Bureau of Medicine and Surgery
7700 Arlington Blvd., Falls Church, VA 22042

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Manual of Naval Preventive Medicine

Chapter 3

PREVENTION OF HEAT AND COLD STRESS INJURIES (ASHORE, AFLOAT, AND GROUND FORCES)

DISTRIBUTION STATEMENT "A"

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NAVMED P-5010-3

Chapter 3
Manual of Naval Preventive Medicine
Heat and Cold Stress Injuries (Ashore, Afloat, and Ground Forces)

15 Aug 2023

To: Holders of the Manual of Naval Preventive Medicine

1. Purpose. This revision provides guidance intended to be used in the prevention and treatment of heat and cold stress injuries. The information in this chapter describes the physical and physiological measurements necessary to assess the effects of hot and cold environmental conditions for ashore, afloat, and ground forces.

2. Background. The Navy and Marine Corps Force Health Protection Command (NAVMCFORHLTHPRTCMD) Technical Manual, NEHC-TM-OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries, contains more detailed information on this topic.

3. Information Management Control. Reports required in article 3-9c and article 3-22a and 3-22b of this manual are exempt from reports control per Secretary of the Navy Manual 5214.1 of December 2005, part IV, subparagraph 7k.

4. Action. Replace entire Chapter 3 with this version.

D. K. VIA
Chief, Bureau of Medicine and Surgery
Acting

Releasability and distribution:
This publication is cleared for public release and is available electronically only via the Navy Medicine Web site, https://www.med.navy.mil/directives/Pages/Publications.aspx

CHAPTER 3
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ASHORE, AFLOAT, AND GROUND FORCES)

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HEAT AND COLD STRESS INJURIES
(ASHORE, AFLOAT, AND GROUND FORCES)

SECTION I. INTRODUCTION

3-1. Purpose

a. This chapter provides guidance to be used in the prevention and treatment of heat and cold stress injuries. The information contained in this chapter describes the physical and physiological measurements necessary to assess the effects of hot and cold environmental conditions for ashore, afloat, and ground forces. Target audience for this document is preventive medicine and providers caring for personnel potentially suffering from the effects of heat and cold exposure.

b. The Navy and Marine Corps Force Health Protection Command (NAVMCFORHLTH-PRTCMD) Technical Manual, NEHC-TM-OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries, contains more detailed information on this topic.

3-2. Thermal Stress and Strain

a. Thermal stress is a combination of multiple factors affecting the body's gain or loss of heat (environmental, physiological, and clothing). Figure 3-1 shows how the body gains or loses heat to the surrounding environment.

b. Environmental physiologists employ the term "stress" to designate the force or load acting upon the biological system and the term "strain" to designate the resulting distortion of the biological system. Thermal stress factors include heat, cold, humidity, radiation, air movement, and surface temperatures. Thermal strain manifests itself in specific cardiovascular, thermoregulatory, respiratory, renal, and endocrine responses.

3-3. Roles and Responsibilities

a. Afloat Forces: Follow guidance as set forth in the OPNAVINST 5100.19F.

b. Ashore Forces: Follow OPNAVINST 5100.23H and Occupational Safety and Health Administration regulations, where applicable. Per MARADMIN 111/15, Officers, staff noncommissioned officers, noncommissioned officers, and other supervisors should ensure Marines, Sailors, and civilian personnel are familiar with heat and cold stress injury prevention.

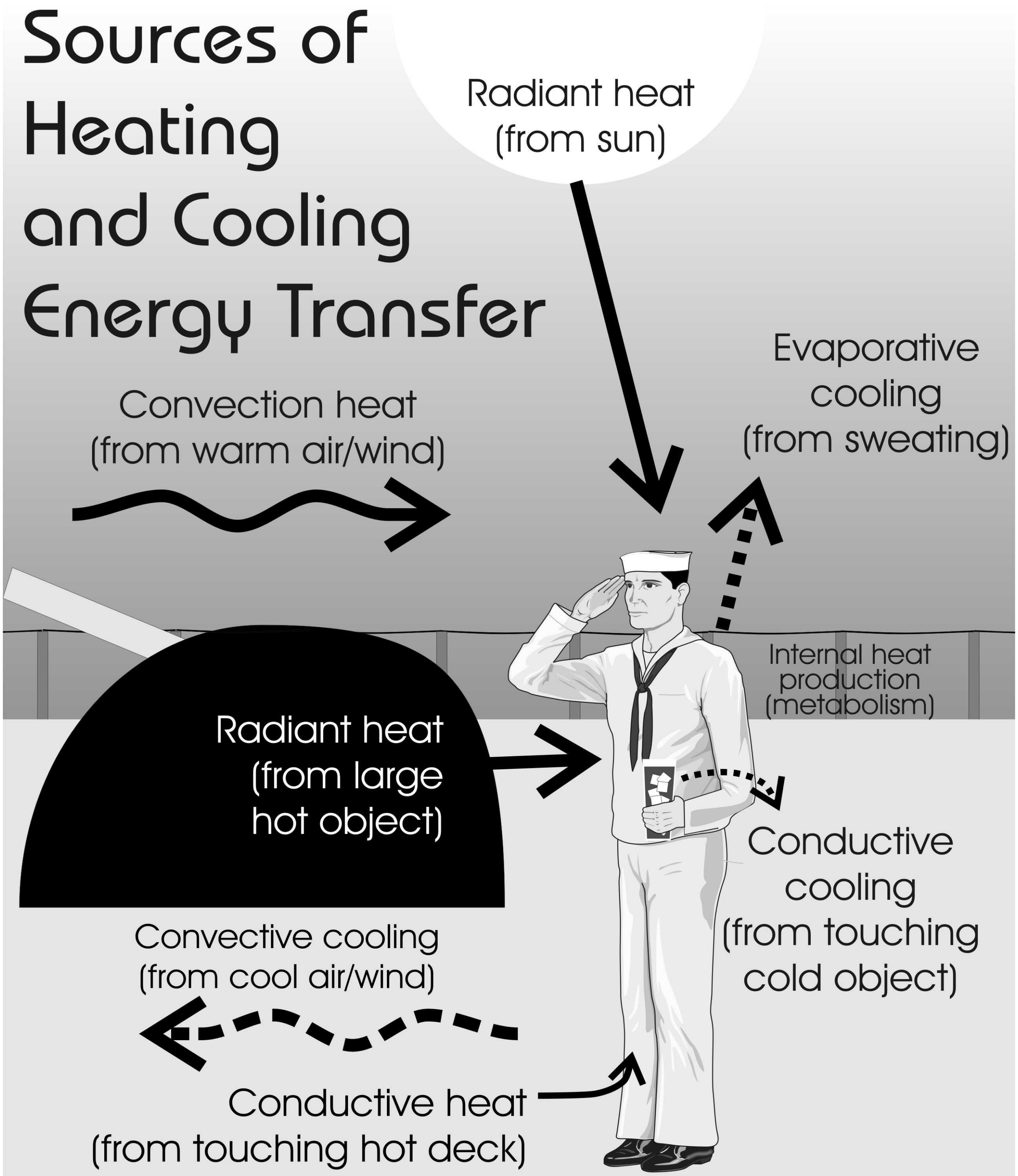

Figure 3-1. How We Gain or Lose Heat to the Environment

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(ASHORE, AFLOAT, AND GROUND FORCES)

SECTION II. HEAT STRESS

3-4. Heat Stress Effects

a. Heat stress and heat strain have immediate, and possible long-term effects on humans. The immediate effects are reduced performance and efficiency, and, if there is heat injury, lost duty time due to systemic heat injury. Prolonged or severe exposure, is viewed as contributing to:

(1) Progressive loss of performance capability

(2) Increased susceptibility to other forms of stress

(3) Reduced heat tolerance

b. Each individual should know how to minimize heat stress, recognize symptoms of heat illness and injury, and provide basic first aid.

3-5. Environmental Measurements

a. Dry-Bulb (DB) Temperature. DB is the prevailing air temperature measured with an ordinary alcohol-in-glass thermometer whose bulb is kept dry and shielded from radiation (radiant heat, such as sunlight).

b. Wet-Bulb (WB) Temperature. WB is measured with a thermometer, similar to that used for DB temperature, except that a wet wick is fitted closely over the bulb (or sensor). A "natural" WB temperature is obtained with no movement of air over the wick except that which occurs naturally in the environment (unventilated areas will have little air movement, while ventilated or outdoor areas will have more). Although the natural WB temperature depends on the DB temperature and the moisture content of the air, it does not provide a direct indication of the amount of water vapor in the air. The WB temperature is of greater value in planning corrective engineering actions than the "natural" WB temperature. Use of psychometric WB has been the Navy standard for over 40 years. When the WB and DB temperatures are identical the air is said to be "saturated," and the relative humidity (RH) is considered to be 100 percent. Any decrease in the moisture content of the air will result in evaporation from the wick of the WB thermometer, and the thermometer will be cooled to a temperature that reflects the reduced moisture content of the air.

c. Humidity. Humidity is an expression of the quantity of water vapor mixed with other atmospheric gases. The absolute humidity (AH) is the mass of water vapor present per unit volume of air (kg/m^3); the gas pressure (Torr) exerted by this water vapor is referred to as the vapor pressure. The ratio of the actual amount of water in the air (AH) to the maximum quantity of water that the air can hold at a given temperature is the RH. The temperature at which the AH reaches a maximum and the air becomes saturated with water vapor is called the dew point (Td). Vapor pressure is a measure of water content in the atmosphere under given conditions.

d. <u>Psychrometer.</u> A psychrometer is an instrument for measuring atmospheric humidity utilizing a DB and WB thermometer and whirled manually or by motorized unit to provide the airflow necessary to obtain WB temperature reading. A psychrometric chart helps translate this information into RH values and other thermodynamic characteristics of moist air. Motorized psychrometers should be used for reproducibility of measurements. The national stock number (NSN) for the approved unit is IH-6685-00-935-1389; calibration is not required. Electronic, motorized psychrometers are available to provide direct readout of DB, WB, RH, and Td. Air movement or velocity is usually expressed in feet per minute (fpm) or cubic feet per minute (cfm). Depending upon the velocity of air movement, airflow is measured using different instruments. Low velocities (down to 10 fpm) require a heated kata thermometer (heated alcohol thermometer) or thermo-anemometer ("hot-wire" anemometer or equivalent); high unidirectional air velocities may be measured with a velometer or vane anemometer.

e. <u>Radiant Heat</u>. Radiant heat is the transfer of thermal energy from one object to another without warming of the intervening space. The wave lengths involved range from the visible portion of the electromagnetic spectrum (0.3-0.7 microns) to the longer radio waves. In industrial situations, any part of the heat radiation spectrum may be present. Natural environments generally include two bands: solar radiation from ultraviolet to near infrared, and heat radiation in the far infrared portion of the spectrum. Both forms of radiation liberate thermal energy when absorbed. Not all of the radiant heat that strikes a surface is absorbed. Any surface that has a high reflectance will minimize absorption of radiant heat; conversely, a surface with low reflectance will increase absorption of radiant heat. Humans with dark-pigmented skin and light-colored skin are essentially alike in absorbing the longer wavelength radiant heat (e.g., indoors); however, in the sunlight darker skin has a higher absorbance than lighter skin. The intensity of radiant heat can be measured by use of a radiometer (e.g., pyrheliometer), or a globe thermometer (GT).

f. <u>GT</u>

(1) GT is measured using the Vernon GT technique, which consists of a 6-inch hollow copper sphere, with a 0.022 inch thick wall, painted matte (flat) black on the outside, and contains a temperature sensor like that of an unshielded DB thermometer with its bulb, or an equivalent, at the center of the sphere. The black globe temperature typically requires about 20 minutes to reach equilibrium (i.e., to accurately reflect environmental temperature). Smaller globes, from 1.64-2.0 inch outside diameter, have been developed which have shorter equilibrium time. However, the GT value obtained from the smaller globe should be equated to a GT value from a 6-inch globe using a mathematical algorithm to obtain an accurate Vernon GT measurement. GTs is required in the assessment of thermal stress because they integrate radiant heat exchange and convective heat loss into a single value.

(2) The GT value is neither radiant heat by itself nor what is known as the "mean radiant temperature." The GT value is a composite of radiant and convective heat transfers.

(3) While there are several heat stress equations or indexes that provide heat exposure, the only index authorized by the Bureau of Medicine and Surgery (BUMED) is the Wet-Bulb Globe Temperature (WBGT) index.

g. Heat Stress Index (HSI). The HSI provides heat exposure guidance only using DB and RH values and does not incorporate GT. The HSI is not the same as the heat index (HI). The HI was established by the National Weather Service for weather purposes and provides a number of how hot it may feel to a person.

h. Wet Globe Temperature (WGT) Index. The WGT or "Botsball" has been used in the distant past to obtain heat stress measurements. However, BUMED does not endorse use of the WGT Botsball to determine heat stress guidance for Navy and Marine Corps personnel.

i. WBGT Index

(1) WBGT is unique in that it takes into account the four physical variables of the thermal environment (air temperature, DB; humidity, RH or WB; radiant heat, GT; and air movement). WBGT is obtained from the measurement of DB, GT, and WB (measured directly or derived from RH) and is calculated as (DB x 0.1) + (GT x 0.2) + (WB x 0.7). While there are numerous WBGT equations, the above equation is the standard for all Navy and Marine Corps environments (indoor and outdoor). Direct measurement of air velocity is not necessary and the GT integrates radiant heat and convective heating and cooling into one value.

(2) Other indices of heat stress and strain are of limited use. No other value is to be used to calculate stay times, determine flag conditions, etc.

(3) The requirement to measure WBGT generally is determined by DB temperature, duration of work exposure, and intensity of work (effort).

(4) Frequency of WBGT Index measurement

(a) Shipboard temperatures are monitored using DB thermometers, with frequency of temperature measurement determined by whether DB temperatures exceed 85°F: if DB temperatures do not exceed 85°F, then temperatures are measured every 4 hours; if DB temperatures do exceed 85°F, then temperatures are measured every hour. For less strenuous work (physiological heat exposure limits (PHEL) curves I through III), if watch or work length is 4 hours or less, then WBGT readings must be taken if the DB temperature is 100°F or more; if watch or work length is greater than 4 hours, then WBGT readings must be taken if the DB temperature is 90°F or more. For more strenuous work (PHEL curves IV through VI), WBGT readings must be taken if the DB temperature is 85°F or more. (Heat stroke fatalities have occurred at temperatures below 85°F, so the requirement to take WBGT readings above 85°F does not imply heat stress is not a concern below that temperature, especially if strenuous exertion, extra clothing, or other factors are involved.) OPNAVINST 5100.19F, section B, chapter 2, subparagraph 3b(3)(a) through 3b(3)(c) contains instructions on frequency of shipboard WBGT measurements.

(b) Shore guidance for the WBGT Index is not detailed in any DoD or Defense Health Agency (DHA) level instruction (Technical Manual NEHC-TM-OEM 6260.6A provides WBGT Index information). Many activities now use the Automated Heat Stress System (AHSS) which records WBGT readings continuously, see article 3-5j(3). If a command has no AHSS, it is reasonable for shore commands to measure WBGT every 4 hours if DB (air) temperatures do not exceed 85°F, and every hour if DB temperatures exceed 85°F (i.e., following a schedule similar to shipboard units) and during training evolutions.

j. Equipment

(1) WBGT Meter, also known as a heat stress meter, is the approved DHA environmental measurement device. The heat stress meter is a compact instrument that independently measures the DB temperature, WB temperature or RH, and globe temperature. The instrument displays each of these values as well as computes and displays the WBGT Index value. Currently, the approved heat stress meters are identified in article 3-5j(1)(a) through 3-5j(c):

(a) The QUESTemp 48N (figure 3-2).

(b) The AHSS, figure 3-3, is described in article 3-5j(3) is a legacy heat stress meter, no longer available in the stock system. This meter may be used until it is no longer repairable.

(c) The Stortz WBGT Kit; is primarily used by Marine Corps personnel in the field.

A B C

A. Globe thermometer
B. Relative humidity sensor
C. Dry bulb thermometer

Figure 3-2. QUESTemp 48N

Figure 3-3. AHSS Unit

(2) The two heat stress meters authorized for shipboard use are the legacy RSS-220 and the QUESTemp 48N. The replacement meter for the legacy RSS-220 is the QUESTemp 48N. Functional RSS-220 meters can continue in service; however, when no longer repairable must be replaced with QUESTemp 48N meters. Like the RSS-220, the QUESTemp 48N has a 3-year laboratory calibration requirement. Follow manufacturer calibration requirements (most models require annual calibration). The Planned Maintenance System for the Quest 48N is available under the Maintenance Index Page 4361. Instead of a rechargeable battery pack, the QUESTemp 48N heat stress meter uses a 9-volt battery with an optional AC adaptor. The QUESTemp 48N performs traditional heat stress monitoring without maintaining a wet bulb. Mathematical models were developed to create a waterless wet bulb calculation through a combination of dry bulb temperature, globe temperature, RH, and air flow. Empirical data indicates that these calculations are accurate. The QUESTemp 48N displays the WBGT value and automatically calculates and displays stay times in order to manage work and rest regimens as defined in the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) Handbook, U.S. Navy PHEL charts, and Flag Conditions for U.S. Navy/Marine Corps Ashore.

(3) The AHSS provides a measurement of WBGT through the use of a DB, GT, and RH sensor. This computerized system automatically measures the WBGT environment and calculates the appropriate heat exposure guidance for both afloat and ashore personnel. The AHSS displays the data every minute, stores the data in a file on the computer hourly, and can print out a heat stress survey on demand. A WB value (psychometric/WB value) is derived from

the measured DB and RH values. The advantage of using an RH sensor is that the RH value can provide information on the potential for evaporation of sweat to cool the body (i.e., 15 percent RH is a dry environment while 75 percent RH is a humid or wet environment). In contrast a WB value is of little use without knowing the DB value. Additionally, the RH sensor does not require constant maintenance to keep the wick clean and properly wetted. Use of the AHSS has been implemented afloat to provide PHELs stay time guidance and ashore to provide flag condition guidance. AHSS units do not need calibration stickers.

(4) Commands may use commercial off-the-shelf (COTS) portable direct reading WBGT heat stress monitors for shore establishment measurements. Ensure GT is Vernon 6-inch equivalent and the overall measurement accuracy is within 1°F or 0.5°C. With any heat stress meter, careful monitoring and adherence of procedures and equipment maintenance is necessary to ensure valid assessment of WBGT conditions. For all measurements, ensure that:

(a) Outside readings are measured in an area that is not shaded and is likely to reflect conditions experienced by troops.

(b) Heat stress meters are kept clean, calibrated, and operational. WB measurements are taken using a clean 100 percent cotton wick which extends into clean, non-mineralized water, and above the thermometer reservoir; or a RH sensor provides the WB reading for the WBGT calculation instead of a WB thermometer, as in the QUESTemp 48N.

(c) Heat stress data is consistently recorded in a heat stress log.

(5) Stock numbers for the Navy and Marine Corps approved WBGT meters and accessories as listed:

- The QUESTemp 48N, NSN 6685-01-584-0785 (Shipboard AEL 2-870003051).
- Standard Nickel-Cadmium Rechargeable AA Batteries, NSN 90-6140-449-6001.
- AHSS Unit, NSN 7H H 6685-LL-H54-6414.
- The Stortz WBGT Kit, NSN 6665-00-159-2218.
- RSS-220 WBGT Meter, NSN 7G-6685-01-055-5298 (Shipboard AEL 2-870003051).
- Accessories (spare sensor/wind tunnel assembly, globe, wicks, etc.) NSN 90-6685-01-055-5299 (Shipboard APL 100l10001).
- Globe Assemblies NSN 90-6665-01-149-8635.

3-6. Preventive Measures

a. Controlling Risk Factors

(1) Heat disorders have a worldwide distribution and may even occur in cold climates where metabolic heat production exceeds an individual's adaptive abilities. Heat stress is commonly encountered in military operations, and may cause injury or death, resulting in decreased readiness.

(2) Most heat stress injuries are preventable. The body constantly generates heat; activity (work or exercise) generates more heat. The body cools itself in heat stress conditions primarily by sweating. Risk factors and conditions that predispose to heat stress injuries are listed in table 3-1:

Table 3-1. Risk Factors and Conditions that Predispose to Heat Stress Injuries
1. High humidity
2. Lack of air movement (wind)
3. Overhead sun
4. Elevation below sea level
5. Sunburn or other skin condition
6. Clothing or gear that hinders skin "breathing"
7. Illness
8. Recent immunizations
9. Prior heat injury
10. Recent heat stress exposure
11. Age (very young or very old)
12. Lack of acclimatization (a new exposure to a hot, humid environment)
13. Dehydration
14. Medications
15. Substance abuse
16. Fatigue
17. High activity level
18. Being around very hot objects (e.g., hot steel)

(3) Preventive measures against heat stress injury are focused on limiting exposure to heat stress (by decreasing activity or avoiding hot environments), acclimatization (taking 3 weeks to gradually get used to the heat), maintaining adequate hydration and limiting strenuous activity. Activity is controlled by observing work-rest cycles, which are established based on the WBGT index.

b. Warning Signs of Heat Strain

(1) Symptoms (feelings of being overheated or of chills) and signs (confusion, incoordination, decreased sweating, and "gooseflesh") of impending heat stroke should be closely followed. Although body temperature measurement should ideally be measured with a rectal thermometer, oral (mouth) thermometers (provided the person has not had hot food or water for 5 minutes and cold food or water for 30 minutes) or ear probes (provided no water has splashed in the ear) may be used instead if a rectal thermometer is unavailable.

(2) Supervisory personnel should be able to recognize the signs and symptoms of excessive heat strain and impending heat stroke and heat exhaustion. Chapter 11 of NEHC-TM-OEM 6260.6A provides information on the signs and symptoms of heat stress injuries. Also, the medical department representative can provide training to supervisory personnel on the signs and symptoms of heat stress injuries.

c. Engineering Controls. Increased ventilation, insulating warm or heat generating equipment or items from workers, isolating heat generating equipment or items (e.g., steam generating plant equipment) and processes from workers and work spaces, implementing structural cooling controls, or locating heat generating processes near outdoor air or cool water, etc., can minimize worker exposure to heat stress.

d. Administrative Controls. Engineering methods are not always effective and often must be supplemented or preceded by other measures. In physiologically compensable environments, performance in the heat can be improved greatly by proper selection and acclimatization of workers. In all hot environments, improved performance can be achieved by controlling fatigue, nutrition and alcohol, and by periodic examination for underlying illness and the early symptoms of heat strain.

(1) Scheduling Activity. Training exercises requiring sustained or severe physical effort, and those conducted in the prone position should be scheduled, when possible, in early morning or at night as radiant heat from the sun and hot ground will add additional stressors to persons exposed. Outdoor classes should be conducted in the shade with adequate exposure to cooling wind. When environmental heat stress is excessive, heat illness can be prevented by curtailing or suspending non-essential physical training (PT) and undue heat stress exposure. If operational mission requirements, excluding training programs, may preclude application of pertinent heat stress guides, the Medical Department should be forewarned in order to adequately prepare facilities and staff for an anticipated increase in number of heat illnesses. Mental and physical dysfunction under thermal stress may be expected to amplify the frequency of accidental injury and mishaps.

(2) Flag Conditions

(a) Flag condition refers to a series of outdoor WBGT environments that provide ashore heat exposure or physical activity guidance to Navy and Marine Corps personnel.

(b) Flag condition guidance, contained in table 3-2, is not a substitute for the PHEL curves nor is it possible to comply with this guidance in combat situations. When the WBGT Index reaches specific temperatures, color-coded flags are flown in strategic locations so all personnel will be aware of the current heat stress index and make appropriate work schedule adjustments. Since shore facilities vary in size geographically, the flag closest to the specific site during hot weather operations should be used to determine level of the specific operation.

1. White Flag (WBGT Index below 80°F). Extremely intense physical exertion may precipitate heat exhaustion or heat stroke.

2. Green Flag (WBGT Index of 80°F to 84.9°F). Heavy exercises for non-acclimatized personnel will be conducted with caution and under constant supervision. Organized PT evolutions in boots and utilities are allowed for all personnel.

3. Yellow Flag (WBGT Index of 85°F to 87.9°F). Strenuous exercises, such as marching at standard cadence, will be suspended for non-acclimatized troops in their first 3 weeks of heat exposure. Avoid outdoor classes in direct sunlight.

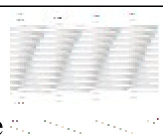
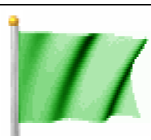
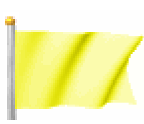
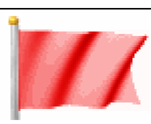
4. Red Flag (WBGT Index of 88°F to 89.9°F). All PT will be halted for those troops who have not become thoroughly acclimatized by at least 12 weeks of living and working in the area. Those troops who are thoroughly acclimatized may carry on limited activity not to exceed 6 hours per day.

5. Black Flag (WBGT Index of 90°F and above). All strenuous outdoor physical activity that is not essential (*including organized, unit, or individual PT*) mission requirements will be halted for all units.

(c) Wearing body armor or nuclear, biological, or chemical (NBC) protective uniforms adds approximately 10 points to the measured WBGT. Limits of exposure should be adjusted accordingly.

(d) PHEL curve and Flag condition heat exposure guidance are based solely on WBGT index. Use of the heat stress index (or any measurement other than WBGT) to provide PHEL or Flag guidance is not authorized.

Table 3-2. Regulating Physical Exertion in Hot Weather by Wet-Globe Temperature (WBGT) Index

Flag Color	WBGT Index(°F)	Intensity of Physical Exercise
White 	**Less than 80**	Extremely intense physical exertion may precipitate heat exhaustion or heat stroke.
Green 	**80 – 84.9**	Discretion required in planning heavy exercise for unseasoned personnel.
Yellow 	**85 – 87.9**	Strenuous exercise and activity (e.g., close order drill) should be curtailed for new and non-acclimatized personnel during the first 3 weeks of heat exposure.
Red 	**88 – 89.9**	Strenuous exercise curtailed for all personnel with less than 12 weeks training in hot weather.
Black 	**90 and Above**	PT training and strenuous exercise suspended for *all personnel* (excludes operational commitment not for training purposes).
Note: This table may not be used in lieu of the PHELs for afloat commands.		

(3) Essential Outdoor Physical Activity will be conducted at a level appropriate for the degree of personnel heat acclimatization as determined by the unit's commanding officer in coordination with the unit's medical officer or medical personnel. All efforts should be made to reschedule major hot weather training activities to occur during cooler periods of the day, such as early morning or late evening.

(4) Recovery. Adequate recovery from acute or cumulative fatigue (at least 7 hours of uninterrupted sleep in a thermally comfortable environment per 24 hours), optimal physical fitness for the work to be done, and absence of illness and febrile reactions (e.g., elevated body temperature following immunization) will increase resistance to heat stress injury.

(5) Clothing. Clothing should be worn loosely at the neck, at the cuffs of sleeves, and at the bottom of trousers to facilitate convective cooling (cool air carrying heat away from the body). Wearing Navy coveralls over any other clothing imposes a major heat load upon the body due to added insulation and weight, and is not recommended in hot, humid environments. Starch must not be utilized where evaporative cooling from clothing is a major factor. Outdoors, helmet liners or headgear of similar design provide more cooling and protection of the head than caps.

e. Sweating. Evaporation of perspiration from the skin (sweating) is the primary way the body loses heat when the air temperature exceeds 95°F. Evaporative heat loss from the respiratory mucosal surfaces is minimal, representing perhaps only 2 percent of the metabolic heat. Thermoregulation is mediated by circulatory (e.g., central and capillary blood flow), neural (e.g., hypothalamic, autonomic pathways), and biochemical (e.g., ionic and endocrine) functions involving central or peripheral levels of response.

(1) When temperature balance mechanisms for the body fail, the body's core temperature will continue to increase. As heat storage increases, skin and deep-tissue temperature rise, cardiovascular, respiratory and metabolic functions accelerate, and renal function is depressed.

(2) Increased metabolic heat pushes the cycle faster to the point of cardiovascular and renal failure and irreversible damage to the nervous system and muscles. The cycle can be broken only by timely and definitive therapy. Therefore, every effort should be made to relieve excessive heat stress.

f. Acclimatization. Acclimatization is important to prevent heat stress injuries, and is defined as the process of physiologic adaptation to heat stress conditions. (Although previously used here interchangeably with acclimatization, acclimation most accurately refers to short-term adaption to heat stress under laboratory conditions. Acclimatization is the proper term applicable to naval personnel.) Acclimatization is accomplished by incrementally increasing daily exposure to exertion in heat stress and takes approximately 3 weeks to complete. Advantages of acclimatization are listed in article 3-6, subparagraphs 3-6f(1) through 3-6f(8):

(1) Tolerance of and performance in heat stress conditions is improved.

(2) Sweat rate increases and begins at a lower core temperature.

(3) Sweat sodium concentration decreases.

(4) Plasma volume increases.

(5) During exercise in the heat there is lowered heart rate and lowered core temperature at each level of sub-maximal workload.

(6) A decrease in perceived exertion.

(7) The level of hyperkalemia is attenuated after acclimatization (mild exercise in severe heat conditions induces significant hyperkalemia).

(8) Individuals exercising in the heat have an increased ability to conserve sodium. Heat acclimatization occurs more rapidly in persons who are physically fit. Physical conditioning is also advantageous in the body's response to dehydration, a heat stress-related condition. Inactivity results in decreased acclimatization after only a few days or weeks, and exposing heat-acclimatized individuals regularly to cold temperatures (e.g., 4 hours daily for 21 days) can cause a significant loss in heat acclimatization. To achieve maximum benefits from acclimatization, it is extremely important that moderate (i.e., more than sedentary) work be performed during the adaptation process and moderate work be maintained regularly to remain acclimatized. Stable acclimatization at any one level of heat stress does not guarantee full acclimatization to a higher level of heat stress. Various body systems adapt at different rates.

g. Fluids (Drinks). Water and electrolyte solutions (e.g., sports drinks) may be used to replace fluids lost through sweating. Water is generally adequate, readily available, and should be encouraged as the main means of hydration. The extra electrolytes in sports drinks are not necessary, and soft drinks contain high amounts of sugar, carbonation and acidity. Supervisory personnel must know that personnel cannot be trained to resist dehydration. "Water discipline" or "water hardening" (i.e., learning to go without water in the heat) is a false concept that must be replaced with "water freedom" where drinking moderate amounts of cooled water at frequent intervals is encouraged. "Forced drinking" (i.e., drinking even though not thirsty) during activity in hot environments should be used, as thirst lags behind actual need for water by up to 4 hours. An individual may lose up to 2 percent of body weight before feeling the sensation of thirst.

h. Salt (Sodium Chloride). Salt intake is especially important in the early stages of heat acclimatization. The current estimated "'normal'" dietary intake of salt in the general United States population is about 3,400 mg daily, and is generally adequate even in the early stages of heat acclimatization (when salt concentration in sweat is highest, thus salt loss is also highest). Use of salt tablets during exercise in the early stages of acclimatization, if required, must be closely monitored by medical personnel. Proper sodium chloride levels can be achieved by providing adequate water, a normal diet, and a salt shaker on the table. Deviations from these recommendations must be governed by the past and present medical histories of individual workers and adjusted according to individual need by the medical department representative. Field rations contain a variable amount of sodium chloride, depending upon the Federal Stock Number and the manufacture dates. Standard military rations, including A ration, B ration, T ration, meal, ready-to-eat, and the go to war ration, contain 5-7 grams of sodium (about 12.5-17.5 grams of salt) per meal. Restricted rations, including ration, lightweight (RLW-30), food packet, long range patrol, and food packet, survival, general purpose improved, contain 2.5-3.5 grams of sodium (about 6.5-9 grams of salt) per meal. Field grade salt tablets are 10 grain (0.648 grams; 0.255 grams of sodium and 0.393 grams of chloride) each.

i. Cooling Systems. Some microclimate cooling systems have been shown to be a safe and effective means of reducing or preventing the ill effects of heat stress. There may be highly specialized applications of such units, but each is to be carefully examined with sufficient supporting data. Where possible, the key issue is to perform the necessary corrective engineering actions to eliminate impedances of the workers and permit the workers to perform their normal duties in an effective manner without physical encumbrances. However, there are environments, work locations, or work activities where engineering actions are not feasible or are inadequate and a cooling system may be appropriate. Cooling systems should be evaluated before implementation as vendors have become very aggressive in marketing their product directly to commands without the appropriate medical and scientific evaluation. Each cooling system is to be evaluated with regard to the effectiveness to provide adequate cooling with little impact on ergonomics, unrestricted body movement, and optimum safety of personnel. As such, all cooling garment products should be evaluated by the DHA and the appropriate Navy Medicine readiness and training command or Navy Medicine readiness and training unit prior to procurement and use. Some microclimate cooling systems may require a more comprehensive physiological and environmental evaluation by the appropriate Navy testing and evaluation authority.

j. Other Cooling Methods. Immersion of hands and forearms in cool water (approximately 50°F, for example) for 10 minutes during rest breaks may expedite recovery from heat stress when exercising with NBC protective garments.

3-7. Heat Illnesses and Injuries

a. Military populations are prone to heat disorders because battle or training may increase heat stress and limit normal compensatory behavior (such as seeking shade, resting, and drinking water).

b. Acclimatization measures for newly arriving personnel should be followed to allow for an appropriate adjustment period due to exposure of new environmental conditions, preventing potential heat related illness and injuries.

c. The spectrum of heat illnesses ranges from mild to severe as body temperature increases:

(1) Hyperthermia. Hyperthermia (i.e., elevated body core temperature) results when the body's cooling system is unable to regulate its temperature. This stress to the body can degrade mission performance and morale, increase the risk of accidents, and possibly risk the safety of fellow sailors, marines, and civilian personnel. Sweating is the primary mechanism to cool the body in heat stress conditions. If the signs of heat stress go unrecognized and untreated, serious, even life-threatening health problems can result, such as heat stroke.

(2) Heat Rash (Miliaria). Heat rash is a skin irritation caused by heat stress exposure. It usually appears as tiny red bumps on the neck, groin area, or under the arms. Removing the person from heat or applying cooling water or water-based lotion can help relieve heat rash.

(3) Heat Syncope. Heat syncope (fainting) is most likely to occur when non-acclimatized personnel are first exposed to heat stress. It can usually be avoided by not requiring personnel to stand still in the heat (for example, standing in formation), particularly after exercise. Victims should be promptly removed to a cool place and allowed to rest.

(4) Heat Cramps. Heat cramps are painful cramps, usually affecting the extremities and abdomen. They primarily occur in individuals performing vigorous physical exercise in heat stress conditions. Heat cramps will decrease by reducing the intensity of exercise or ceasing physical activity. Electrolyte (e.g., salts such as sodium and potassium) replacement can lessen the intensity of heat cramps (use of salt tablets is not recommended). Remove the individual from direct sunlight or source of heat being generated, remove wet clothing, and have the individual drink water or a sports drink to help replenish the loss of nutrients.

(5) Heat Exhaustion. Heat exhaustion may be related to either dehydration or salt depletion. Call for medical assistance, and relocate the individual to a shaded, well ventilated area, and loosen or remove their clothing (unless in a chemical environment). Fan the individual and have them slowly drink at least one quart or one full canteen of water. Personnel must obtain medical treatment and clearance to ensure they are properly recovering and rehydrating prior to engaging in any activity.

(6) Heat Stroke. Heat stroke is the most serious form of heat injury and is considered a medical emergency (also known as "sun stroke"). When the body generates more heat than its capable of release via cooling methods, evaporative cooling via sweating fails, core body temperature rises rapidly as thermoregulation fails which results in the body losing its ability to self-regulate and cool down. Listed are noteworthy considerations and highlights of technical guidance:

(a) Heatstroke requires immediate medical treatment. Summon emergency medical services or transport the individual to the nearest military or civilian emergency room depending on circumstances.

(b) While seeking or waiting for emergency medical services, simultaneous efforts should:

1. Assess airway, breathing, circulation (blood pulse or pressure), and mental status.

2. Take immediate action to lower the affected individual's body temperature via the best means available: remove from heat to a cool area or into shaded outdoor area, immerse in cold water tub, use a cooler filled with ice water to soak and place cold towels over body (rotate depending on quantity), use a shower or hose with cold water, use of an evaporative

cooling blanket, assist in evaporative cooling using circulating air via fans, other mechanical devices, or other readily available methods. Refer to chapter 4 of NAVMCFORHLTHPRTCMD Technical Manual, NEHC-TM-OEM 6260.6A, Treatment of Heat Stroke.

(c) Common symptoms and signs include the following: high body temperature, heavy sweating with subsequent absence of sweating, rapid breathing and heart rate, confusion, agitation, nausea and vomiting, flushed skin, disorientation, headache, fatigue, bizarre behavior, combativeness, hallucinations, loss of consciousness, and coma.

(d) Diagnosis will be performed by observing the symptoms and signs of the patient during treatment by the appropriate medical authority.

(7) Rhabdomyolysis. Rhabodymyolysis (Rhabdo) is a medical condition, sometimes caused by heat stress and prolonged physical exertion, in which muscle fibers rapidly break down, die, and release electrolytes and proteins into the bloodstream. Left untreated this can lead to kidney damage, seizures, irregular heart rhythms, and death.

(a) Symptoms include muscle cramps, muscle pain, joint pain and stiffness, dark urine, weakness, and inability or decreased ability to perform physical exercise at the normally expected level or duration.

(b) Rhabdomyolysis is diagnosed in a clinical setting using laboratory tests that measure the level of enzymes, creatine kinease (CK) and creatine phosphokinease (CPK), that are elevated with muscle damage.

d. PT and other strenuous physical exercise often cause heat injuries, especially when an individual is:

(1) Inadequately hydrated.

(2) Inadequately acclimatized to the surrounding environment.

(3) Exposed to extreme heat, such as direct sunlight or heat producing equipment.

(4) Wearing personal protective equipment such as Joint Service lightweight integrated suit technology, firefighting ensemble, radiation protective suits, or other personal protective equipment.

(5) Inside closed spaces, such as inside an armored vehicle.

(6) Wearing body armor.

(7) Inadequately rested.

(8) Not completely recovered from heat exposure in the previous 24 hours.

(9) Taking certain medications (e.g., antihistamines, stimulants) or dietary supplements.

3-8. Treatment of Heat Stress Injuries

a. The treatment of heat stress injuries is beyond the scope of this document. The technical manual, Prevention and Treatment of Heat and Cold Stress Injuries at: NEHC-TM-OEM 6260.6A contains detailed guidance for treating heat stress injuries.

b. Medical texts, established military treatment facility procedures, the above technical manual, and experienced medical providers should be consulted as necessary.

c. All personnel should be aware that the essential first aid for victims of heat stress is immediate removal from heat stress and immediate, rapid cooling. Unless water intoxication is suspected, alert victims should be provided with cool or iced water to drink. Figure 3-5 depicts an algorithm for the response to heat stress collapse and incapacitation.

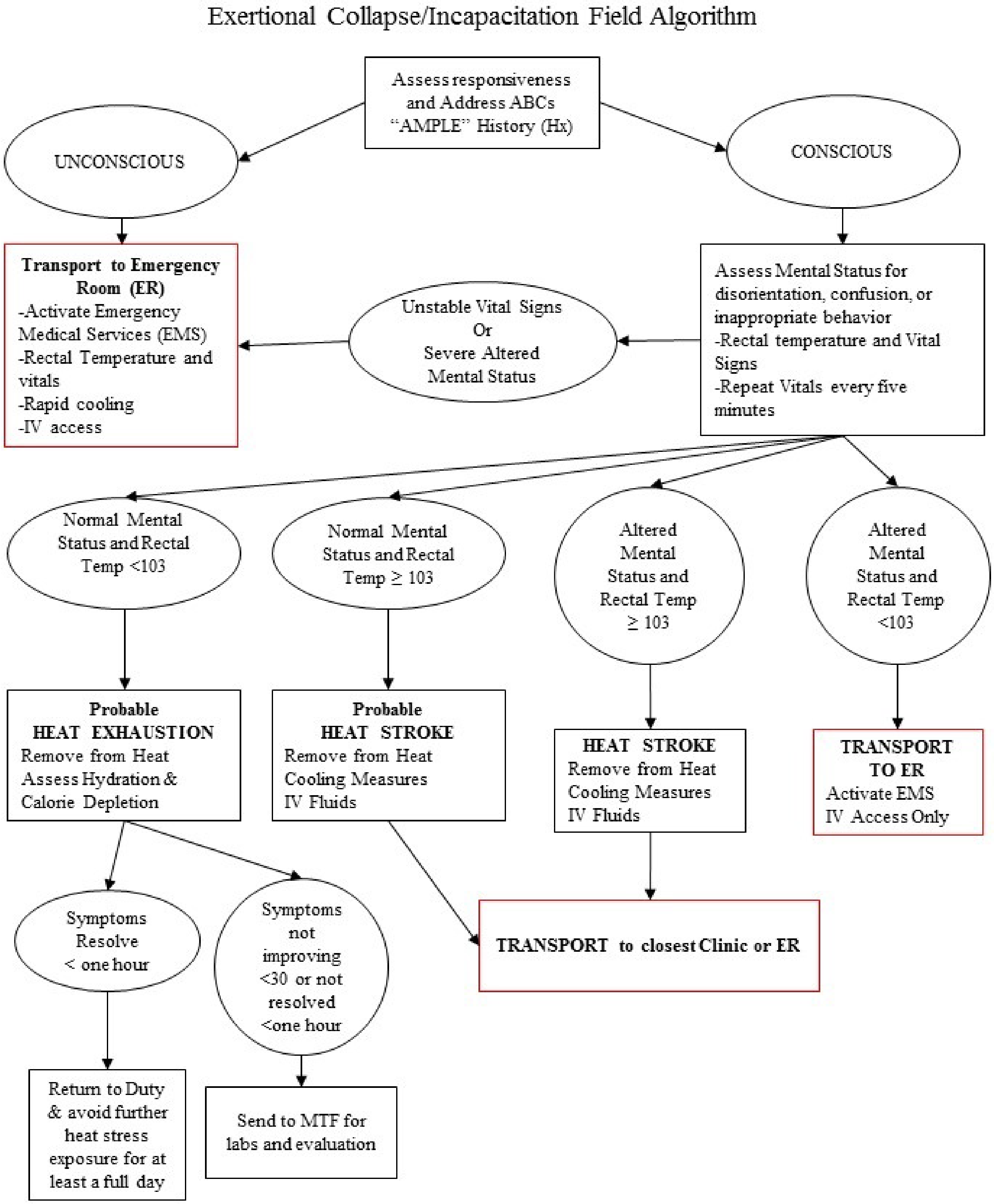


Figure 3-4 Exertional Collapse/Incapacitation Field Algorithm.

3-9. Training and Reporting

a. Per MARADMIN 111-15 commanders and officers in charge (OIC) will ensure all potentially exposed ground forces personnel are initially trained in the causes, prevention, and treatment of heat injuries. After initial training, subsequent refresher training will be conducted at the discretion of the commander or OIC or whenever personnel are expected to be exposed to hot environments. Supervisors and those caring for personnel exposed to heat or cold stress should become familiar with the NAVMCFORHLTHPRTCMD Technical Manual, NEHC-TM-OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries, summary chapters (chapters 11 and 12 in the 2007 edition).

b. Per OPNAVINST 5100.19F, section B, chapter 2, shipboard personnel will be trained in the causes, prevention, and treatment of heat injuries and the heat stress program.

c. Heat injuries will be reported through the Disease Reporting System internet (DRSi), found at Log In | DRSi (health.mil) or https://drsi.health.mil/NDRSi, per BUMEDINST 6220.12C and NAVMCFORHLTHPRTCMD Technical Manual, NMCPHC-TM 6220.12 (Medical Surveillance and Reporting). A simultaneous report will also be submitted to the Naval Safety Command per OPNAV M-5102.1 and MCO 5100.29C Vol 9. Reporting is submitted through the Risk Management Information - Streamlined Incident Reporting (RMI SIR) system. RMI can be located at https://afsas.safety.af.mil.

3-10. Ship Design Resources. Detailed engineering specifications that relate to heating and cooling design for ships are the responsibility of Naval Sea Systems Command and are found in the Naval Sea Systems Command Technical Manual, Heating, Ventilation, and Air-Conditioning Design Criteria Manual for Surface Ships of the United States Navy. Commander, Navy Installations Command has responsibility for shore establishments.

3-11. Afloat. Refer to OPNAVINST 5100.19F, section B, chapter 2, Heat Stress

a. PHEL Curves

(1) In 1973 the Navy developed a series of six PHEL curves based on a sequence of laboratory and shipboard studies. These curves determine maximum exposure limits or stay times for various environmental conditions and individual work rates. The Navy's PHEL limits, which allow core temperature rise to 102.2°F (39°C), recognize that under conditions of maximum work and heat stress, the heat strain will be readily apparent, but it will be reversible. In contrast, National Institute for Occupational Safety and Health Permissible Exposure Limits were designed to restrict core temperature rises to a maximum of 100.4°F (38°C).

(2) The Navy's PHEL curves assume personnel are healthy and acclimatized. Since the PHEL curves apply to greater than 95 percent of the naval population, there may be individuals who occasionally exceed the stay times without incurring a heat injury, and conversely, there may be individuals who incur a heat injury without exceeding the stay times. However, non-compliance with the PHEL stay times will increase the potential for serious heat injuries. For more detail, please see OPNAVINST 5100.19F, section B, chapter 2, Heat Stress.

b. <u>Determining Stay Time Using PHEL Curves</u>

(1) To determine the correct PHEL curve stay time, both the WBGT index and the degree of effort entailed by the particular job are required. The more strenuous the job the shorter the allowable exposure limit. Each of the six PHEL curves pertains to a different work rate, ranging from light work (PHEL Curve I) to heavy work (PHEL Curve VI). Figure 3-6 provides the relationships of various metabolic rates, heat stress, and maximum safe exposure times. Examples of light work include sweeping and mopping, painting, adjusting automatic combustion controls, changing and cleaning lube oil strainers, and bleeding hydraulic oil. Examples of heavy work include manually chipping and wire brushing in preparation for painting, handling cargo and supplies, replacing large valves, cleaning lube oil sumps, and disassembly or reassembly of large or heavy equipment. The PHEL curves apply to shipboard normal acclimatized, healthy personnel who have had adequate rest (6 hours continuous sleep in the last 24 hours), adequate water intake, and adequate recovery time from previous heat-stress exposure (2 hours recovery for every 1 hour exposure or 4 hours maximum). Personnel are assumed to be wearing clothing consisting of at least 35 percent cotton fiber, not containing starch, and readily permeable to water.

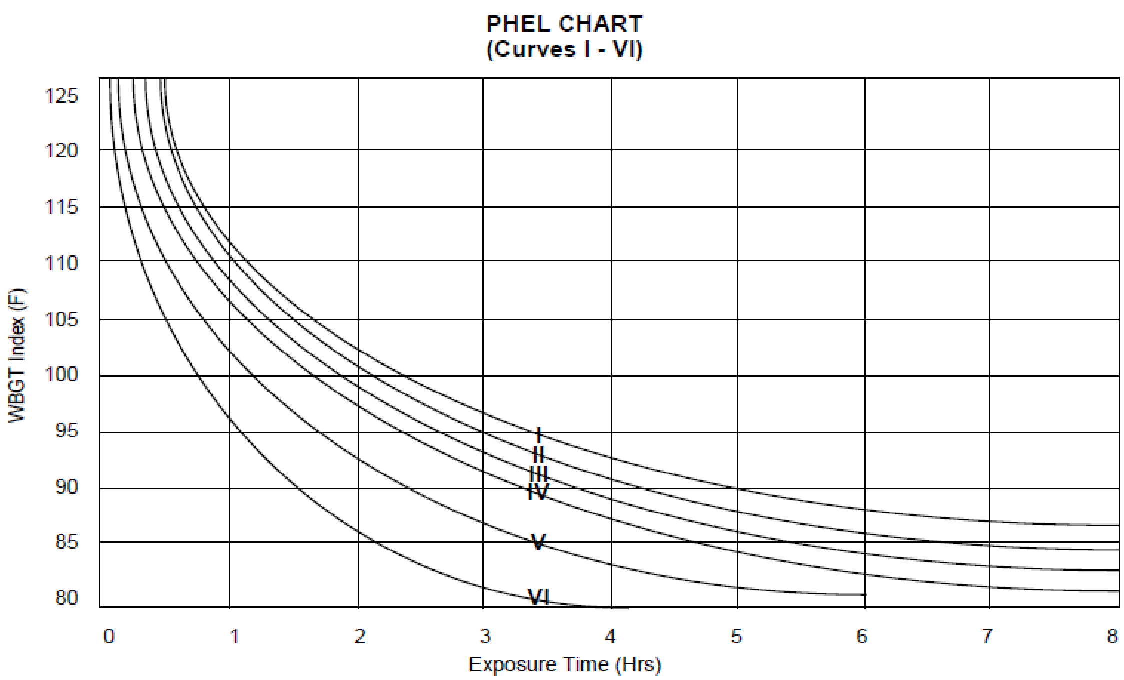


Figure 3-5. PHEL Chart

(2) It must be emphasized that the PHELs are maximum allowable standards and they should be applied only in cases of short-term work exposures of up to 8 hours duration. The limits presume that no prior heat injury or predisposing condition is present and that no cumulative heat fatigue exists prior to re-exposure. Also, full acclimatization to the present heat stress environment is assumed.

(3) The PHEL curves do not provide heat exposure guidance for personnel wearing layered or impermeable clothing such as chemical and biological warfare clothing, firefighting protective clothing or ensemble, or chemical protective clothing (worn for use during clean-up of hazardous material spills) or any type of body cooling garment or device.

(4) PHEL curves for routine watches and casualty control exercises are given in table 3-2, table 3-3, and figure 3-5. PHEL curves in table 3-4 apply where there is the apparent presence of fuel combustion gases (or "stack gas") or fuel vapors. Time Weighted Mean (TWM) metabolic rates, activity (including movements about the spaces) and lengths of time of the activity have been taken into account. For remaining safe stay time situations where different heat stress conditions, actual exposure times, or recovery times apply, see article 3-8h.

c. Watch Duration. Under normal operations, routine watches in engineering spaces are expected to be 4 hours at a PHEL III or lower. PHEL IV through VI apply to above average work rates. Heat stress surveys will be conducted for PHEL I through III at a DB temperature of 100°F when the watch or work length is 4 hours or less. If the watch or work length is greater than 4 hours, then the Heat stress survey will be conducted when the DB is 90°F or greater. For PHEL IV through VI, a DB temperature of 85°F indicates a heat stress survey should be taken.

d. Rounding the WBGT to a Whole Number. To use the PHEL table, the recorded WBGT index is rounded to the next higher whole number value. For example: 85.1°F would be rounded to 86°F and 89.9°F would be rounded to 90°F; but 92.0°F would remain 92°F. Using the whole number value of the WBGT index, the heat-stress surveyor would obtain the permissible stay time in hours and minutes under the column for the PHEL curve determined using table 3-3. Hence, for a recorded WBGT index of 85.1º F or 85.8ºF (both rounded to 86°F), the stay time for PHEL Curve III is 5 hours, 55 minutes.

e. Fuel Combustion Gas Impact

(1) Fuel combustion gases (stack gas) and fuel vapors can have severe physiological impact on personnel and a reduction in PHEL stay times. The effects of these environmental factors are intensified by heat stress. Prolonged exposure to relatively low concentrations can impact the ability of personnel to work safely. If someone entering a workspace or area for the first time in approximately 4 hours or more can smell the odor of stack gas or fuel vapors, then a harmful concentration may be present. Personnel should be checked for these listed:

(a) Eyes watering or burning, sore throat, i.e., irritation of mucous membranes.

(b) Difficulty breathing normally.

(c) Impaired senses such as tingling or numbness of the tip of the tongue, tip of the nose, finger tips, or toes.

(d) Impaired judgment.

(2) If two or more of the above symptoms are exhibited, then exposure limits must be reduced as listed:

(a) Prompt removal of affected personnel to fresh air is essential.

(b) Using the latest WBGT index values, determine the PHEL stay time by using table 3-4.

(c) Calculate the PHEL stay time for existing heat-stress conditions, and divide that stay time by three to obtain the new stay time. For example, if the exposure limit due to heat stress is 4 hours, then the exposure limit with stack gas or fuel vapors present would be reduced to 1 hour, 20 minutes.

f. Curve Selection

(1) Applicable PHEL curves should be determined by selecting the appropriate curve listed in table 3-3.

(2) Non-routine operations, such as performing operations in out-of-normal plant configurations, increases in normal watchstander work rate, and minor equipment casualties require the use of the next higher number curve above than specified in table 3-3 for routine operations. For example, if the stay time for a particular watchstander is determined to be PHEL Curve I during normal operations, then the exposure limit for the watchstander should be determined using PHEL Curve II during difficult or more active than normal watches.

(3) Engineering casualty control exercise watchstanders will have their stay times determined by selecting the appropriate curve listed in table 3-3.

(4) Personnel conducting heavy repairs or other strenuous work will have their stay time determined by using PHEL Curve VI.

(5) As indicated, the PHEL curves and the assignment in table 3-3 are based on normal, healthy personnel who have adequate rest and recovery from previous heat-stress exposures. Personnel having repetitive exposures to heat stress without sufficient recovery time may experience cumulative fatigue. Additionally, personnel with a cold or respiratory infection, lacking sufficient sleep (less than 7 hours in the past 24 hours), experiencing dehydration, having clinically confirmed hypertension or taking medication which adversely effects body temperature are much more prone to systemic heat injuries. Maximum exposure limits for these personnel cannot be reliably predicted using the PHEL Chart. The senior medical department representative (SMDR) on a case-by-case basis will determine appropriate exposure limits for these personnel.

(6) If, after determining personnel stay times a heat injury occurs, then the stay times for all other personnel in the space will immediately be reduced by recalculating stay times using the next numerically higher PHEL curve than specified by table 3-3. The work and health status of

the individual suffering the injury will be promptly reviewed. When the cause of the injury has been determined, the stay times for personnel in the space will be determined using the latest WBGT index and the normally appropriate curves as indicated in table 3-3.

Table 3-3. Physiological Heat Exposure Limits (PHEL) Curve General Applicability Aboard Ships

PERSONNEL	PHEL CURVE	
	Routine Watch	Casualty Control Drills
Steam Propelled Ships		
Propulsion Spaces		
1. Boiler Technician of the Watch (BTOW)	II	III
2. Console Operator	I	I
3. Upper Levelman (checkman)	II	III
4. Lower Levelman	II	III
5. Main Feed Pump (MFP) Watch	II	III
6. Burnerman	II	III
7. Engineering Officer of the Watch	I	I
8. Machinist's Mate of the Watch	II	III
9. Throttleman	I	I
10. Electrician Mate of the Watch	I	I
11. Upper Levelman Ship Service Turbine Generator	II	III
12. Lower Levelman (Lube Oil or Condensate)	II	III
13. Evaporator Watch	I	II
14. Messenger (see note below this table)	III	IV
Auxiliary Spaces		
All Watches	II	II
Diesel Propelled Ships		
1. All Engineering Watch Personnel (unless specified below)	I	II
2. Evaporator Watch	II	II
3. Messenger	III	IV
Gas Turbine Propelled Ships		
CG-47 Class Ships		
1. All Engineering Watch Personnel	I	II
DDG-51 Class Ships		
1. All Engineering Watch Personnel (unless specified below)	II	III
2. Sounding and Security Watch	III	III
Steam Catapult Spaces (including water break rooms)		
1. All Watches	II	II

Table 3-3. Physiological Heat Exposure Limits (PHEL) Curve General Applicability Aboard Ships (Continued)

PERSONNEL	PHEL CURVE Routine Watch	PHEL CURVE Casualty Control Drills
All Other Surface Ship Spaces		
1. ECC Monitors and Inspectors	I	II
2. Laundry Personnel	III	NA
3. Scullery Personnel	V	NA
4. Galley and Food Service Line Personnel	II	NA
5. Elevator Machinery Rooms	II	II
Submarines		
Engine Room		
1. EOOW	I	I
2. EWS	II	III
3. Throttleman	I	I
4. Reactor Operator	I	I
5. Electrical Operator	I	I
6. Upper Level	II	III
7. Lower Level	II	III
8. Evaporator Watch	I	II
9. Engineering Drill Monitors	NA	II
Auxiliary Spaces		
1. All Watches	II	II
Other Spaces		
1. Food Service Personnel	II	NA

Note: Messenger stay times should be determined by taking the average of all WBGT Index values for the space not including the console booth. In most cases this will give a longer stay time than using PHEL Curve values listed for the messenger above.

g. TWM WBGT (Afloat)

(1) The TWM WBGT value is intended for use in especially hot environments where reduced stay times have been imposed on personnel. The TWM WBGT is an optional provision, for use if an air-conditioned booth or cooler workspace is available to afford some relief from the heat.

(2) When the TWM is used it changes the WBGT value for that individual and increases the length of time spent at the watch station or work location. Proper calculation of the TWM WBGT as listed:

$$\text{Time (Cooler space)} = \frac{[\text{WBGT (work location)} - \text{WBGT (desired)}] \times 60}{\text{WBGT (work location)} - \text{WBGT (cooler space)}}$$

Example: Engineering spaces on a guided missile destroyer (DDG) in the Indian Ocean are manning a 4-hour watch rotation. The temperature on a hanging DB thermometer in a main space measured 101°F during the latest heat-stress survey:

Engine Room Operator	WBGT = 92	PHEL = II	Stay Time = 4:10
Central Control Station (CCS) (top watch)	WBGT = 92	PHEL = III	Stay Time = 3:30
Propulsion System Monitor	WBGT = 80	PHEL = I	Stay Time = 8:00

The propulsion system monitor has a stay time less than 4 hours while other watch stations have stay times that are equal to or greater than 4 hours. The engineer officer decides to incorporate a TWM WBGT for the propulsion system monitor to maintain a 4-hour watch for all watch space personnel, then looks up the WBGT value (in table 3-3) to achieve a 4-hour stay time (90 WBGT = stay time of 4 hours) and does the calculation. The time that the propulsion system monitor must spend in the cool space each hour to achieve a 4-hour watch would be calculated as listed:

For the Propulsion System Monitor:

Time (booth) =	$\frac{\text{(WBGT (watch station) – WBGT (desired)) x 60}}{\text{WBGT (watch station) – WBGT (booth)}}$

The 90 WBGT value is from the PHEL Table

Time (booth) =	$\frac{92\text{-}90 \times 60}{92\text{-}80}$	= 10 minutes

Thus, if the propulsion system monitor can spend 10 minutes each hour in the cool booth, he may work a 4-hour watch.

Table 3-4. PHEL Time Limits for PHEL Curves I-VI Without the Presence of Fuel Combustion Gases or Fuel Vapors

WBGT Index (F)	Total Exposure Time in Hours: Minutes					
	I	II	III	IV	V	VI
80.0	>8:00	>8:00	>8:00	8:00	6:35	4:30
81.0	>8:00	>8:00	>8:00	7:45	6:00	4:05
82.0	>8:00	>8:00	8:00	7:05	5:25	3:40
83.0	>8:00	8:00	7:45	6:25	4:55	3:20
84.0	>8:00	8:00	7:05	5:55	4:30	3:05
85.0	8:00	7:45	6:30	5:20	4:05	2:50
86.0	8:00	7:05	5:55	4:55	3:45	2:35
87.0	7:25	6:30	5:25	4:30	3:25	2:20
88.0	6:45	5:55	4:55	4:05	3:10	2:10
89.0	6:10	5:25	4:30	3:45	2:50	2:00
90.0	5:40	5:00	4:10	3:25	2:40	1:50

Table 3-4. PHEL Time Limits for PHEL Curves I-VI Without the Presence of Fuel Combustion Gases or Fuel Vapors (Continued)						
WBGT Index (F)	Total Exposure Time in Hours: Minutes					
	I	II	III	IV	V	VI
91.0	5:15	4:35	3:50	3:10	2:25	1:40
92.0	4:50	4:10	3:30	2:55	2:15	1:30
93.0	4:25	3:50	3:15	2:40	2:00	1:25
94.0	4:05	3:35	3:00	2:25	1:50	1:15
95.0	3:45	3:15	2:45	2:15	1:45	1:10
96.0	3:25	3:00	2:30	2:05	1:35	1:05
97.0	3:10	2:45	2:20	1:55	1:25	1:00
98.0	2:55	2:35	2:10	1:45	1:20	0:55
99.0	2:40	2:20	2:00	1:40	1:15	0:50
100.0	2:30	2:10	1:50	1:30	1:10	0:45
101.0	2:20	2:00	1:40	1:25	1:05	0:45
102.0	2:10	1:50	1:35	1:15	1:00	0:40
103.0	2:00	1:45	1:25	1:10	0:55	0:35
104.0	1:50	1:35	1:20	1:05	0:50	0:35
105.0	1:40	1:30	1:15	1:00	0:45	0:30
106.0	1:35	1:25	1:10	0:55	0:45	0:30
107.0	1:30	1:15	1:05	0:50	0:40	0:25
108.0	1:20	1:10	1:00	0:50	0:35	0:25
109.0	1:15	1:05	0:55	0:45	0:35	0:25
110.0	1:10	1:00	0:50	0:40	0:30	0:20
111.0	1:05	1:00	0:50	0:40	0:30	0:20
112.0	1:00	0:55	0:45	0:35	0:25	0:20
113.0	0:55	0:50	0:40	0:35	0:25	0:15
114.0	0:55	0:45	0:40	0:30	0:25	0:15
115.0	0:50	0:45	0:35	0:30	0:20	0:15
116.0	0:45	0:40	0:35	0:25	0:20	0:15
117.0	0:45	0:40	0:30	0:25	0:20	0:10
118.0	0:40	0:35	0:30	0:25	0:15	0:10
119.0	0:35	0:35	0:25	0:20	0:15	0:10
120.0	0:35	0:30	0:25	0:20	0:15	0:10
121.0	0:35	0:30	0:25	0:20	0:15	0:10
122.0	0:30	0:25	0:20	0:15	0:15	0:10
123.0	0:30	0:25	0:20	0:15	0:10	0:10
124.0	0:25	0:25	0:20	0:15	0:10	0:05
125.0	0.25	0.20	0.20	0.15	0.10	0.05

Table 3-5. PHEL Time Limits for PHEL Curves I-VI With the Presence of Fuel Combustion Gases or Fuel Vapors

WBGT Index (F)	Total Exposure Time in Hours: Minutes					
	I	II	III	IV	V	VI
80.0	4:50	4:15	3:30	2:55	2:15	1:30
81.0	4:25	3:50	3:10	2:40	2:00	1:20
82.0	4:00	3:30	2:55	2:25	1:50	1:15
83.0	3:40	3:10	2:40	2:10	1:40	1:10
84.0	3:20	2:55	2:25	2:00	1:30	1:00
85.0	3:00	2:40	2:10	1:50	1:25	0:55
86.0	2:45	2:25	2:00	1:40	1:15	0:50
87.0	2:30	2:10	1:50	1:30	1:10	0:45
88.0	2:20	2:00	1:40	1:25	1:05	0:40
89.0	2:05	1:50	1:30	1:15	1:00	0:40
90.0	1:55	1:40	1:25	1:10	0:55	0:35
91.0	1:45	1:30	1:15	1:05	0:50	0:30
92.0	1:35	1:25	1:10	1:00	0:45	0:30
93.0	1:30	1:20	1:05	0:55	0:40	0:25
94.0	1:20	1:10	1:00	0:50	0:35	0:25
95.0	1:15	1:05	0:55	0:45	0:35	0:20
96.0	1:10	1:00	0:50	0:40	0:30	0:20
97.0	1:10	0:55	0:45	0:40	0:30	0:20
98.0	1:05	0:50	0:40	0:35	0:25	0:15
99.0	0:55	0:45	0:40	0:30	0:25	0:15
100.0	0:50	0:45	0:35	0:30	0:20	0:15
101.0	0:45	0:40	0:35	0:25	0:20	0:15
102.0	0:40	0:35	0:30	0:25	0:20	0:10
103.0	0:40	0:35	0:30	0:25	0:15	0:10
104.0	0:35	0:30	0:25	0:20	0:15	0:10
105.0	0:35	0:30	0:25	0:20	0:15	0:10
106.0	0:30	0:25	0:20	0:20	0:15	0:10
107.0	0:30	0:25	0:20	0:15	0:10	0:10
108.0	0:25	0:25	0:20	0:15	0:10	0:05
109.0	0:25	0:20	0:15	0:15	0:10	0:05
110.0	0:25	0:20	0:15	0:15	0:10	0:05
111.0	0:20	0:20	0:15	0:10	0:10	0:05
112.0	0:20	0:15	0:15	0:10	0:10	0:05
113.0	0:20	0:15	0:15	0:10	0:05	0:05
114.0	0:15	0:15	0:10	0:10	0:05	0:05
115.0	0:15	0:15	0:10	0:10	0:05	0:05
116.0	0:15	0:10	0:10	0:10	0:05	0:05
117.0	0:15	0:10	0:10	0:05	0:05	0:05

h. Remaining Safe Stay Time

(1) If a person's status changes during the period of a watch, e.g., the person assumes a watch in a different location or works at a different exertion level, stay times will be computed using the procedures for remaining safe stay times.

(2) There are a number of situations where it is necessary to estimate the remaining safe stay times relative to various heat stress conditions, different work levels and to account for recovery periods. A simplified approach to estimating the remaining safe stay times is given in the below equation:

Table 3-6. Remaining Safe Stay Time Equation
RSSt = [1 - ({Et - R/2} / At1)] x [At2]
Where: RSSt = remaining safe stay time (in minutes) Et = elapsed time on station (in minutes) R = recovery time in a cool environment (in minutes) At1 = allowed PHEL time in first environment (in minutes) At2 = allowed PHEL time in second environment (in minutes)

Note: Application of the Remaining Safe Stay Time Equation assumes some cumulative fatigue will take place.

(3) Four examples will help illustrate calculating Remaining Safe Stay Times:

(a) The level of physical work was changed from heavy to light work and the heat stress is higher in the light work phase, the elapsed time of the first exposure is known, and no recovery is permitted between the two levels of physical work.

1. Elapsed exposure time in the first heat stress condition was 3 hours (180 minutes).

2. The first heat stress condition had a WBGT of 83.0°F and work was consistent with PHEL Curve VI. [PHEL VI at 83.0°F permits a maximum of 3 hours, 20 minutes (200 minutes)].

3. There was no recovery in a cool environment between the first environment and the second (WBGT 94.3°F (which is rounded to 95°F) with work equal to PHEL Curve I). [PHEL I at 95°F permits a maximum of 4 hours (240 minutes).]

4. Therefore, RSSt #l = [1 - ({180 - (0/2)} / 200)] * [240] = 24 minutes. The second exposure situation should not exceed 24 minutes.

(b) The level of physical work was unchanged at the same heat stress level, but the two exposures were separated by a 40-minute recovery period in a cool environment; the elapsed time was known for the first exposure.

1. Elapsed exposure time in the first heat stress condition was 3 hours (180 minutes).

2. Both heat stress conditions had WBGT values of 91.3°F (which is rounded to 92°F) and the level of work was consistent to PHEL Curve I in both cases. [PHEL I at 92°F permits a maximum of 5 hours, 8 minutes (308 minutes) each].

3. Recovery, between the 2 exposures, was permitted for 40 minutes.

4. Therefore, RSSt #2 = [1 - ({180 - (40/2)} / 308)] x [308] = 148 minutes or 2 hours, 28 minutes. The second exposure situation should not exceed 2 hours, 28 minutes.

(c) The level of physical work was the same in 2 different heat stress environments, the exposure time in the first condition was known, and the 2 exposures were separated by a 40-minute recovery in a cool environment.

1. Elapsed exposure time in the first heat stress condition was 3 hours (180 minutes).

2. The first heat stress condition had a WBGT of 91.3°F (which is rounded to 92°F) and work equaled that for PHEL Curve I. [PHEL I at 92°F permits a maximum of 5 hours, 8 minutes (308 minutes)].

3. There was 40 minutes recovery in a cool environment between the first environmental exposure, and the second exposure at a WBGT of 94.3°F (which is rounded to 95°F) with work equivalent to PHEL Curve I. [PHEL Curve I at WBGT of 95°F permits 4 hours (240 minutes) stay time].

4. Therefore, RSSt #3 = [1 - ({180 - (40/2)} / 308)] x [240] = 115 minutes or 1 hour, 55 minutes. The second exposure situation should not exceed 1 hour, 55 minutes.

(d) The level of physical work changed from an intermediate level to lighter level and the heat stress was considerably higher during the second exposure. Both the elapsed time for the first exposure and the recovery time between exposures were known.

1. Elapsed exposure time in the first heat stress condition was 3 hours, 15 minutes (195 minutes).

2. The first heat stress condition had a WBGT of 87.7°F (which is rounded to 88°F) and work was consistent with PHEL Curve IV. [PHEL IV at 88°F permits a maximum of 4 hours, 15 minutes (255 minutes)].

3. There was 50 minutes recovery in a cool environment between the first exposure and the second; the work during the second exposure was equivalent to PHEL Curve II, but the WBGT value was 100.9°F (which is rounded to 101°F) for the second exposure. [PHEL II at 101°F allows a maximum of 2 hours, 5 minutes (125 minutes)].

4. Therefore, RSSt #4 = [1 - ({195 - (50/2)} / 255)] x [125] = 42 minutes. The second exposure situation should not exceed 42 minutes.

i. Alternative Measures. It is sometimes impossible to control environmental heat within the specified limits in the face of increased operational demands. Alternative administrative or engineering measures may therefore be useful in limiting heat stress and reducing the incidence of heat casualties. Table 3-7 provides alternative measures.

Table 3-7. Measures to Limit Heat Stress and Reduce Incidence of Heat Casualties
1. Insulate the source of heat.
2. Ventilation with cool air.
3. Reduce humidity (partial water vapor content) by stopping steam leaks and venting steam to the outside.
4. Provide clothing that will maximize evaporative cooling.
5. Cool garments or systems.
6. Limit exposure time (refer to PHEL Chart).
7. Avoid cumulative fatigue; maintain overall physical health.
8. Spray with water mist.
9. Eliminate the presence of fuel combustion gases and fuel vapors.
10. Modify work rest cycles.
11. Automate and isolate operations that generate excessive heat when feasible.

j. WBGT Estimation

(1) Emergency estimation of WBGT may be performed if no working or calibrated WBGT equipment is available.

(2) The emergency environmental monitoring equipment method discussed here has the potential of significantly underestimating the level of heat stress; this limitation can result in an increased risk of personnel experiencing heat injury. When there are no operable WBGT meters aboard ship, there are two alternative monitoring methods that may be used while the ship is underway; motorized psychrometers (NSN 1H-6685-00-936-1389) carried aboard ships for meteorological purposes, or commercially available hygrometers. These psychrometers only measure DB and WB temperatures. They do not have a globe thermometer and therefore cannot account for radiant and convective heating or cooling. Hence all of the components in the WBGT Index equation are not available to calculate the WBGT Index. If using the motorized psychrometers DB and WB temperatures must be measured with the psychrometer shield in its proper position (the flared-open end of the shield must be facing away from the psychrometer).

GT can be approximated by taking the difference (ΔT) between the DB temperature and the GT from previous heat stress surveys conducted under similar plant operating conditions (power level, number of operating boilers, and approximately the same load on the propulsion plant). This difference (ΔT) should be added to the DB temperature measured with the psychrometer. See Table 3-8 for sample calculations.

Table 3-8. Sample Calculation of Estimated WBGT			
Psychrometer WB	83.6	Previous GT	110.4
Psychrometer DB	99.1	Previous DB	98.3
		ΔT =	12.1
Estimated GT(DB+ ΔT) = 99.1 + 12.1 = 111.2			
WBGT Formula = (0.1 x DB) + (0.7 x WB) + (0.2 x GT)			
WBGT = (0.1 x 99.1) + (0.7 x 83.6) + (0.2 x 111.2)			
WBGT = 90.7			

(3) The WBGT Index values obtained by this strictly emergency monitoring method should be used with the PHEL Chart (figure 3-5) or tables (tables 3-3 and 3-4). The resultant exposure limits will be approximations only.

3-12. Shore and Ground Forces

a. <u>Shore Guidance</u>

(1) For shore commands the information in table 3-9, based on the ACGIH TLV® for Chemical Substances and Physical Agents and Biological Exposure Indices (BEI)®, should be used as guidance to determine work and rest criteria for work situations in a heat stress environment. Table 3-9, American Conference of Governmental Industrial Hygienists (ACGIH) Threshhold Limit Values (TLV)® and Work and Rest Criteria, available in the Thermal Stress chapter of the current edition ACGIH publication, may be used to help identify workers at risk for heat injury who should be monitored for (and limited from excessive) heat stress exposure. Examples of typical work levels for Navy and Marine Corps shore settings are found in table 3-10. Work and rest criteria do not apply for physical fitness or PT activities where the heat stress flag conditions found in article 3-6, subparagraph 3-6(2)(d) exist and guidance from table 3-2 should be followed. Work and rest criteria do not apply to ships, submarines, and small craft where PHEL curves are to be used. Spot cooling and general ventilation should be used whenever possible. Good airflow increases evaporation and cooling of the skin.

Table 3-9. American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV)® and Work and Rest Criteria								
	WBGT Values (°C/ °F)							
	Acclimatized				Unacclimatized			
Work Demands	**Light**	**Moderate**	**Heavy**	**Very Heavy**	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75 to 100% Work	31/88	28/82	N/A	N/A	28/82	25/77	N/A	N/A
50 to 75% Work	31/88	29/84	27.5/82	N/A	28.5/83	26/79	24/75	N/A
25 to 50% Work	32/90	30/86	29/83	28/82	29.5/85	27/81	25.5/78	24.5/76
0 to 25% Work	32.5/91	31.5/88	30.5/89	30/86	30/86	29/83	28/82	27/81
Source: ACGIH®, *2021 TLVs® and BEIs®* book. Copyright 2021. Reprinted with permission.								

(2) These WBGT values are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a core body temperature of 38°C (100.4°F). They are also based on the assumption that the WBGT index of the resting place is the same or very close to that of the workplace. Where the WBGT index of the work area is different from that of the rest area, a time-weighted average should be used (consult the electronic version of the *ACGIH 2021 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* or most current edition) available at: http://www.acgih.org/. These WBGT values apply to physically fit and acclimatized individuals wearing light summer clothing. If heavier clothing that impedes sweat or has a higher insulation value is required, the measured WBGT value must be adjusted accordingly. If wearing coveralls or field uniform, add 6 to the measured WBGT value. If wearing body armor or NBC protective clothing, add 10 to the measured WBGT value. Exposure limits should be adjusted accordingly.

Table 3-10. Examples of Work Levels for Navy and Marine Corps Activities	
WORK LEVEL	**ACTIVITY**
Light Work	Sitting - office activities
	Driving car
	Standing light work mostly arm movement
	Standing watch duties
Moderate Work	Laboratory work
	Normal walking, moderate lifting
	Meal preparation and serving
	Driving a truck, forklift, etc.
	Laundry and dry cleaning work
Heavy Work	Maintenance and repair work such as replacing tires, engine work, etc.
	Hand sawing wood
	Pick, shovel, and axe work
	Setting up tents
Very Heavy Work	Shoveling wet sand, filling and stacking sand bags

b. Ground Forces Guidance

(1) Guidance for ground forces focus mostly on field training exercises and work schedules.

(2) Field training exercises requiring sustained or severe physical effort should be scheduled, when possible, in early morning or at night. Outdoor classes should be conducted in the shade with adequate exposure to cooling wind. Even when training exercises are performed in early morning or at night, high metabolic heat production by those performing physical activity can induce heat exhaustion or heat stroke. Therefore, it is important to be aware of all factors that may precipitate systemic heat injuries. Careful monitoring of the WGBT index is essential to the prevention of heat injury in the field. Heat casualties can be expected at WBGT readings of 75°F and above, unless preventive measures are instituted. Heavy work can cause heat injury at lower temperatures, especially if body armor or protective clothing is worn.

(3) Work schedules must be tailored to the situation. When temperatures are high, work must be curtailed or even suspended under severe conditions. The temperature at which work schedules modification will take place depends on humidity, radiant heat, wind velocity, character of the work, degree of acclimatization, and other factors. Work can be scheduled during the cooler hours of the day, such as morning and evening, and still meet the workload requirement. In garrison areas it is important that WBGT readings be conducted for the area. While deployed to areas of operation in the field, medical personnel are relied upon to have, operate, and maintain WBGT equipment and follow the work and rest guidance in article 3-12, subparagraph 3-12a. Commanders should be familiar with NEHC-TM-OEM 6260.6A, of which chapter 11, section C11. Heat Stress Injuries Prevention and Treatment is a summary of relevant information for leaders not involved with patient care.

(4) The effects of thermal stress can be lessened within an area while in garrison by employing a few shading techniques to provide protection from the radiant sun's rays. Camouflaged netting can reduce temperatures inside tents and other facilities exposed to the direct rays of the sun. This is especially important in common use areas such as dining tents, recreation areas, and berthing. Hydration of troops should be promoted by providing protected sources of cool drinking water in numerous locations throughout the camp.

(5) The Urine Chart in figure 3-6 can be used as a guide to determine if personnel are drinking enough water to stay hydrated. It is not to be substituted for other guidance regarding stay times or hydration, and accurate urine chart color reproduction (e.g., when printed) is important. Large volumes of relatively clear urine indicate proper hydration. Small volumes or dark urine indicate dehydration and the need to drink more fluids. A yellow or darker color associated with numbers 4 to 8 in the Urine Chart indicates that a Service member should be drinking more water and if the color persists should see a medical department representative. Some foods, vitamins, prescriptions, and over-the-counter drugs may alter urine color or have a diuretic effect.

Figure 3-6. Urine Chart

Validated in: Urinary Indices of Hydration Status, INT. J. Sport Nutrition 4:265-279, 1994

SECTION III. COLD STRESS

3-13. Cold Stress Effects

a. The adverse effects of low environmental temperatures on the human body may be localized, generalized, or both. They may occur at temperatures above or below freezing and under wet or dry conditions. The features of cold injury are dependent on the environmental temperature (ambient and wind chill temperature), exposure time and individual susceptibility or resistance. The body's response to total cooling is to try and maintain thermal energy and increase heat production. Shivering is the body's attempt to increase heat production. With prolonged or severe exposure, the defense mechanisms fail, heat loss exceeds heat production, and the body temperature falls.

b. Few aspects of cold weather operation are as important as having a well-indoctrinated crew and unit. Everyone, from the commanding officer to the newest Seaman and Marine, must have a good understanding of the cold weather environment with which they will be faced and what will be expected of them.

c. Each individual should know how to minimize cold stress, recognize the symptoms of cold injuries, and provide basic first aid. Common cold stress conditions are listed in article 3-19.

3-14. Temperature and Wind

a. As the temperature drops, more insulation is required to keep the body from losing heat. Excessive loss of body heat, which can occur even in mild temperatures, may lead to death by hypothermia.

b. When exposed to cold, it is vital to implement control measures in order to prevent risk of cold stress injuries and to maintain mission readiness.

c. Wind is another factor that can affect body temperature. Parts of the body exposed directly to the wind will lose heat quickly, a phenomenon commonly referred to as "wind chill." On bare skin, wind will significantly reduce the temperature of the skin (through evaporation) to below the ambient air temperature, making it feel colder than the temperature alone indicates.

3-15. Environmental Measurements - Wind Chill

a. The wind chill temperature is how cold the human body will feel due to a combination of cold temperature and air movement (wind). As the air speed increases in cold temperatures, heat is drawn from the surface of the body, driving down skin temperature and eventually the internal body temperature. Therefore, the combination of wind and temperature creates the effect of wind chill, which makes it feel much colder. The Wind Chill Temperature Index is displayed in figure 3-7.

b. Determining wind chill is accomplished by measuring the ambient temperature and wind speed. The temperature and wind speed can be measured by multiple devices (Dry bulb thermometer and an anemometer or wind gauge) or with the use of a hand held weather meter similar to the Kestrel® used by the Forward Deployed Preventive Medicine Unit (FDPMU), components of the Navy and Environmental Preventive Medicine Units (NEPMUs). The operating range of the meter being used to measure temperature in cold environments is to be verified, as most meters used to measure heat stress may not be designed for use in cold environments. An anemometer or wind gauge will be required to measure wind speed. The hand held weather meter should have the ability to measure temperature, barometric pressure, wind speed and air speed, headwind, tailwind, crosswind, dew point temperature, RH and possibly wind chill. If the hand held weather device does not have a wind chill function, the data gained from the other features can be used to determine the wind chill from the chart in figure 3-7.

	Temperature (°F)																	
Wind (mph) / 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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill } (^\circ F) = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T = Air Temperature (°F) V = Wind Speed (mph)

Effective 11/01/01

Figure 3-7. National Weather Service Wind Chill Temperature Index

3-16. Afloat Personal Protection

a. The effects of exposure are not readily recognized. The rotation interval for exposed personnel standing topside watches may be varied with weather conditions. Watch rotation of 20-30 minutes is effective and recommended.

b. Personnel who get wet on deck must go below immediately and change into dry clothing.

c. Whenever topside look-outs start feeling cold, they should flex fingers and toes. The look-outs should be periodically checked by watch personnel.

d. Provide for portable, topside heaters or enclosures for personnel involved in extended topside evolutions as much as possible. Hangar space heaters have proven effective.

e. Anticipate that routine evolutions could take twice as long in cold weather.

f. Periodically inspect berthing space temperatures and ventilation. Ensure adequate bedding materials are available.

g. Provide for additional heaters for particularly exposed areas, such as the Signal Bridge and Pilot House.

h. Hot beverages and soup should be available on the mess deck 24-hours a day and distributed to look-outs and flight-deck crews.

3-17. Preventive Measures

a. General Prevention. Most cold-related health consequences are preventable. Preventive measures include adequate shelter, proper cold weather clothing and layers and gear for the face, hands, feet, and head, adequate nutrition, adequate hydration, limiting or avoiding alcohol, gradual acclimatization (taking a few weeks "to get used to the cold"), changing socks at least daily (or more often if wet), and using proper equipment for specific tasks such as dry suits for diving, anti-exposure suits on deck, and plastic-coated tools and equipment.

b. Risk Factors

(1) Within the usual age range of Sailors and Marines, age is not a significant factor of susceptibility to cold injury.

(2) A previous episode of cold injury increases an individual's susceptibility to subsequent cold injury.

(3) Extreme cold exposure may bring about mental weariness or fatigue, which may lead to apathy and neglect of survival behaviors.

(4) Strenuous activity generates a large amount of heat and leads to sweating. The resulting perspiration, which becomes trapped in the clothing, markedly reduces the insulating quality of the clothing. Conversely, immobility causes decreased body heat production that results in cooling, especially of the extremities. Wiggling the extremities such as the fingers and toes, and massaging the ears and nose will increase circulation and keep them warm. When exercise is not possible, frequent changes of position will encourage circulation.

(5) Humidity affects environmental cold stress by affecting the speed of evaporation of sweat from the skin. Wet skin or clothing increases conductive and convective heat loss in a cold environment. This is especially increased due to cold wind, or when in contact with cold surfaces.

(6) Personnel from warmer climates appear to be predisposed to cold injury. However, proper acclimatization will help compensate for this predisposition.

(7) Proper personal hygiene must be maintained in cold weather operations. Personnel involved in field operations may neglect basic hygiene and become susceptible to skin disease because of the lack of hot water and convenient washing facilities.

(8) Poor nutrition predisposes a person to cold injury. The standard military ration will provide adequate nutrition for appropriately clothed and protected personnel during most cold weather operations. Increased caloric intake, especially in the form of carbohydrates, is important for the production of internal body heat in very cold operations. Proper nutrition includes hydration. Adequate water intake must be maintained in cold environments. Adequate water intake is as important in cold environments as in hot environment since personnel may not be aware of sweat or respiratory water loss.

(9) Medical personnel will find detailed information on salt and water requirements in article 3-6, subparagraphs 3-6g and 3-6h of this manual. It is important to note that caution must be taken to prevent dehydration from occurring in the cold even though this is far different from a heat stress environment typically associated with dehydration.

(10) Personnel taking prescription medications must be aware medications may potentially trigger an adverse effect on blood circulation and sweating mechanisms.

(11) Alcohol (ethanol) can cause dilation of peripheral blood vessels, resulting in accelerated heat loss to the environment. Alcohol can also cause cutaneous capillary dilation, which in turn may inappropriately increase cutaneous blood flow during cold exposure and result in decreased skin temperature, causing the core temperature to drop more quickly. More importantly, alcohol may inhibit appropriate behavior (e.g., seeking shelter from cold, changing into dry clothing, etc.).

(12) Nicotine causes the peripheral blood vessels to constrict decreasing blood flow to the extremities predisposing individuals to local cold injuries such as frost bite.

c. Acclimatization. Similar to the notation about adaptation to heat stress in article 3-6, subparagraph 3-6f of this manual, acclimatization may also occur with adaptation to cold stress after repeated exposure to cold conditions. Benefits of acclimatization to cold are very limited compared to benefits of acclimatization to heat.

d. Cold Weather Clothing. One of the most challenging yet seemingly simple tasks encountered in a cold weather environment is trying to keep people properly dressed and warm. Having both the proper clothing and the necessary amount of clothing to carry out the mission is imperative in cold weather. It is essential that personnel be able to function in the cold, i.e., maintain sufficient mobility, warmth and dryness to safely perform their duties. The best way to avoid cold weather casualties starts with wearing the right clothes, and wearing them properly.

Personnel should be well-informed on all aspects of cold weather clothing, including variety and usage. Clothing acquired from cold weather clothing supply systems should be in sufficient quantity and properly sized to adequately protect the crew.

(1) Personnel performing work in cold weather environments should wear or carry adequate amounts of the proper types of clothing for the conditions. Clothing must be worn in layers so additional layers can be removed easily before sweating causes the material to lose its insulating properties. Outer layers should be wind resistant. Loose clothing allows for efficient blood circulation and creates air pockets that provide insulation. Clothing must be kept clean and dry to prevent deterioration of the material. Rain suits must be large enough to adequately cover the cold weather clothing. Wearing NBC protective clothing during strenuous activity in cold weather may increase the risk of hyperthermia (and even heat injury) and cause sweat accumulation in clothing; this compromises insulation and increases the risk of hypothermia during subsequent periods of inactivity. All exposed skin areas need protection from the cold and wind. The face is especially vulnerable to cold injury; as much as 75 percent of heat loss can occur through the head so ensuring proper face and head protection is vital. Heat injuries may also occur in cold weather operations, so wearing appropriate clothing can help prevent various types of heat and cold injuries from occurring.

(2) Cold weather insulated rubber boots (black or white) are typically issued to personnel during cold weather operations to protect their feet from various elements. Frequently changing socks is important with these boots because of increased foot sweating. Retention of moisture may lead to fungal infections and, if moisture retention is excessive, trench foot may occur. Cold injuries can still occur in these boots if the feet are not exercised. Carry additional socks to properly change soiled and wet socks as often as needed. Dirty socks should be washed whenever possible. Sweating of the feet may be controlled by the use of antiperspirants containing aluminum chlorohydrate. Feet should be massaged daily, toenails trimmed, and blisters cleaned and protected.

(3) Mittens are more protective than gloves because fingers generate more heat when they're not separated from each other by fabric, as they are with gloves. Gloves present more surface area for heat loss and are therefore less efficient than mittens in keeping hands and fingers warm. Wet leather gloves must be dried slowly to prevent shrinkage and hardening of the leather. The wool liners must be dried slowly to prevent shrinkage.

(4) Normally, much of the solar radiation that reaches the earth is absorbed into the ground and the surrounding environment. However, in the snow the majority of the sun’s rays are reflected off the facets of ice crystals; reflected rays may therefore be absorbed by the skin or pass into the eye. When working in snowy environments, use of sunscreen and sunglasses is strongly recommended. Sunglasses should be worn during daylight hours regardless of whether the sun is shining or overcast. A bright, cloudy day is deceptive and can be as dangerous to the eyes and skin as a day of brilliant sunshine. Glasses will also protect against blowing snow. The risk of snow blindness and sunburn is increased at high altitudes; thin, clear air allows more of the damaging (ultraviolet) rays of sunlight to penetrate eyes and skin.

e. Signs of Cold Injuries. Personnel must be trained to recognize signs of cold injuries in other individuals. When blanching (pale area) of the skin is noticed, immediate action may prevent the development of a potential cold injury. Holding (not rubbing) a warm hand on the blanched area until it returns to a normal color is an effective treatment for a cold ear, nose, or cheek. Fingers can be warmed against the bare abdomen, chest, or armpit. If an individual complains of an abrupt loss of cold sensation or extreme discomfort in the affected body part, immediate action must be taken. Remove the person from the cold environment, as these are classic signs of early cold injury.

f. Manual Dexterity. Exposure to the cold may negatively influence manual dexterity (the ability to use hands in a skillful, coordinated manner for grasping and precise movements). Hand skin temperature, rather than body surface temperature, is the critical factor. When hand skin temperature is 55°F (12.8°C) or lower, manual performance is impaired. Touching very cold objects (such as touching cold metal with the tongue or fingers) may freeze the body part to the object; the frozen part and object should be warmed until they can be easily separated, as pulling away will damage the skin and possibly lead to an infection.

3-18. Cold Water Immersion

a. Effects of Cold Water Immersion. Immersion in cold water impairs swimming performance (at 64°F or 18°C). Personnel immersed in cold water cannot reliably assess how cold they are. With immersion in mildly cool water, stability of the temperature of cutaneous receptors may lead to hypothermia without personnel being aware of their condition. In frigid water complex physiological responses are triggered that shut down the blood circulation to most parts of the body except heart, lungs, and brain. Though blood, in such situations, contains only a limited amount of oxygen, it can be enough to sustain life and prevent damage to brain tissue for considerable periods of time, if body core temperature has dropped (a cooled brain needs less oxygen than one at normal temperature). It takes 10-15 minutes before the core body temperature begins to drop; surface tissues cool more quickly. A victim may experience labored breathing and stiffness of limbs. As core temperature drops to 95ºF there will be violent shivering; at 90-95ºF mental facilities cloud; at 86-90ºF there is muscular rigidity and loss of consciousness. Below 86ºF there is diminished respiration and possible heart failure, below 80ºF respiration becomes almost undetectable and death is imminent.

b. Cold Water Survival

(1) Survival time in cold water will depend on several factors, such as water temperature, sea state, and having a floatation device. In cold water at 32°F (0°C) the ventilation rate initially increases (more than 4 times a normal baseline for the first 2 minutes of immersion). After 10 minutes of immersion, mean skin temperature falls to 41°F (5°C). After 20 minutes of immersion, shivering metabolism peaks. Swimming increases heat production to 2.5 times that of holding still in cold water but also increases the cooling rate 35 percent. The colder the water, the shorter the survival time (e.g., 1 hour at 32°F or 0°C). Figure 3-8 shows the survival time in cold water as a function of water temperature. Actual survival without flotation devices may be much less.

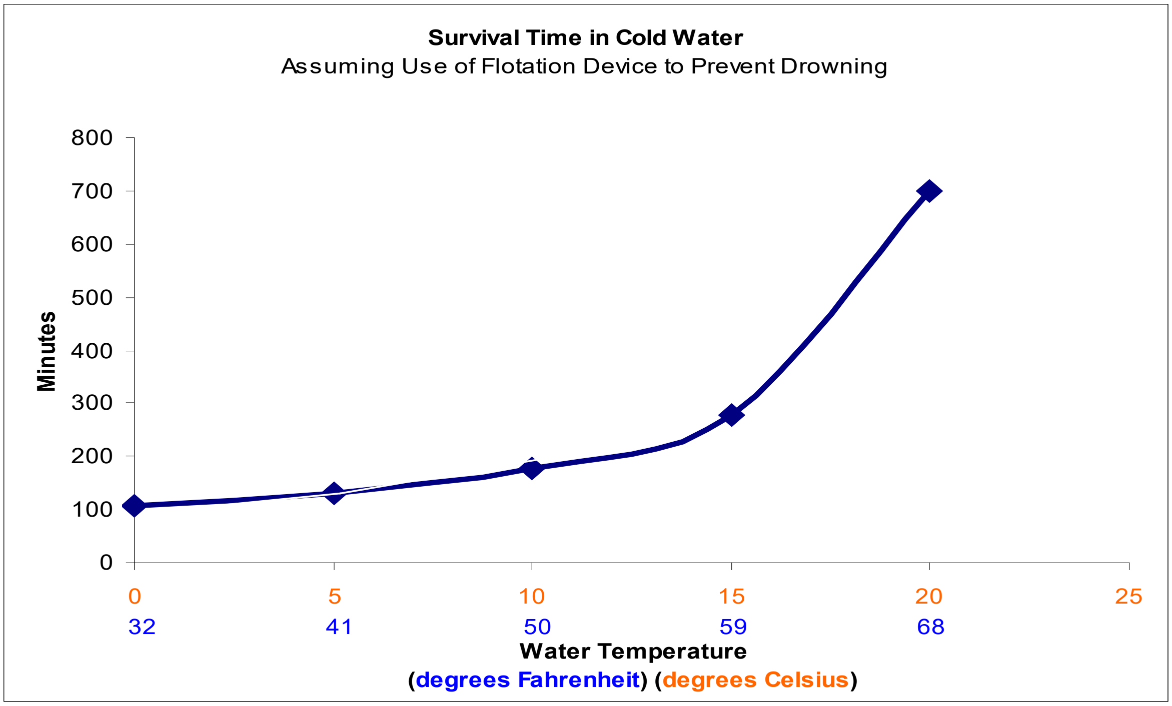


Figure 3-8. Survival Time in Cold Water (Estimated)

(2) *Do's* of cold water immersion:

(a) Wear a personal flotation device and several layers of clothing.

(b) Try to keep lungs inflated with air to maintain buoyancy.

(c) Use minimum movement to prevent the escape of trapped air in clothing, which acts as an insulator.

(d) Maintain Heat Escape Lessening Posture (HELP) until help arrives. The HELP position (figure 3-9) is creating a fetal position with arms and legs withdrawn close to the body. This position protects the body's three major areas of heat loss (groin, head and neck, rib cage and armpits). An alternative is to huddle with two or more persons in the water to decrease heat loss and support buoyancy.

(e) Take advantage of floating objects to assist with flotation.

(3) *Don'ts* of cold water immersion:

(a) Do not panic! Actions within the first 10 seconds can mean a difference between survival and death.

(b) Do not struggle! Struggling will squeeze insulation air out of clothing and ingesting cold water may constrict breathing passages.

(c) Do not swim for land that is over a mile away.

(d) Do not remove clothing.

(e) Do not float on your back. Instead rely on the natural buoyancy of the body and use the hands in a semi-vertical position in the water, with the head just above the water surface. The greatest heat loss is from the head and neck so immersion of those areas by floating on the back, can swiftly begin the onset of hypothermia and death. See figure 3-9 to adopt the HELP. If immersed with others, huddle to maintain body heat.

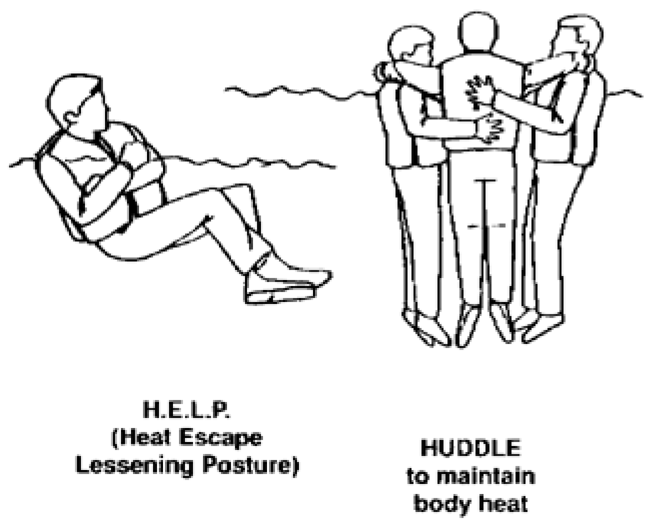


Figure 3-9. Recommended Cold Water Immersion Postures

3-19. Cold Stress Exposure Injuries. It is essential to recognize cold weather hazards in order to survive in the cold. Prevention of injuries is, of course, the objective of being safety conscious. When injuries occur, an accurate, early diagnosis will greatly reduce the dangers and aid in a speedy recovery. There are four common types of cold stress injuries: cold shock, nonfreezing injuries, freezing injuries, and hypothermia. The terms "nonfreezing" and "freezing" injuries refer to localized areas of the body exposed to cold stress, which may result in temporary impairment or permanent scarring or loss of the affected body part. Whole-body cold stress can result in hypothermia, which, if severe or if not treated in time, can result in organ damage or death.

a. Cold Shock. "Cold shock" (not true "shock" in the medical sense) may be produced when personnel pass from heated areas into air-conditioned spaces. Individuals experience a rapid loss of body heat due to an increased evaporation of sweat from wet skin and damp clothing. Persons entering cold rooms (e.g., walk-in freezers, cold storage boxes, etc.) should be protected by the temporary use of suitable clothing or limiting the frequency and duration of exposures.

b. Non-freezing Cold Injury. Non-freezing local (i.e., limited to one part of the body, such as hands or feet) injuries occur at ambient temperatures above 32°F, and are associated with prolonged exposure to cold water or dampness. Keeping clothing and exposed extremities dry is the primary preventive measure against non-freezing cold injury.

(1) Trench foot (immersion foot) is a cold injury to extremities exposed to non-freezing temperatures, usually prolonged exposure involving moisture. On exposure to water from 32°F to 59°F (0°C to 15°C), clinical trench foot will develop if exposure lasts 12 to 48 hours (depending on the water temperature). Contributing factors include nutritional deficiency, trauma (rubbing or walking on affected feet), wind, improper clothing type and integrity, circulatory stagnation and tissue anoxia from dependency, inactivity, hemorrhage, shock, and improper technique used to rewarm an injured limb. Trench foot is a very serious injury that may result in permanent nerve or tissue damage, or, untreated, may require amputation. In contrast to frostbite, trench foot injuries that have been rewarmed intermittently during cold exposure may be less severe (hence the need to distinguish between non-freezing and freezing cold exposure injuries).

(2) Chilblain (chilblains) is a red or purple discoloration of the distal extremity skin (including ears and nose) occurring after exposure to the cold (generally moist cold). It is most common in young women although it can happen at any age, and relapses characteristically in autumn and winter. It also may be associated with underlying connective tissue disorders (specifically lupus erythematosus). Symptoms include pruritic, painful (especially burning) red patches on the fingers or toes, generally bilaterally. Sunlight may aggravate the lesions. Significant scarring may result.

c. Frostnip. This is the mildest freezing injury of the skin, and involves freezing of water on the skin surface. The skin is reddened and may be swollen. Recovery is complete (similar to a mild sunburn) with removal from cold exposure.

d. Frostbite. A freezing injury, commonly referred to as frostbite, only occurs at environmental temperatures below freezing.

(1) The extent of tissue destruction depends primarily on the environmental temperature and length of exposure. Frostbite symptoms include a cold or burning sensation, progressing to numbness. Frostbite is classified as first (superficial), second (full-thickness, usually with clear blisters), third (skin and subcutaneous tissue, sometimes with hemorrhagic blisters), and fourth degree (deeper structures, including tendons, muscles, and bone).

(a) First Degree Frostbite. First degree frostbite is a partial thickness injury of the skin, sparing deeper structures. It is characterized by erythema, edema, and hyperemia. There is no blister formation or necrosis. Victims complain of pain (for example, a burning sensation). Prior to thawing, in frostbite that is severe first degree or worse, skin is gray or whitish (often described as “waxy” or “waxy-white”). Swelling occurs within 3 hours of rewarming and may last 10 days. Desquamation starts in about a week, and may last up to 1 month. Resolution is expected to be complete and without scarring.

(b) Second Degree Frostbite. Second degree frostbite is characterized by blisters or blebs, which may not form until after rewarming, and by erythema and edema. It is a full-thickness injury that spares subcutaneous tissue. Blisters (which usually form after rewarming) contain serous fluid. Victims may complain of numbness. There is no permanent tissue loss, but the consequences include increased cold sensitivity, hyperhidrosis ("sweaty" feet or hands), burning or prickling sensation, pain, and necrosis of pressure points on the feet. The vast majority of frostbite injuries in the military are either first or second degree.

(c) Third Degree Frostbite. Third degree frostbite includes injury to the skin and subcutaneous tissue. Hemorrhagic blisters may be present (usually after rewarming), with bluish skin and cellular damage to the skin. Initially, involved areas are anesthetic, becoming painful on rewarming. Skin loss by sloughing is expected, with permanent tissue loss and scarring.

(d) Fourth Degree Frostbite. Fourth degree frostbite involves skin, subcutaneous tissue, and deeper structures, including bone, tendon, or muscle. Affected areas are anesthetic, even after rewarming, although severe paresthesia may develop days to weeks later.

(2) Signs of frostbite vary and include white patches, diffuse redness, hardening or waxy appearance of the skin, mottled gray coloration, tenderness, diminished light touch, and anesthesia (no sensation).

e. Hypothermia. Whereas exposure of the extremities or limited areas of skin may cause localized cold stress injuries, exposure of the whole body, or significant portions of the body, to uncompensated cold stress may cause hypothermia. Although hypothermia has been defined as "body temperature significantly below 98.6°F (37°C)" a more specific definition of hypothermia applicable to clinical practice is the unintentional lowering of body core temperature below 95.0ºF (35.0ºC). Individuals may not reliably assess whether they are experiencing hypothermia, especially under certain conditions (e.g., during immersion). Symptoms of hypothermia begin subtly with fatigue and loss of concentration. Ataxia, impaired judgment, and slight confusion may be subtle symptoms but may progress to stupor, coma, and resemble rigor mortis. Hypothermia may be classified as mild, moderate, or severe. Table 3-11 provides the classifications:

Table 3-11. Classification of Hypothermia

Severity	Fahrenheit Core Temperature
Mild	90.0° to 95.0°F
Moderate	82.5° to < 90.0°F
Severe	< 82.5°F

f. Underlying Conditions. Cold stress may also exacerbate or unmask underlying conditions, such as acrocyanosis, rosacea, cold agglutinin disease, cold panniculitis, xerosis, cold-induced urticaria, vibration white finger, Raynaud's phenomenon, and paroxysmal cold hemoglobinuria. Persons with those conditions should take extra precautions to wear adequate clothing and equipment, or avoid cold stress exposure entirely.

3-20. Other Injuries Related to Cold Weather

a. Carbon Monoxide Poisoning. There is increased risk of carbon monoxide poisoning in cold weather. As fuels are burned to provide warmth, carbon monoxide is given off. The colorless, odorless gas can cause asphyxiation in poorly ventilated spaces. Personnel must be aware of and constantly reminded of the need for adequate ventilation of enclosed spaces where fuel heaters are being used.

b. Snow Blindness (Solar Keratitis). Snow blindness and sunburn are caused by exposure of unprotected eyes and skin to ultraviolet (UV) radiation. Snow blindness results when solar radiation "sunburns" unprotected eyes. Eyes may feel painful, gritty, and there may be tearing, blurred vision, and headache. The use of protective eyewear or goggles that block more than 90 percent of UV radiation will help to prevent snow blindness. Side shields or deeply wrapped lens designs should be used. If sunglasses are not available, opaque eye covering (for example, tape-covered eyeglasses) with narrow horizontal slits provide adequate field-expedient eye protection.

c. Sunburn. The threat of sunburn depends on the intensity of sunlight, not the air temperature. Snow, ice, and lightly colored objects reflect the sun's rays, increasing the risk for injury. Sunburn to the skin increases heat loss during cold exposure, increasing susceptibility to hypothermia. Sunburn can be prevented by using a sunscreen that contains para amino benzoic acid of at least a 15 sun protection factor. For cold weather, an alcohol-free sunscreen lotion will be used that blocks both ultraviolet A and ultraviolet B rays.

d. Respiratory Tract. Cold weather leads to a host of possible complications for the respiratory system. Problems include narrowing of the airway, nasal discharge, and upper respiratory tract infections. Allergy-prone soldiers are most susceptible to bronchospasm during heavy exercise in very cold air and must be watched carefully. Bronchospasm can also be caused by fumes from fuel-fired heaters. Proper ventilation and maintenance of these heaters are crucial. Use of a nasal spray consisting of water or sterile saline solution relieves the dryness and discomfort from breathing dry heated air.

e. Dehydration. Everybody exposed to the cold will need to increase fluid intake. Greater amounts of water must be consumed on a daily basis. Warm drinks that replenish nutrients and provide heat are particularly important. Caffeine drinks can cause dehydration and should be used in moderation in the cold. Everyone has experienced dehydration on a warm summer day, but a person can also experience dehydration in cold climates, which is not as easily recognized, and symptoms vary from summer temperatures. Normally the body controls fluid balance by filtering off excess water through urination and drinking (due to thirst) to replace lost water. In the cold, both of these mechanisms are disrupted:

(1) In extreme cold, personnel do not become thirsty as dehydration sets in.

(2) Also in extreme cold, urination increases.

f. Extreme Cold. The factors mentioned in article 3-20e(1) and 3-20e(2), coupled with excessive caffeine intake, result in increased urination, and can lead to dangerous dehydration. The water present in the blood (approximately 60 percent) helps carry warmth to the body, so the dehydrated individual is at even greater risk for the injuries discussed. Early signs of dehydration can include low pulse rate, constipation, and dark urine (in reduced amounts).

3-21. Treatment of Cold Stress Exposure Injuries. The NEHC-TM-OEM 6260.6A, section C9, *(Diagnosis and Treatment of Cold Stress Injuries)* provides guidance on treatment for cold stress injuries. Basic guidance for most non-threatening cold injuries includes:

a. Treatment of cold injuries is rewarming (i.e., warm packs, warm but not hot water). Do not rewarm the skin until you can keep it warm. Warming and then re-exposing to the cold has the potential to do more harm.

b. Affected parts should be elevated and kept stationary.

c. Avoid weight-bearing positions.

d. Do not rub the affected area.

e. Smoking should be prohibited until recovery is complete as smoking constricts blood vessels.

f. Chilblain and trench foot injuries are best rewarmed using air at room temperature.

g. Rewarming of frostbite should be delayed until the victim has been removed from risk of re-exposure to the cold and can be kept at bed rest. (Thawing and re-freezing can worsen frostbite injury.) Treatment of frostbite is rapid rewarming, using immersion in water at or just above body temperature (no more than 108°F or 42.2°C). Water hotter than 108°F should not be used, as it can injure body tissue, especially in persons whose feeling (sensation) is not intact.

h. Additional measures include intravenous fluids, medication, and hyperbaric oxygen. Frostbite victims should receive prompt and ongoing medical care until cleared by a medical professional.

i. Treatment of hypothermia is immediate removal from cold exposure, changing to dry clothes, and rapid rewarming. Victims of severe hypothermia should be immediately evacuated to nearest military or civilian emergency room for further evaluation and treatment.

j. Cold injury victims may show signs of cardiovascular arrest that reverse after rewarming, and should be aggressively treated. All life-saving measures should be initiated.

3-22. Cold Stress Injuries Reporting Requirements

a. All cold stress-related injuries will be reported through the Disease Reporting System internet (DRSi), found at Log In | DRSi (health.mil) or https://drsi.health.mil/NDRSi, per BUMEDINST 6220.12C and NAVMCFORHLTHPRTCMD Technical Manual, NMCPHC-TM 6220.12 (Medical Surveillance and Reporting).

b. A simultaneous report needs to be generated and submitted to the Naval Safety Command per OPNAV M-5102.1 and MCO 5100.29C Vol 9. Reporting is completed through the Risk Management Information - Streamlined Incident Reporting (RMI SIR) System. RMI can be located at https://afsas.safety.af.mil.