the hottest part of the day.
(6) Thermal stress levels are to be displayed around the base or the deployed area, using a color-coded system, such as flags or boards as highlighted in Table A2.2. of Attachment 2. Consideration must be given to increasing the frequency of WBGT measurements in particularly hit environments.

3–2. The WCT

Cold injury prevention relies upon minimizing exposure and reducing heat loss using clothing. Operations in cold regions of the world expose personnel to the hazards of cold stress and consequent risk of hypothermia, FCI and NFCI. In November of 2001, Air Force Weather Units implemented the revised WCT Index chart for 2001/2002 as shown in Table A3.1. of Attachment 3. Specifically, the new calculations account for:

(1) A calculated wind speed as an average height of five feet or the typical height of an adult human face based on readings from the National Standards height of 33 feet, the typical height of an anemometer.
(2) Basis on a human face model.
(3) Modern heat transfer theory and heat loss from the body to the surroundings during cold and breezy or windy days.
(4) Lowering the calm wind threshold to 3 mph.
(5) A consistent standard for skin tissue thermal resistance.
(6) Assume no impact from sun (i.e., clear night sky).

3–3. Tasked Personnel

Tasked personnel remain responsible for the determination of the wind chill index zones of risk and displaying colored flags or boards at home stations or deployed locations in order to minimize the risk of cold injury to personnel IAW the WCT.

Chapter 4

THE ADMINISTRATIVE APPLICATION OF THE WBGT AND WCT INDICES

4–1. Fluid Replacement

Water is the key component of sweat that enables heat loss to occur. Therefore, it is essential to maintain fluid intake to meet loses secondary to evaporation and maintain hydration. All water referred to in this VDFP is to be cool, potable, and from a guaranteed safe source.

4–1–1. Thirst an Unreliable Guide to Level of Hydration

Thirst is an unreliable guide to the level of hydration in either a hot or cold environment. Personnel are to drink adequate water before, during, and after high thermal risk activities. Urine color is a reliable indicator of an individual's hydration status. Personnel exposed to either extreme of hot or cold environments are to be instructed to drink sufficient water that their urine remains colorless. The risks of over hydration and potential electrolyte imbalance are to be emphasized to all personnel.

4–2. Fluid Composition, Sodium Intake and Dietary Supplementation

Replacement fluid composition remains the subject of academic debate and research. The Military Committee on Nutritional Research (1994) considered electrolyte replacement, endurance and performance. In summary, there was little direct evidence that electrolyte supplementation was beneficial, except in a small proportion or endurance athletes. However, the low concentration of electrolytes found in most fluid replacement beverages can enhance palatability and thus serve to encourage fluid consumption. Notwithstanding this potential benefit, the only study to examine high sodium intake, both as a supplement to diet in food and electrolyte drinks, during heat acclimatization found detrimental cardiovascular and performance effects. Under-hydration was postulated as a potential mechanism since a 1 liter of water must be consumed for each 5 g of sodium chloride added to the diet. Personnel are to be encouraged to maintain a normal diet, with supplemental salt to taste and must maintain a regular intake of water. Palatability of fluids may be enhanced by the addition of commercial electrolyte powders.

4–3. Workload and Fluid Intake in Hot Environments

Guidelines for work/rest schedules and fluid intake in the WBGT precaution zones for un-acclimatized personnel in a hit environment are shown in Table A4.1. and Table A4.2. of Attachment 4. Tables A5.1. and A5.2. of Attachment 5 provide a broad description of advisory work/rest schedules against WBGT index and a broad guide to the determination of workload intensity. Line managers are to ensure that all personnel under their supervision are aware of these limitations.

4–4. Workload and Fluid Intake in Cold Environments

In cold environments the principle routes of fluid loss and subsequent deficit are cold induced diuresis, respiratory water loss, cold weather clothing, and the metabolic cost of movement and reduced fluid intake. Personnel should be encouraged to maintain fluid intake in accordance with the un-acclimatized recommendations in Table A4.1. and Table A4.2. of Attachment 4. Personnel are to be encouraged to eat a normal diet, incorporating moderate carbohydrate and fat intake.

4–5. Precautionary Measures During Exercise in the Heat

The following general precautionary measures are to be applied when exercising in heat:

(1) Clothing should be lightweight, loose fitting and preferably natural fiber. Dress and equipment increase the risk of heat illness by increasing workload and by reducing the body area available for the evaporation of sweat. In hot environments, loose fitting clothing is to be worn, particularly at the neck and wrists to allow air circulation. Furthermore, appropriate headgear is to be worn, in addition to the use of sun block to prevent sunburn.
(2) When battle dress uniform (BDU) is required for a particular activity, the use of BDU Hot Weather is to be mandated and enforced when a yellow flag or higher WBGT heat condition is expected for the day.
(3) During endurance exercise, small quantities of fluid should be drunk at frequent intervals and water sprayed on the skin at every opportunity.
(4) The use of sweat inhibiting deodorants should be avoided.

(5) Personnel should not exercise in the heat immediately after a glucose or high carbohydrate meal due to the diversion of blood from the skin to the gastrointestinal tract.
(6) Endurance events should be cancelled if the WBGT index exceeds 82°F.

4–6. Cold Environment Considerations

Cold impinges on the safety of operations by a variety of mechanisms comprising:

(1) Exposure of hands and arms with subsequent reduction in sensation and manual dexterity.
(2) Discomfort and subsequent distraction.
(3) Limitation of movement and duties while wearing bulky protective clothing.
(4) Contact with freezing metal components and risk of FCI.
(5) Dehydration.
(6) Sleep deprivation is associated with higher sensations of cold and shivering.

4–7. Cold Exposure Reduction

Advisory work/rest schedules and practices in a cold environment are shown in Table A3.2 of Attachment 3. Moreover, the following may reduce cold exposure:

(1) Elimination of non-essential outdoor tasks.
(2) Where possible, performing tasks indoors.
(3) Provision of temporary shelter for essential outdoors work, preferably heated.
(4) Increasing the number of personnel allocated to a task and operating in a rotational duty system.
(5) Layered protective clothing systems are available.

4–8. Training and Education

Personnel assigned to hot or cold weather operations should receive thorough training in the bio-medical problems of heat and cold, with continuation training annually. Training should include the subtle psychomotor signs of thermal injury. Suggested topics include the following:

4–8–1. Climate

Local weather conditions, heat stress index concepts and warnings, wind-chill concepts and warnings.

4–8–2. Heat Illness

Fluid replacement, work/rest schedules, signs and symptoms, first aid treatment.

4–8–3. Cold Injury

Signs and symptoms of freezing and non-freezing cold injuries, human performance in the cold, psychomotor effects, fluid replacement.

4–8–4. Protective Clothing Systems

Principles of use, design, proper wear and maintenance, risk of wet clothing, associated hazards of protective clothing systems including reduced mobility, impaired hearing, visual fields and generation of static electricity.

Chapter 5

FIRST AID AND EMERGENCY TREATMENT GUIDANCE FOR HEAT AND COLD INJURY

5–1. Heat Illness

Recognition of heat illness is the key principle in treatment and management. In general, any individual experiencing the following signs or symptoms during physical activity in a hot environment or while wearing personal protective clothing should be presumed to be suffering from heat illness:

(1) Dizziness or confusion.
(2) Nausea or vomiting.
(3) Staggering.
(4) Disturbed vision.
(5) Confusion, collapse or loss of consciousness.

5–2. Heatstroke

5–2–1. Predisposing factors for heatstroke

Heatstroke develops when the body is unable to dissipate excess heat under various combinations of high environmental temperature, high humidity, lack of wind, vigorous activity, heat retaining clothing, and dehydration.

5–2–2. Clinical presentation of heatstroke

Early symptoms include excessive sweating, headache, nausea, dizziness, hyperventilation and disturbance of consciousness. Consciousness may be lost or clouded and there may be some hallucinations. There may be muscle twitching or convulsions and loss of control of the body sphincters. In severe cases, there may be a deep coma with pinpoint pupils and shock with tachycardia. Tachypnea (rapid breathing) is often present and breathing may become difficult and vomit subsequently inhaled. The patient feels warm or hot and has a high core temperature usually in excess of 103ºF. Sweating may or may not be present. The diagnosis depends on a high index of suspicion.

5–2–3. Medical Complications of heatstroke

Heatstroke victims are in danger of developing irreversible damage of the brain, kidneys, liver, and adrenal glands with subsequent death. Disseminated intra-vascular coagulation (blood clotting) may occur.

5–2–4. Treatment of Heatstroke

Heatstroke is a medical emergency. Treatment should be started as early as possible. Clinical outcome is a function of both the severity and duration of temperature elevation. Unnecessary cooling is safer that waiting for a definite diagnosis. **COMPREHENSIVE EMERGENCY MANAGEMENT OF HEAT STROKE IS BEYOND THE SCOPE OF THIS PAMPHLET AND REQUIRES RESOURCES FOUND IN AN EMERGENCY DEPARTMENT OR INTENSIVE CARE UNIT.** On suspicion of heatstroke the following guidelines may be applied while arranging for and during emergency transportation to definitive care (intensive care support will eventually be required):

(1) Lie patient flat, remove him or her from heat to the greatest extent possible and remove any restrictive clothing.

(2) Non-immersion. In the field, cool by removing clothing, spraying with water, and fanning (helicopter downdraft cooling has been used successfully on heatstroke victims). If available, apply cold packs or ice packs over major arteries (e.g., neck, axillae and groin – with care to avoid frostbite), apply sheets soaked in ice water or ice water slush to part of the body.

(3) No medication has been shown to decrease core temperature.

5–3. Heat Syncope, Heat Exhaustion, and Heat Cramps

Heat exhaustion is caused by excessive exposure to heat and depletion of body fluids. Victims sweat profusely and may shiver and have goose bumps. Weakness, nausea, dizziness, headache, poor judgment, rapid pulse, and a normal or slightly elevated body temperature are present. Heat cramps occur in healthy individuals during or following strenuous physical activity. Muscles, oftentimes those in the calf, cramp and produce severe pain. Fainting from the heat is referred to as heat syncope. Treatment includes rest in a cool, shaded environment and fluid replacement. Cramped muscles should be stretched or massaged.

5–4. Sunburn

Unprotected exposure to sun can cause sunburn, accelerate skin aging, may cause drug photosensitization, and depress skin immune responses. Sunburn also increases the risks of skin cancer; basal and squamous cell carcinomas on exposed areas and melanomas anywhere on the body. Altitude and reflective surfaces such as fresh ice, snow, sand, metal, concrete, and wind increase the risk and severity of sunburn.

5–4–1. Sunburn Prevention and Treatment

Clothing and sunscreens according to skin type can prevent sunburn. Sunscreens are to protect against ultraviolet (UV) A and UV B and provide a minimum sun protection factor of 15. The table below outlines sunburn treatment guidelines:

Table 5.1. Sunburn Treatment Guidelines

Mild Sunburn	Severe Sunburn (blistering)
Avoid further exposure Cool soak-tap water Emollients Aspirin and other non-steroidal anti-inflammatory drugs Topical steroids	Seek medical evaluation and treatment.

5–5. Cold Injury

If body heat loss exceeds heat production then hypothermia will develop. The condition is defined as occurring when the body's core temperature falls to 95°F or below. Recognizing the early signs and symptoms of hypothermia is the key to treatment and management. These include:

(1) Profound shivering.
(2) Slurred speech.
(3) Psychological symptoms include aggressive or withdrawn behavior.
(4) Progressive reduction in the shivering response and loss of consciousness.

5–6. Hypothermia

Hypothermia is defined as a core temperature below 95°F and develops as the rate of heat loss exceeds heat production. Three types of hypothermia can be distinguished, based upon the mechanism of cold exposures comprising:

a. **Immersion.** Very severe cold stress occurs, for example, following ejection or immersion into water.

b. **Exhaustion.** Less severe cold stress, most frequently following a combination of wind and wet exposure with moderately low temperatures.

c. **Urban.** Cold is relatively mild and prolonged. Most common in the elderly or malnourished.

5.6.4. **Diagnosis of Hypothermia.**

In a cold environment, the possibility of hypothermia should always be suspected. Early symptoms comprise changes in behavior followed by uncoordinated movement, staggering, dysarthria (poor speech articulation) and subsequent clouding and loss of consciousness (Grumble, Mumble, Fumble and Stumble)

with an eventual fall in heart and respiratory rate with death as the final outcome. It should be noted that similar symptoms occur in hyperthermia (elevated body temperatures), exhaustion, and hypoglycemia (low blood sugar). Measuring the core temperature, usually rectally, aids accurate diagnosis. However, low reading thermometers may not be readily available where casualties occur. Thus, for practical purposes, an individual should be treated as a cold casualty if the body feels "as cold as marble," particularly if the armpit is profoundly cold.

5.6.5. **Pre-Hospital Management of Hypothermia.**
In all three preceding situations, removing the casualty from the cold environment prevents further heat loss. Movement must be gentle in order to avoid triggering cardiac arrest. Until the casualty is in shelter wet clothes should not be removed. Layers of insulating materials should be placed on top of the casualty's clothing, including the head, and covered with a layer that is water and wind proof. Foil blankets are often recommended, but are no more effective than a similar thickness of cheaper plastic. These measures will probably be sufficient in immersion hypothermia. With urban hypothermia no additional heat, either surface or central, should be applied before admission to a hospital, as this may precipitate fatal pulmonary or cerebral edema or both by reversing inter-compartmental fluid shifts.

5.6.6. **Resuscitation After Hypothermia.**
Respiratory obstruction should be cleared and, if necessary, expired air ventilation started using the same criteria and rate as in normothermia (normal body temperature). Cardiopulmonary resuscitation, at the same rate as in normothermia, should be started if indicated. Casualties totally submerged in very cold water, especially those who are young, have been known to recover even after submersion of up to one hour. Resuscitation must start immediately on rescue. The indication for commencing cardiopulmonary resuscitations comprises:

5.6.6.1. No carotid pulse is detectable for at least on minute **OR** cardiac arrest is observed; that is, the pulse disappears or there is a reasonable chance that cardiac arrest occurred within the previous two hours.

5.6.6.2. There should be a reasonable expectation that effective cardiopulmonary resuscitation can be continued, with only brief periods of interruption for movement, until the casualty can be transported to a hospital and advanced life support can be provided.

5–7. Freezing and Non-Freezing Cold Injury

As skin temperature approaches 30°F, intense vasoconstriction of peripheral blood vessels take place with the potential for freezing of tissues and subsequent frostbite (FCI). Moreover, prolonged contact with water or wet clothing in the temperature range of 53°F can result in NFCI, a condition where the peripheral nerves de-myelinate with resultant swelling, numbness and blanching followed some time later by intense pain and hyperemia (increased blood flow, engorgement) in the affected body area. The following freezing cold injuries are described:

a. **Frostbite.** Frostbite is a localized lesion caused by freezing, usually affecting the feet, hands, ears, nose, and cheeks. The cornea has been affected in individuals not protected by goggles. Penile freezing can occur during exercise in tight or inadequate clothing or from direct contact with a metal zipper. Restricted peripheral circulation secondary to tight shoes or boots can increase the risk of frostbite as does dehydration, fatigue and exposure at altitude. In frostbite the tissues are hard, insensitive, and white or mottled in appearance. No attempt should be made to thaw frostbite if there is any chance of the affected area becoming refrozen. The freeze-thaw-refreeze cycle causes greater damage than continuous freezing. It is safer to walk on frozen feet even for 72 hours.

b. **Frostnip.** In frostnip, painful exposed skin blanches and loses sensation, but remains pliable. The affected area should be warmed by placing it in the armpit or under clothing. Tingling is followed by hyperemia and within a few minutes sensation is restored and normal activity can be resumed.

5–7–1. Treatment

Rewarming should be carried out in a hot whirlpool bath, with gradual spontaneous rewarming as a second option. Beating, rubbing with snow, or rewarming with excessive heat can produce disastrous loss of tissue. Treatment of frostbite should be under the care or direction of a physician. After recovery the sufferer can return to full activities with limitation imposed by the degree of any tissue loss.

5–7–2. NFCI

NFCI is characterized by tissue damage following prolonged exposure to temperatures above freezing, classically in the region of 59°F. The following clinical presentations are identified:

a. **Trench Foot.** Trench foot is the common title for non-freezing cold injury; others include immersion injury, paddy foot, tropical immersion foot and peripheral vasoneuropathy after chilling. Peripheral nerve de-myelination with potential muscle necrosis and atrophy develops over a long period of time as the affected body part is exposed to cold temperatures of around 60°F. As in frostbite, damage is more likely if the casualty is also suffering from fatigue, dehydration, immobility, or wearing tight footwear. The feet are initially cold and numb, giving the sensation of "walking on cotton wool" and in combination with joint stiffness, the casualty walks with legs apart in order to maintain balance. Initial examination reveals feet that are cold, swollen, and blotchy pink-purple or blanched.

b. **Treatment.** Remove the person from the cold environment and allow the affected body part to rewarm spontaneously. After rewarming, the feet become hyperemic, hot and red with paraesthesia or pain, often similar to electric shocks. These symptoms may be severe and last for several weeks, especially in weight bearing. Severe cases produce bleeding into the skin, ulceration, and blistering that may progress to gangrene. Consequent to nerve and other tissue damage, there is likely to be persistent or permanent hypersensitivity to cold with anesthesia or hyperanesthesia or problems with the bony structure of the feet.

5–8. Other Effects of Cold

Further into FCI and NFCI, the following may also be seen in a cold environment:

a. **Raynaud's Disease / Syndrome.** Cold at a severity that does not affect normal people may cause severe arterial vasoconstriction, most commonly affecting the fingers, in individuals with Raynaud's Syndrome. In severe cases this might lead to digital ulceration and tissue loss. Protection from the cold by suitable clothing, gloves, and shoes is usually sufficient. However, chemical hand warmers may be necessary. Individuals with Raynaud's are strongly advised not to smoke.

b. **Muscle Injury.** Muscle and tendon tears may occur when a person is cold, since muscle action is insufficient and may be uncoordinated in concert with joint stiffness. An active warm up, sufficiently energetic and prolonged to ensure that the whole body is warm is an effective means for reducing the risk of injury and enhancing performance.

c. **Shivering.** Cold causes shivering that can produce a performance deficit in manual skills that require steadiness.

d. **Reduced Manual Dexterity.** The fingers are much less sensitive in the cold with subsequent loss of manual dexterity. Cold impairs coordination, reduces visual acuity, general alertness and slows reflexes. Individuals are prone to making mistakes in the cold and may misinterpret sights or sounds.

Chapter 6

SUMMARY

6–1. Summary
In summary, this pamphlet provides guidance for the prevention of thermal illness secondary to heat or cold exposure. Thermal illness may follow a rise or fall in body core temperature that is not compensated by the individual's thermo-regulatory system. Further, exposure of the extremities or bare skin to cold air or water may result in tissue damage and subsequent cold injury. The fundamental approach to be taken by Commanders is one of risk assessment and management.

6–2. Commander's Summary
Commanders should make every effort to protect personnel under their command from the adverse effects of the environment, allowing for the operational imperative, in order to maximize mission efficiency.

6–3. Comprehensive Approach
Although medical personnel have an active input in the prevention and treatment of thermal casualties, the multi-disciplinary approach of utilizing weather personnel and other personnel that have been trained to monitor the thermal environment can provide a comprehensive assessment of risk to personnel. Moreover, the overall approach to thermal injury prevention and risk management, in equal measure, involves administrative techniques as well as physical. Thus, this document provides guidance to commands on thermal measurement techniques, assessment tools, work and rest schedules, and basic medical treatment guidelines.

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References:

AFPAM 48-151, 'Thermal Injury,' 18 November 2001

AFPAM 48-151_GM1, 'Air Force Guidance Memorandum to AFPAM 48-151, Thermal Injury,' 31 March 2011.

Supporting Information:

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) Handbook, 1999.

American Conference of Governmental Industrial Hygienists (ACGIH) 2012 Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) Booklet, 2012.

Quantico Marine Corps Base Order 6200.1B, 'Heat Casualty Prevention Program,' 14 August 2012.

Abbreviations:

ACGIH – American Conference of Governmental Industrial Hygienists.

BDU – Battle Dress Uniform

BEI – Biological Exposure Indices

EHS – Exertional Heat Stroke

FCI – Freezing Cold Injury

MDI – Modified Discomfort Index

NFCI – Non-Freezing Cold Injury

TLV – Threshold Limit Value

Tbg – Temperature: Black Globe

Tdb – Temperature: Dry Bulb

Tnwb – Temperature: Natural Wet Bulb

UCHS – Uncompensable Heat Stress

USARIEM – US Army Research Institute of Environmental Medicine

UV – Ultra-violet Radiation

WBGT – Wet Bulb Globe Thermometer Index

WCT – Wind Chill Temperature Index

Attachment 2

WET BULB GLOBE THERMOMETER TABLES

Table A2.1. Wet Bulb Globe Thermometer (WBGT) Index Reference Values

Metabolic Rate Class	**Metabolic Rate (M)**		**Reference Value of WBGT**			
	Related to a unit skin surface area W/m^2	Total (for a mean skin surface area of $1.8m^2$) W	Person acclimatized to heat (F)		Person **NOT** acclimatized to heat (F)	
0 (Resting)	M<65	M<117	91.4		89.6	
1	65<M<130	117<M<234	86		84.2	
2	130<M<200	234<M<360	82.4		79	
3	200<M<260	360<M<468	No Sensible Air Movement 77	Sensible air Movement 79	No Sensible Air Movement 72	Sensible air Movement 73.4
4	M>260	M>468	73.4	77	64.4	68

Table A2.2. Wet Bulb Globe Thermometer (WBGT) Stages, Temperature Ranges and Flag Colours.

STAGE	Temperature Range	Flag Color
1	78 – 81.9 F WBGT	No Flag Required
2	82 – 84.9 F WBGT	Green
3	85 – 87.9 F WBGT	Yellow
4	88 – 89.9 F WBGT	Red
5	90 F WBGT and higher	Black

Attachment 3

WIND CHILL TEMPERATURE INDEX REFERENCE VALUES

Table A3.1. Wind Chill Temperature (WCT) Index

Wind (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Note: Frostbite times are for exposed cheek skin.

30 Minutes	10 Minutes	5 Minutes

FROSTBITE RISK
LOW – freezing is possible, but unlikely (WHITE)
HIGH – freezing could occur in 10-30 minutes (LIGHT GRAY)
SEVERE – freezing could occur in 5-10 minutes (MEDIUM GRAY)
EXTREME – freezing could occur in <5 minutes (DARK GRAY)

Table A3.2. Time in minutes until the occurrence of cheek frostbite in the most susceptible 5 percent of personnel

Wind Speed (mph)	Air Temperature (°F)											
	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	>120	>120	>120	>120	31	22	17	14	12	11	9	8
10	>120	>120	>120	28	19	15	12	10	9	7	7	6
15	>120	>120	33	20	15	12	9	8	7	6	5	4
20	>120	>120	23	16	12	9	8	8	6	5	4	4
25	>120	42	19	13	10	8	7	6	5	4	4	3
30	>120	28	16	12	9	7	6	5	4	4	3	3
35	>120	23	14	10	8	6	5	4	4	3	3	2
40	>120	20	13	9	7	6	5	4	3	3	2	2
45	>120	18	12	8	7	5	4	4	3	3	2	2
50	>120	16	11	8	6	5	4	3	3	2	2	2

Note: Wet skin could significantly decrease the time for frostbite to occur.

FROSTBITE RISK
LOW – freezing is possible, but unlikely (WHITE)
HIGH – freezing could occur on 10-30 minutes (LIGHT GRAY)
SEVERE – freezing could occur in 5-10 minutes (MEDIUM GRAY)
EXTREME – freezing could occur in <5 minutes (DARK GRAY)

Table A3.3. List of recommended preventive measures to decrease frostbite risk

Frostbite Risk Level	Preventive Measures
Low	• Recommend W/R cycle: 50 minutes work/10 minutes warming • Increase surveillance with self and buddy checks. • Wear appropriate layers and wind protection for the work intensity. • Cover exposed flesh, if possible. • Wear VB boots below 0°F. • Provide warming facilities below 20°F. • Avoid sweating.
High	• Recommend W/R cycle: 40 minutes work/20 minutes warming • Mandatory buddy checks every 20-30 minutes. • Wear appropriate layers and APECS. Protect head, face and hands. • Cover exposed flesh. • Wear VB boots below 0°F. • Provide warming facilities. • Avoid sweating.
Severe	• Recommend W/R cycle: 30 minutes work/30 minutes warming • Mandatory buddy checks every 10 minutes. • Wear appropriate layers and APECS or cold weather parka. Protect head, face and hands. • Wear VB boots. • Provide warming facilities. • Work groups of no less than two personnel. • No exposed skin. • Stay active. • Avoid sweating.
Extreme	• Mission critical work only due to extreme risk. • Keep task duration as short as possible. • Wear appropriate layers, cold weather parka and wind protection. Protect head, face and hands. • Wear VB boots. • Provide warming facilities. • Work groups of no less than two personnel. • No exposed skin. • Stay active. • Avoid sweating

Notes: Work/Rest (W/R), Vapor Barrier (VB), All Purpose Environmental Clothing System (APECS)

Attachment 4

TRAINING GUIDELINES FOR ACCLIMATIZED AND UN-ACCLIMATIZED PERSONNEL WEARING HOT WEATHER BDU

Table A4.1. Training Guidelines for Average Acclimatized Personnel Wearing BDU, Hot Weather

Heat Cat. / Flag Color	WBGT (F)	EASY WORK		MODERATE WORK		HEAVY WORK	
		Work Rest Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr
1	78 – 81.9	No Limit	0.5	No Limit	0.75	40/20 min	0.75
2 (Green)	82 – 84.9	No Limit	0.5	50/10 min	0.75	30/30 min	1.0
3 (Yellow)	85 – 87.9	No Limit	0.75	40/20 min	0.75	30/30 min	1.0
4 (Red)	88 – 89.9	No Limit	0.75	30/30 min	0.75	20/40 min	1.0
5 (Black)	>90	50/10 min	1.0	20/40 min	1.0	10/50 min	1.0

Table A4.2. Training Guideline for Average Unacclimatized Personnel Wearing BDU, Hot Weather

Heat Cat. / Flag Color	WBGT (F)	EASY WORK		MODERATE WORK		HEAVY WORK	
		Work Rest Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr	Work Rest Cycle	Water Intake Qt/hr
1	78 – 81.9	No Limit	0.5	50/10 min	0.75	30/30 min	0.75
2 (Green)	82 – 84.9	No Limit	0.5	40/20 min	0.75	30/30 min	1.0
3 (Yellow)	85 – 87.9	No Limit	0.75	30/30 min	0.75	20/40 min	1.0
4 (Red)	88 – 89.9	50/10 min	0.75	20/40 min	0.75	10/50 min	1.0
5 (Black)	>90	40/20 min	1.0	10/50 min	1.0	Not Allowed	Not Applicable

Notes:

a. For all 3 work rates, individual water requirement may vary by +/- 0.25 Qt/hr.
b. When performing work/exercise with restrictive or impermeable clothing arrangements should be made for remote site measurement of the WBGT and 10 degrees F added to the measurement before using tables 2 or 3. Add 15 degrees WBGT for combat armor.
c. Rest means minimal physical activity, i.e., sitting or standing, accomplished in the shade of possible.

Attachment 5

PERMISSIBLE HEAT EXPOSURES AND WORKLOAD DETERMINATION

Table A5.1. Permissible Heat Exposures (Values in ^{0}F WBGT)

WORK AND REST REGIME PER HOUR	WORK LOAD		
	LIGHT	MODERATE	HEAVY
Continuous Work	86	80	77
75% Work / 25% Rest	87	82	78
50% Work / 50% Rest	89	85	82
25% Work / 75% Rest	90	88	86

Table A5.2. Guide to Determination of Workload

EASY WORK	MODERATE WORK	HEAVY WORK
-- Walking on hard surface @ 2.5 mph with ≤30 lb load -- Weapon Maintenance -- Manual of Arms -- Marksmanship Training -- Drill and Ceremony	-- Walking on hard surface @ 3.5 mph with <40 lb load -- Walking loose sand @ 2.5 mph with no load -- Patrolling -- Low crawl, high crawl -- Defense position construction -- Field Assaults	-- Walking on hard surface @ 3.5 mph with ≥40 lb load -- Walking on loose sand @ 2.5 mph with load

Attachment 6

LOCALLY PRODUCED WET BULB GLOBE THERMOMETER (WBGT) STATION

Figure 1. Instrument Station

The figure shown below depicts the proper instrument station. Although the thermo screen shelter is not shown in the drawing, it should be in the immediate vicinity. The shelter is used to house the dry bulb thermometer and spare instruments. Certain items such as clamps, stoppers and flasks are standard and should be available from local resources.

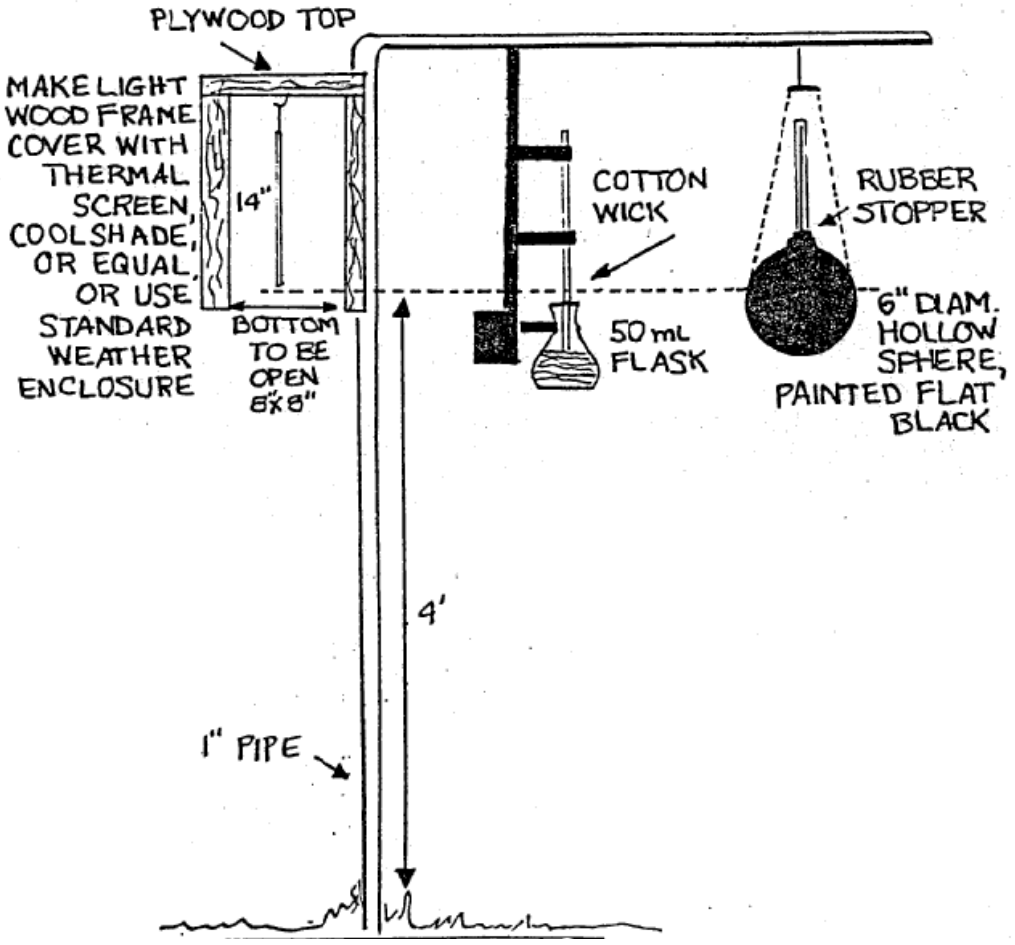


Figure 2. Thermo Screen Shelter

Instructions for thermo screen shelter (for the dry bulb thermometer). The thermometer is a standard thermometer (mercury or, preferably, alcohol-based) about 12 inches long and graduated from 30°F to 150°F. The thermometer is housed in a thermo screen shelter immediately adjacent to the wet bulb and black globe thermometers. The inside dimensions of the shelter is 12 to 14 inches high by 8 inches wide and 8 inches deep. The shelter is constructed of light wood and louvered on the sides and door and open on the bottom. It is covered with a thermal screen cool shade or a standard weather enclosure. The shelter is situated so the thermometer is about 4 foot above the ground.

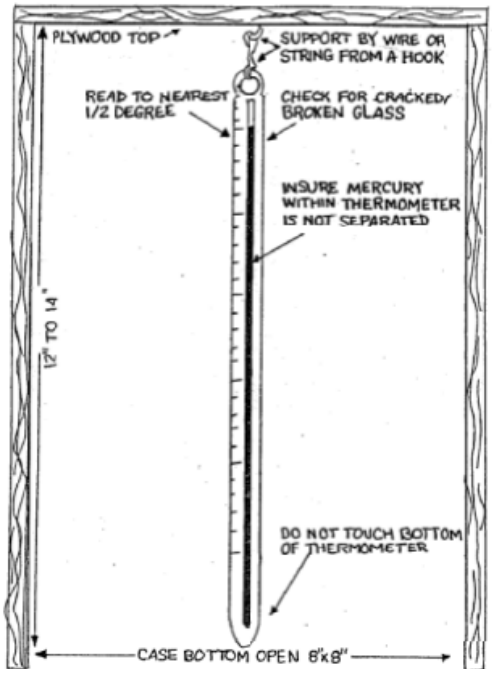
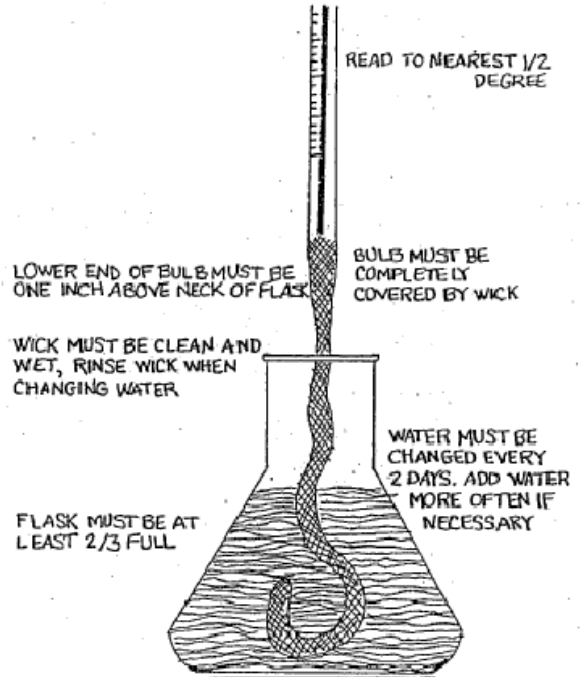
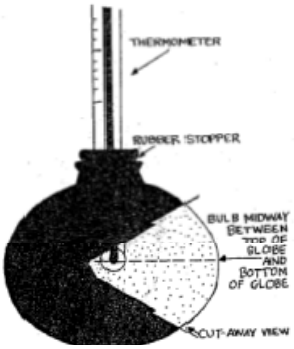


Figure 3. Natural Wet Bulb Thermometer



a. This uses either a mercury or alcohol-based thermometer (same as the dry bulb thermometer) with a wet wick around the bulb and exposed in an un-shaded location to natural air movement and solar radiation. The bulb of the wet bulb thermometer should be mounted at the same height above ground as the bulb of the dry thermometer. The bulb and flask (water reservoir) are suspended using horizontal clamps.
b. The wick consists of a white COTTON (other fabrics will affect the temperature readings) shoelace with the tips cut off. One end covers the bulb of the thermometer and the other end is immersed in the water reservoir. Fresh water must be added daily to the reservoir. The wick should be rinsed in fresh water every two days and washed weekly.
c. The bulb of the thermometer must be 1 inch above the mouth of the reservoir and freely exposed to the air.

Figure 4. Black Globe Thermometer



a. The Black Globe Thermometer consists of a 6 inch diameter copper sphere painted flat black on the outside. Into the neck of the globe a thermometer of the same type and size as the dry and wet bulb thermometers. The thermometer is held in place using a tight-fitting one-hole rubber stopper. The bulb of the thermometer is positioned to be in the center of the sphere.
b. The globe thermometer is suspended using a braided wire or strong cord with the globe being positioned about 4 feet above the grounds (at the same level as the dry and wet bulb thermometers). The support must be positioned so that no shadow will fall onto the globe.
c. The purpose of the Black Globe Thermometer is to combine the thermal effects of the air and thermal radiation from the sun and other hot surfaces. To perform reliably, it must be positioned in an area exposed to the sun and wind and not shielded in any way.
d. The Black Globe Thermometer requires no specific attention other than maintaining a clean flat black coating and draining any accumulated water (after rain) from the interior of the globe.