CHAPTER B2

HEAT STRESS

B0201. DISCUSSION

a. This chapter establishes Navy policy and procedures for the control of personnel exposure to heat stress and applies to all ships, including submarines. Ships shall not expose personnel to excessive heat stress and shall provide a shipboard work environment that minimizes the probability of such exposure.

b. This chapter applies to heat stress control and personnel protection for most shipboard operating conditions. It does not apply for the determination of heat exposure limits specifically for personnel wearing layered or impermeable clothing such as chemical/biological warfare clothing, fire fighting 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.

c. Heat stress is any combination of air temperature, thermal radiation, humidity, airflow, workload, and health conditions that may stress the body as it attempts to regulate body temperature. Ships can determine maximum exposure limits for various environmental conditions and individual work rates. Adherence to these maximal heat exposure guidelines can prevent or reduce the adverse physiological effects of heat stress. Sufficient recovery time in a cool environment will help reverse the harmful effects of heat stress. Recognizing personnel heat stress symptoms and obtaining prompt medical attention for affected persons is an all hands responsibility.

d. To obtain accurate and reliable data on heat stress conditions, ships shall conduct heat stress surveys to record dry-bulb (DB), wet-bulb (WB), and globe temperature (GT) readings. They must take DB and WB temperature with both thermometers shielded from radiant heat and the WB also must be properly ventilated to determine the effects of airflow. Measurement is accomplished by means of a globe thermometer that provides a value representing radiant and convection heat transfers to or from the body. The Navy uses either a wet-bulb-

globe temperature (WBGT) meter or an automated heat stress system (AHSS) to measure each of the above temperatures. The WBGT index is calculated using dry bulb, wet-bulb, and globe temperature. The WBGT index and physical exertion level are used determine how long an individual may be exposed safely to heat stress conditions. Appendix B2-A presents this information in a columnar format by means of the physiological heat exposure limits (PHEL) tables.

e. While heat stress conditions can occur anywhere on board a ship, machinery spaces, laundries, sculleries, galleys, incinerator rooms, flight decks, and steam catapult rooms are the most likely to have conditions that may cause heat stress. Conditions of elevated heat stress include operations in hot and humid climates, arduous physical tasks, steam and water leaks, boiler air casing leaks, missing or deteriorated thermal insulation, and ventilation system deficiencies.

In addition, other factors that reduce physical stamina and enhance susceptibility to heat stress illness are dehydration, lack of sleep, illness, use of medication, drugs, alcohol, and the presence of atmospheric contaminants such as combustion gases or fuel vapors.

f. PHEL curve stay-time guidance is not limited to watchstanders, but applies to all personnel present in the workspace. Exposure time for personnel completing their watch rotation but returning to the workspace to perform other duties (i.e., repairs, PMS) may be limited by the existing heat stress conditions. Additionally, the recovery time guidance provided in section B0204(d) may require a specific rest/recovery time out of the workspace between intervals of working in the space and standing the watch in the workspace.

g. Heat Acclimatization. In most individuals, continued (i.e., daily) exposure to heat stress causes a series of physiologic adaptations called acclimatization, whereby the body becomes more efficient in coping with the heat stress. Heat acclimatization occurs gradually, usually requiring three weeks or more (although most of the process occurs in the first week).

B0202. RESPONSIBILITIES

a. The commanding officer shall:

(1) Establish and enforce an effective heat stress policy that ensures personnel heat exposures are limited per this chapter except in an operational emergency.

(2) Review and initial daily, heat stress surveys that result in reduced stay times.

(3) Conduct an inquiry into the circumstances surrounding all heat injuries that result in unconsciousness.

(4) Report to the immediate superior in command (ISIC) those material deficiencies, beyond ship's force capability to correct, which contribute to heat stress conditions aboard the ship.

(5). Report heat stress related cases as specified in paragraph B0204f.

(6) For ships without an automated heat stress system (AHSS) installed, ensure at least two portable, calibrated, and operable WBGT meters are available onboard.

(7) If an AHSS is installed, maintain at least one portable, calibrated, and operable WBGT meter on-board in the event that the automated system should fail.

b. The medical department representative (MDR) shall:

(1) Review all engineering and non-engineering heat stress surveys to determine obvious inaccuracies, reduced PHEL stay times, and any personnel protective actions being taken. Submit heat stress surveys that result in reduced stay times to the commanding officer daily for review.

(2) Provide training to divisions on heat stress health hazards, symptoms, prevention, and first aid procedures, upon request.

(3) Prepare reports of heat stress related cases as specified in paragraph B0204f.

(4) **For submarines,** the MDR conducts heat stress surveys in engineering spaces.

c. The engineering officer/reactor officer shall:

(1) Ensure dry-bulb thermometers are installed per paragraph B0204b(1) and temperatures are monitored and recorded per paragraph B0204b(3) and (4).

(2) Assign and qualify engineering department personnel to perform heat stress surveys in engineering spaces.

(3) Assign and qualify supervisors to review dry-bulb temperatures or access AHSS readings and take the required actions per paragraph B0204.

(4) Review heat stress surveys and ensure stay times for engineering/reactor personnel are being properly determined as specified in paragraph B0205. Limit personnel heat exposures accordingly, except as approved by the commanding officer in an operational emergency.

(5) If maintenance or repair is required, record all heat stress related deficiencies on current ship's maintenance project (CSMP). Appendix B2-B provides heat stress trouble-shooting and recommended repair actions.

d. The supply officer, air boss, and other department heads shall:

(1) Ensure dry-bulb thermometers are installed per paragraph B0204b(1) and temperatures are monitored and recorded per paragraph B0204b(3) and (4).

(2) May assign and qualify departmental personnel to conduct heat stress surveys or access AHSS readings of departmental spaces. Qualification of personnel shall be as specified in paragraph B0206b.

(3) Ensure the heat stress surveyor conducts heat stress surveys per B0204c(4) and B0204c(5).

(4) Assign and qualify supervisors to review dry-bulb temperatures or access AHSS readings and take the required actions per paragraph B0204.

(5) Review heat stress surveys and ensure stay times for personnel are being properly determined as specified in paragraph B0205. Limit personnel heat exposures accordingly, except as approved by the commanding officer in an operational emergency.

(6) If maintenance or repair is required, record all heat stress related deficiencies on current ship's maintenance project (CSMP). Appendix B2-B provides heat stress trouble-shooting and recommended repair actions.

e. Division officers shall:

(1) Limit personnel heat exposures per established stay times, except as approved by the commanding officer in an operational emergency.

(2) If maintenance or repair is required, record all heat stress related deficiencies on Current Ship's Maintenance Project (CSMP). Appendix B2-B provides heat stress trouble-shooting and recommended repair actions.

f. Heat-stress surveyors shall:

(1) Be personal qualification standard (PQS) qualified per NAVEDTRA 43460-4B, heat stress monitor.

(2) Perform heat stress surveys as required by paragraph B0204.

g. All hands shall:

(1) Obtain prompt medical attention for personnel who exhibit heat stress symptoms.

(2) Follow recommended work practices and procedures for controlling heat stress hazards.

(3) All hands are required to complete heat stress training upon reporting aboard.

B0203. HEAT STRESS ELEMENTS

a. Monitoring and surveying of heat stress conditions. (See paragraph B0204.)

b. Establishing safe work schedules in heat stress environments. (See paragraph B0205.)

c. Investigating and reporting personnel heat injuries. (See paragraph B0204f and reference B2-1.)

d. Training. (See paragraph B0206.)

e. Recordkeeping. (See paragraph B0204c(3)(f).)

B0204. HEAT STRESS MONITORING AND SURVEYING

a. Definitions:

(1) **Monitoring.** Observing and recording temperatures of dry bulb (DB) thermometers at specified watch and/or workstations.

(2) **Surveys.** Use a WBGT meter or AHSS to measure DB, WB, and GT, and compute the WBGT index to determine the amount of time it is safe to work in a given space. Personnel conducting a survey shall validate the WBGT index using the following formula:

WBGT = (0.1 x DB) + (0.7 x WB) + (0.2 x GT)

(3) **Heat Stress Surveyor.** A trained person assigned to conduct or review AHSS readings for any required surveys.

b. Heat Stress Monitoring:

(1) **Dry-Bulb Thermometer Positioning.** A hanging DB thermometer (alcohol in glass - NSN 9G-6685-00-243-9964) shall be permanently mounted at watch and workstations throughout the ship where heat stress conditions may exist. Evaluation and designation of potential heat stress areas is part of the industrial hygiene survey. A DB thermometer shall also be mounted in non-air conditioned spaces, not normally manned, in which personnel may have to periodically work or conduct

maintenance, such as storerooms. These thermometers shall be mounted in a position so they indicate the most accurate representative temperature for the area where workers/watchstanders spend the majority of their time. Placement of the DB thermometers may be in or out of the ventilation air stream but must be hung at least two feet from any supply ventilation terminal/opening. Thermometers shall be hung with a non-heat conducting material such as plastic tie-wrap or string (never hang with metal wire) and positioned to minimize the influence of any adjacent or local heat or cold sources (avoid direct contact between thermometer and hot/cold structural surfaces). If the difference between the hanging DB thermometer and the DB temperature measured with the WBGT meter, during a survey, is five degrees Fahrenheit or greater at any watch or workstation, then the DB thermometer is not representative of the temperature at the workstation. DB thermometers do not require calibration, so if found inaccurate, the hanging DB must be relocated, replaced, or validated by aligning the etch mark with the freezing point (32 degrees Fahrenheit). A DB thermometer shall be temporarily mounted to monitor conditions where repairs or maintenance are being performed in a heat stress area. The ship shall install DB thermometers, at a minimum, in main machinery spaces, auxiliary machinery spaces, emergency diesel spaces and other engineering spaces containing heat sources, as well as in laundries, dry cleaning plants, sculleries, galleys, bake shops, and steam catapult spaces.

NOTE

"No Calibration Required" (NCR) stickers are not required to be placed on DB thermometers.

(2) **Automated Heat Stress System.** The AHSS units shall be mounted in a position so they indicate the most accurate representative temperature for the area where workers/watchstanders spend the majority of their time. The AHSS units shall be positioned so as to avoid interference with space activity. If ventilation is present at the workstation where an AHSS unit will be installed, then the sensor should be located in relation to the ventilation duct such that airflow to the sensor does not exceed 600 fpm.

NOTE

Dry-bulb thermometers must still be mounted on ships with AHSS. The ability to conduct manual dry-bulb reading procedures must be available in the event that access to the data on the AHSS workstation is unavailable due to power failure, securing of the workspace, etc.

(3) **Dry-Bulb Temperature Readings.** The ship shall record DB temperature readings when the ship is underway or when potential heat stress conditions exist while in port. The ship shall monitor the following compartments when manned: main machinery spaces, (fire rooms and engine rooms), auxiliary machinery spaces, emergency diesel spaces, laundry spaces, sculleries, galleys, bake shops, and steam catapult spaces. Assigned personnel shall monitor compartments as follows:

(a) Every four hours for manned spaces if DB temperatures do not exceed 85 degrees Fahrenheit.

(b) Every hour for manned spaces if DB temperatures exceed 85 degrees Fahrenheit.

(c) Every hour at temporary installations where the DB temperature exceeds 85 degrees Fahrenheit during repair or maintenance operations.

(4) **Dry-Bulb Temperature Recording**

(a) Hanging DB temperatures shall be recorded on a prepared paper log form and reviewed by the space supervisor (e.g., machinist mate of the watch (MMOW), galley captain). If a DB temperature exceeds 100 degrees Fahrenheit (watch/work length four hours or less), or 90 degrees Fahrenheit (watch/work length greater than four hours), or 85 degrees Fahrenheit (in the scullery) per paragraph B0204c(4)(a), the space supervisor shall circle (in red) the DB reading and immediately notify the watch supervisor (e.g., engineering officer of-the-watch (EOOW), division officer, etc.). The watch supervisor shall direct heat stress surveys to be conducted and enforce the resulting stay times.

(b) The space supervisor (e.g., MMOW, galley captain) shall record and review the DB temperatures for the

AHSS either as part of the centralized data acquisition system, or as printed copies. The space supervisor shall initial in the appropriate box and check the appropriate notation in the computer log. If a DB temperature exceeds the temperature per paragraph B0204c(4)(a), the space supervisor shall immediately notify the watch supervisor (e.g., EOOW, division officer). The watch supervisor shall direct heat stress surveys to be conducted and enforce the resulting stay times.

c. Heat Stress Surveys - WBGT Meter

(1) The heat stress surveyor determines environmental heat stress conditions using the WBGT meter (Model RSS 220, NSN 7G-6685-01-055-5298 or heat stress monitor - Model 960, NSN 3H-6665-01-333-2590), or the AHSS which provides a computer display, hard drive storage and printout of the heat stress information. Each method measures dry-bulb, wet-bulb, and globe temperature and integrates them into a single heat stress value, the WBGT index. Appendix B2-C, Use of the WBGT Meter, provides detailed information and procedures regarding the proper use and care of the WBGT meter. The surveyor uses the WBGT index, along with the individual's physical exertion level, to determine the permissible heat exposure limits referred to as the physiological heat exposure limits or PHEL stay times.

NOTE

The operating range for the RSS-220 and Vista Model 960 WBGT meters is 65 degrees Fahrenheit to 150 degrees Fahrenheit. The operating range for the AHSS is 32 degrees Fahrenheit to 150 degrees Fahrenheit and 10% to 95% relative humidity. Use of these meters outside of this range will not provide accurate temperature measurements.

(2) **Measurement Techniques**

(a) When surveying a work or watch station using the WBGT meter, the surveyor shall position the meter where the worker/watchstander would normally stand or where the intended work is to be performed, with ventilation arranged to provide normal ventilation at that location. For specific operating instructions, see appendix B2-C paragraph 3.

(b) The heat stress surveyor shall conduct the first WBGT measurement in the workspace after the meter has been in the space five minutes to enable it to equilibrate to the surrounding area. As the meter is moved from one site to another, the meter should be at each site for three minutes to allow for stabilization of the first reading (DB) in the series to be taken. To determine when each sensor has stabilized, the monitor should watch the 0.1 degrees Fahrenheit digit of the display. When the 0.1 degrees Fahrenheit digit stops changing or when it oscillates between a larger or smaller value, the sensor has stabilized and the value can be recorded. (If oscillating, always record the higher of the two values).

(c) Where AHSS units are used, watchstanders should take care not to shield the automated WBGT sensor from airflow or heat sources so that readings reflect an accurate watchstander stay time.

(3) **Recording and Reporting Survey Results:**

(a) The heat stress surveyor shall record all non-automated survey readings to the nearest 0.1 degrees Fahrenheit on a heat stress survey sheet similar to the OPNAV 5100/17 form available at Navy Forms on-line at http://forms.daps.dla.mil. The surveyor shall use the WBGT index reading to determine the PHEL stay time per section B0205. The surveyor shall record the PHEL curve used and the corresponding exposure time on the survey sheet. Upon completion of the survey and determination of PHEL stay times, the heat stress surveyor shall note any stay times for manned watch or workstations that, under routine conditions, are less than the watch or work period. The surveyor shall circle these readings on the sheet in red. The surveyor shall notify space supervisors and responsible department heads immediately of the reduced exposure times. If a survey results in a PHEL stay time which is less than the work or watch period, the department head responsible for the space shall promptly notify the commanding officer of the condition, indicating action being taken to protect personnel and/or to reduce the excessive heat-stress situation.

(b) The heat stress surveyor shall print all automated survey readings on a pre-formatted Heat Stress Survey Sheet. The surveyor shall circle in red, on the Heat Stress Survey Sheet, any PHEL stay times for manned watch or

workstations that, under routine conditions, are less than the watch or work period. The heat stress surveyor shall notify workspace supervisors and responsible department heads immediately of the reduced exposure times. The department head shall promptly notify the commanding officer of the condition, indicating personnel protective action being taken, and action, if any, to reduce the excessive heat stress situation.

(c) Ships shall use a heat stress survey sheet in a format similar to the OPNAV 5100/17 form available at Navy Forms on-line at http://forms.daps.dla.mil to record heat stress information. Ships using a database or the AHSS may use a computer printout for the heat stress survey sheet. The surveyor shall record the following heat stress information on the heat stress survey sheet manual or computer printout:

1. Date and time of survey;

2. In the follow-on survey form, identify a time and temperature;

3. Stations surveyed, including the following information for each station:

a. Time WBGT measurement was taken at the location;

b. Hanging DB temperature. Not required for the automated system;

c. WBGT meter readings for DB, WB, GT, and WBGT;

d. PHEL curve for the station and the corresponding exposure time.

NOTE

Only the column that pertains to the current watch/work situation needs to be completed (e.g., all four columns do not need to be filled in).

4. The heat stress surveyor shall check to ensure that the WB < DB; GT ≥ DB; and WB < WBGT < GT. Once this is verified then the heat-stress surveyor shall manually calculate the highest WBGT index obtained using the formula:

$$WBGT = (0.1 \times DB) + (0.7 \times WB) + (0.2 \times GT)$$

The surveyor shall compare calculated WBGT to the meter WBGT and the two readings shall be within 0.2 degrees Fahrenheit. A manual calculation of the WBGT value is not required with the AHSS.

(d) The heat stress surveyor shall note any material deficiencies that may be contributing to adverse heat stress conditions and record them on the survey sheet. Additionally, personnel shall comment on the availability of drinking water on the survey sheet.

(e) The surveyor shall record the hanging DB temperatures on the heat stress survey sheet. If the difference between the hanging DB thermometer and the DB temperature measured with the WBGT meter, during a survey, is five degrees Fahrenheit (°F) or greater at any watch or workstation, the DB thermometer is not representative of the temperature at the workstation. Relocate, replace or validate the hanging DB by aligning the etch mark with the freezing point (32 degrees Fahrenheit). Comparing the hanging DB temperature values with the AHSS DB values is not required.

(f) Following the department head's review, all Heat Stress Survey Sheets, including engineering, shall be delivered to the MDR. The MDR shall review all engineering and non-engineering heat stress surveys to determine obvious inaccuracies, reduced PHEL stay times, and any personnel protective actions being taken and submit heat stress survey sheets daily to the commanding officer. The commanding officer shall initial the survey sheets, and return the sheets to the MDR. The MDR shall retain heat stress surveys sheets for one-year.

(4) **Space Surveys.** Ships shall conduct the survey of spaces for heat stress using the WBGT meter or the AHSS:

(a) At all manned watch/workstations within the space whenever the temperature from a permanently mounted hanging DB thermometer reaches or exceeds the following temperature requirements:

PHEL I through III	
Watch/Work length 4 hours or less	DB => 100°F
Watch/Work length greater than 4 hours	DB => 90°F
PHEL IV through VI	DB = 85°F.

NOTES:

1. Daily WBGT space surveys at the hottest time of the day are no longer required.

2. Shipboard conditions cannot be adequately addressed by a single dry bulb value. For watches longer than four hours or activity levels greater than PHEL III, a 100 degrees Fahrenheit temperature would miss potentially serious heat stress conditions. The values listed above take into consideration likely levels of relative humidity, watch duration's, and levels of activity. Under normal operations, routine watches in engineering spaces are expected to be four hours at a PHEL III or lower. PHEL IV through VI apply to above average work rates.

(b) In any space when a heat injury (heat exhaustion or heat stroke) occurs.

(c) Prior to conducting engineering casualty control (ECC) drills:

1. If the drill-set exceeds three hours (not required in spaces not affected by the drill or in areas that are unmanned),

2. If already in a reduced stay time, the surveyor shall use the most current heat stress survey and calculate stay times for ECC watchstanders using the ECC PHEL values in appendix B2-A.

The length of the exercises cannot exceed the watch PHEL stay times.

(d) In any space when the commanding officer determines that a heat stress situation may occur.

(e) As required for follow-on surveys (see paragraph B0204.c(5)).

(5) **Follow-on Surveys.** Once a heat stress survey has been conducted, follow-on surveys for the remainder of that day shall be accomplished as identified below. Surveys on the next day shall be conducted according to paragraph B0204.c(4). Follow-on surveys shall be accomplished using the WBGT meter as follows:

(a) For engineering spaces on nuclear, gas turbine and diesel powered ships.

1. If the survey resulted in a PHEL stay time greater than the duration of the normal watch or work period and did not require a change from the normal watch/work time. No further follow-on surveys are required unless the hanging DB temperature increases by more than five degrees Fahrenheit from the hanging dry bulb temperature in the previous survey.

2. If the survey resulted in a PHEL stay time less than the duration of the manned watch or workstation then the watch/work times shall be adjusted to reflect the new PHEL stay times indicated by the WBGT. A follow-on survey is only required if the DB temperature increases by five degrees Fahrenheit or more from the hanging DB temperature in the previous survey. If the hanging DB temperature drops below the value in paragraph B0204c(4) and return to a normal watch/work time is desired, a survey shall be conducted to ensure conditions allowing a return to normal watch/work periods have been reestablished.

(b) Two options are provided for follow-on surveys for engineering spaces on non-nuclear, steam-powered ships and for laundries, sculleries, galleys, steam catapult spaces and arresting gear spaces.

1. Follow-on surveys where WB and DB temperatures are not monitored and recorded each hour. Follow-on surveys shall be conducted prior to the end if the current manned watch or work period as indicated in the previous survey. Follow-on surveys shall continue to be conducted each watch/work period until the conditions specified in paragraph B0204c(4) no longer exist.

2. Follow-on surveys where WB and DB temperatures are monitored and recorded each hour at manned workstations.

a. If the WBGT survey resulted in a PHEL stay time greater than the duration of the normal watch or work period, a change from the normal watch/work time is not required. Follow-on surveys are not required unless the DB temperature increases by five degrees Fahrenheit or more and/or WB temperature increases by three degrees Fahrenheit or more from the DB and WB temperatures recorded from the previous survey. The DB and WB temperature must be measured each time using the same instrument/device. The WBGT meter, motorized psychrometer, or commercially available hygrometer may be used to measure DB and WB temperature. If the DB temperature drops below the value in paragraph B0204c(4) and return to a normal watch/work time is desired, then a survey shall be conducted to ensure conditions allowing a return to normal watch/work periods have been reestablished.

b. If the WBGT survey resulted in a PHEL stay time less than the duration of the manned watch, or work period, the watch/work time shall be adjusted to reflect the new stay times indicated by the WBGT. Follow-on surveys are not required unless the DB temperature increases by five degrees Fahrenheit or more and/or WB temperature increases by three degrees Fahrenheit or more from the DB and WB temperatures recorded from the previous survey. The DB and WB temperature must be measured each time using the same instrument/device. The WBGT meter, motorized psychrometer, or commercially available hygrometer may be used to measure DB and WB temperature. If the DB temperature drops below the value in paragraph B0204c(4) and return to a normal watch/work time is desired, then a survey shall be conducted to ensure conditions allowing a return to normal watch/work periods have been reestablished.

NOTE:

The department head may elect to have more than one stay time rotation in a workspace if permitted by PHEL. This would allow the majority of personnel to take advantage of a longer stay time instead of limiting all personnel to the most restrictive stay time. If more than one watch time rotation is implemented for a space it shall be indicated on the heat stress survey sheet.

For example: A steam-powered ship in the Indian Ocean has obtained the following readings from an auxiliary space during the latest heat stress survey conducted at 1400:

Top Watch	WBGT = 92	PHEL = II,	Stay time = 4:10
Evap Watch	WBGT = 93	PHEL = II,	Stay time = 3:50
Air Comp Watch	WBGT = 92	PHEL = II,	Stay time = 4:10
SSTG Watch	WBGT = 92	PHEL = II,	Stay time = 4:10
Messenger	WBGT = 92	PHEL = III,	Stay time = 3:30

The engineering officer assigns a 3 X 6 watch (three hours watch in the space and six hours outside the space) for the evap watch and the messenger. The engineer officer assigns everyone else in the space to a 4 X 8 watch (four hours watch in the space and eight hours outside the space). The time outside the space must be in a cooler environment.

(c) **ECC.** A heat stress survey to restore the normal watch is not required at the end of the ECC drill set unless a DB temperature at any manned watch station exceeds the appropriate value identified in paragraph B0204c(4)(a).

(6) **Time Weighted Mean (TWM) WBGT Values.** The TWM WBGT is for use in especially hot environments where reduced stay times have been imposed on watch/work standers. The TWM WBGT is an optional, not mandatory provision, for use if an air-conditioned booth or cooler space is available for personnel to spend time in the cool climate and afford them some relief from the heat in the space. When implemented, the TWM changes the WBGT value for that individual and increases the length of time they can now spend at their watch/work station. Appendix B2-E provides ships that have this ability with a way of properly calculating the new WBGT value.

d. Recovery Time for Personnel Reaching Exposure Limits

(1) Supervisors shall direct personnel standing watch or working in spaces in reduced stay times (except in operational emergencies as directed by the CO) to leave the heat stress environment prior to the expiration of the PHEL stay time. These personnel shall move to a cool, dry area conducive to rapid physiological recovery (an area with a DB temperature of 80 degrees Fahrenheit or less).

(2) Preferred recovery environments are those that are air conditioned within the standards of reference B2-2. Provided there is no evidence of accumulated fatigue, the length of recovery time shall be equal to twice the exposure time or four hours whichever is less. After completing the necessary recovery period in preferred environmental conditions, an individual who nonetheless remains tired, unable to carry out normal work requirements, or has an increased incidence of health disorders shall be referred to the MDR for evaluation.

(3) Supervisors shall direct personnel experiencing heat stress symptoms while standing watch or working in the workspace, to report immediately to the MDR for evaluation.

e. Recommendations for Working in Heat Stress Environments.

(1) Drink more water than satisfies thirst, but not more than 1.5 liters (about one and half quarts) per hour. Do not wait until you are thirsty to start drinking (scuttlebutts must be readily available and in working order). It is important that personnel stay hydrated. A device that has proved very effective in helping personnel to stay hydrated on flight decks, steam catapult spaces, engineering spaces, laundry and in other hot locations on ship is the Camelbak® (or equivalent) drinking system. It holds 1.8 liters of water and is worn like a backpack with a straw mechanism that allows the person to drink anytime or anywhere. The Camelbak® (or equivalent) has proved very effective in helping to keep personnel hydrated especially in areas such as the Arabian Gulf. It is available in the stock system under NSN 9Q-8465-01-396-9855.

(2) Eat three well-balanced meals daily.

(3) Get adequate rest. At least six hours of continuous sleep per 24 hours is recommended.

(4) Except where fire retardant or fire-fighting clothing is required, wear clean clothing composed of at least 35 percent cotton (more natural fiber content allows more effective evaporation of water from clothing).

(5) Do not take salt tablets.

(6) Limit intake of caffeinated drinks.

(7) The fleet has used several cooling vests in the stock system in a limited capacity. Initial research on one of these vests shows that if properly used in a heat stress environment it can reduce thermal strain. However, when using cooling vests, personnel shall adhere to PHEL stay times as described in this chapter until revised PHEL curves are established for the cooling vest.

NOTE

The use of using cooling vests that contain paraffin-based phase change material is not recommended. This material is flammable and may release toxic vapors when burning. The MSDS information should be reviewed prior to using any of these products. This material must be stored per the requirements for flammable material in chapter C23.

f. Reports and Forms

(1) Personnel exposed to excessive heat stress may require the professional judgment of a trained MDR to determine the presence or absence of a heat-related disorder. If the result of the evaluation indicates a heat-related case the MDR shall enter the heat-related injury or illness into the web-enabled safety system (WESS) per reference B2-3.

(2) NAVENVIRHLTHCEN shall provide a fiscal year-end summary of shipboard heat stress cases from the WESS database by type of operation, and ship class to CNO (N09F).

B0205. PHEL DETERMINATION

a. The WBGT index provides a measure of environmental conditions. In order to determine the permissible heat exposure in these conditions, the amount of work of a particular job must be known. The more strenuous the job, the shorter the allowable exposure time. The Navy has developed six PHEL curves, each applying to a different work rate, ranging from light work (PHEL curve I) to heavy work (PHEL curve VI). The PHEL curve general applicability table (table B2-A-1) in appendix B2-A provides the applicable stay times allowed for a specific WBGT reading. For types of work not presented in table B2-A-1, the MDR should

consult reference B2-2, articles 3-12 and 3-13. For comparison, examples of light work include sweeping down, 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 were developed and are accurate for normal, healthy, heat-acclimatized personnel who have had adequate rest, (six hours continuous sleep in the last 24 hours), adequate water intake, and adequate recovery time from previous heat stress exposure (two hours recover for every 1 hour exposure or four hours maximum). Personnel are assumed to be wearing clothing consisting of a least 35% cotton fiber, not containing starch, and readily permeable to water transfer. Table B2-A-2 presents the PHEL chart in a tabular format. Table B2-A-3 presents the PHEL values applicable when fuel combustion gases are present.

b. Procedures

(1) **Curve Selection**

(a) **Routine Operations.** Applicable PHEL curves should be determined by selecting the appropriate curve listed in table B2-A-1.

(b) **Non-routine Operations.** 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 that specified in table B2-A-1 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.

(c) **Engineering Casualty Control Exercises.** Watchstanders shall have their stay times determined by selecting the appropriate curve listed in table B2-A-1.

(d) **Heavy Work.** Personnel conducting heavy repairs or other strenuous work shall have their stay time determined by using PHEL curve VI.

(2) **Effects of Personnel Health Status on Curve Selection.** As indicated, the PHEL curves and the assignment in table B2-A-1 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 may experience cumulative fatigue. Additionally, personnel with a respiratory system cold and/or infection, lacking sufficient sleep (less than six 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 in table B2-A-1. The senior MDR on a case-by-case basis shall determine appropriate exposure limits for these personnel.

(3) **Curve Selection if Personnel Heat Injuries Occur.** If, after determining personnel stay times per this section, a heat exhaustion or heat stroke occurs, then the stay times for all other personnel in the space shall immediately be reduced by recalculating stay times using the next numerically higher PHEL curve than specified by table B2-A-1. The work and health status of the individual suffering the injury shall be reviewed. When the cause of the injury has been reasonably resolved, the stay times for personnel in the space shall be determined using the latest WBGT index and the normally appropriate curves as indicated in table B2-A-1.

(4) **WBGT/PHEL Determination.** The heat stress surveyor shall use the PHEL table (table B2-A-2). To use the PHEL table, the heat stress surveyor must first round the recorded WBGT index to the next higher whole number value. This can be done easily as the WBGT index is recorded in tenths of a degree F. For example: 85.1 degrees Fahrenheit would be rounded to 86 degrees Fahrenheit and 89.9 degrees Fahrenheit would be rounded to 90 degrees Fahrenheit; but 92.0 degrees Fahrenheit would remain 92 degrees Fahrenheit. 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 B2-A-2. Hence, for a

recorded WBGT index of 85.1 degrees Fahrenheit or 85.8 degrees Fahrenheit the stay time for PHEL curve III is five hours and 55 minutes.

(5) The current WBGT/PHEL stay-time guidance for each watchstander can be read from any of the AHSS computer workstations.

(6) **Impact of Personal Status Change on Exposure Limits.** 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 shall be computed using the procedures for remaining safe stay times provided in reference B2-2, article 3-13(5)(b).

(7) **Impact of Fuel Combustion Gases (Stack Gas) and Fuel Vapors on Exposure Limits.**

(a) Fuel combustion gases (stack gas) and fuel vapors can have severe physiological impact on personnel. 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 four hours or more can smell the odor of stack gas and/or fuel vapors, then a harmful concentration may be present. Personnel should be checked for the following symptoms:

1. Eyes watering and/or burning.

2. Difficulty breathing.

3. Tingling or numbness of the tip of the tongue, tip of the nose, finger tips and/or toes.

4. Generalized sensation of mild alcoholic intoxication without alcohol consumption within the past 24 hours.

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

1. Using the latest WBGT index values, determine the PHEL stay time by using table B2-A-3; or

2. Calculate the PHEL stay time for existing heat stress conditions per paragraph B0205b(4), and divide that stay time by three to obtain the new stay time. For example, if the exposure limit due to heat stress is four hours, then the exposure limit with stack gas and or fuel vapors present would be reduced to one hour and 20 minutes. Prompt removal of affected personnel to fresh air is essential. Article 3-11 of reference B2-2 discusses the physiological effects to personnel exposed to stack gas and fuel vapors in detail.

B0206. TRAINING

a. All hands shall receive heat stress training upon reporting aboard. This training may be conducted by showing the heat stress videotape "Play it Cool: Heat Stress Prevention Afloat" (8055801-DN). At a minimum this training must include:

(1) Heat stress health hazards;

(2) Symptoms of excessive heat stress exposure;

(3) Heat stress first aid procedures;

(4) Heat stress monitoring; and

(5) Causes of heat stress conditions.

b. Heat-stress surveyors assigned to perform WBGT surveys shall be trained and qualified using the heat stress surveyor watchstation 303 (formally heat stress monitor watchstation 303) of the safety programs afloat personnel qualifications standard (PQS), NAVEDTRA 43460-4B within 12 weeks of assignment.

c. Training and information on the automated heat stress system (AHSS) is available in appendix B2-C.

CHAPTER B2

REFERENCES

B2-1. OPNAVINST 5102.1D/MCO P5102.1B

B2-2. NAVMED P-5010-3, Manual of Naval Preventive Medicine, Chapter 3: Ventilation and Thermal Stress Ashore and Afloat

B3-3. NEHC Technical Manual NEHC TM OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries

Table B2-A-1

PHEL CURVE GENERAL APPLICABILITY SELECTION

PERSONNEL	PHEL CURVE	
	Routine Watch	Casualty Control Drills
I. Steam Propelled Ships		
A. Propulsion Spaces		
1. BTOW (Boiler Technician of the Watch)	II	III
2. Console Operator	I	I
3. Upper Levelman (checkman)	II	III
4. Lower Levelman	II	III
5. MFP (Main Feed Pump) Watch	II	III
6. Burnerman	II	III
7. EOOW (Engineering Officer of the Watch)	I	I
8. MMOW (Machinist's Mate of the Watch)	II	III
9. Throttleman	I	I
10. EMOW (Electrician's Mate of the Watch)	I	I
11. Upper Levelman(SSTG) (Ship's Service Turbine Generator)	II	III
12. Lower Levelman (Lube Oil/Condensate)	II	III
13. Evaporator Watch	I	II
14. Messenger (See Note Below)	III	IV

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.

B. Auxiliary Spaces		
1. All Watches	II	II

II. Diesel Propelled Ships		
A. All Engineering Watch Personnel (unless specified below)	I	II
B. Evaporator Watch	II	II
C. Messenger	III	IV
III. Gas Turbine Propelled Ships		
A. FFG-7 and CG 47 Class Ships		
1. All Engineering Watch Personnel	I	II
B. DDG-51 Class Ships		
1. All Engineering Watch Personnel (unless specified below)	II	III
2. Sounding and Security Watch	III	III

*Includes restricted maneuvering and casualty control drills

IV. Steam Catapult Spaces		
A. All Watches	II	II
V. All Other Surface Ship Spaces		
A. ECC Monitors/Inspectors	I	II
B. Laundry Personnel	III	NA
C. Scullery Personnel	V	NA
D. Galley & Food Service Line Personnel	II	NA
VI. Submarines		
A. 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
B. Auxiliary Spaces		
1. All Watches	II	II
C. Other Spaces		
1. Food Service Personnel	II	NA

FIGURE B2-A-1

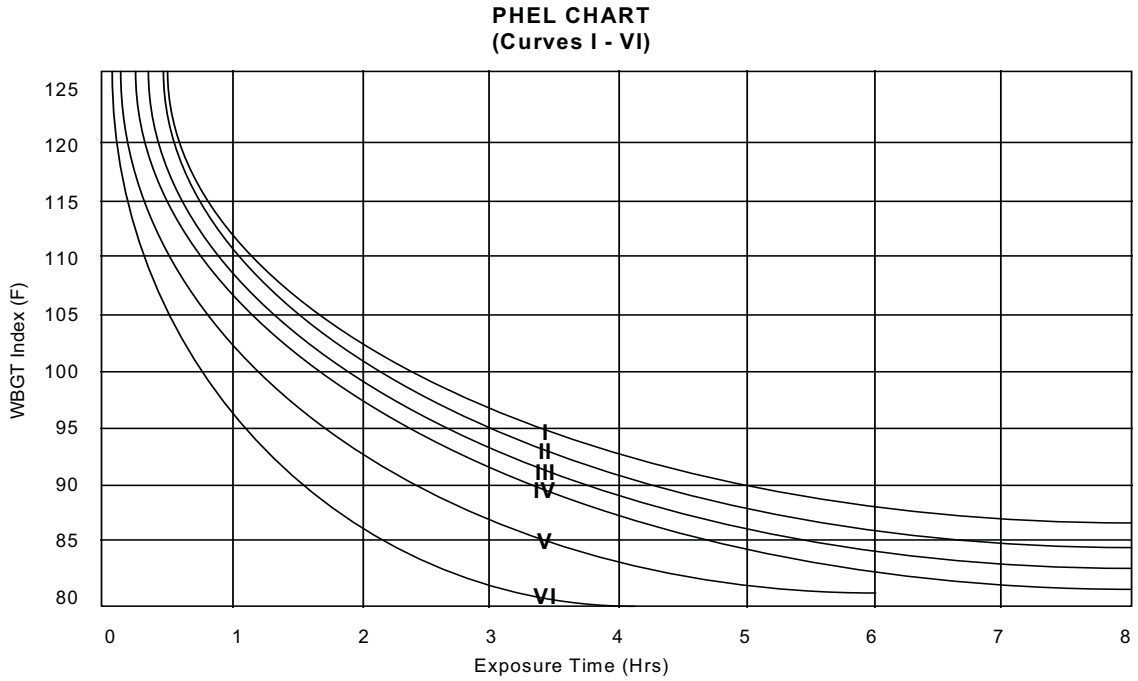


Table B2-A-2

PHYSIOLOGICAL HEAT EXPOSURE LIMITS (PHEL) TIME TABLE

(Without the presence of fuel combustion gases/fuel vapors)

	Six PHEL Curves (Total Exposure Time in Hours: Minutes)					
WBGT Index (F)	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
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

TABLE B2-A-3

(With the presence of fuel combustion gases/fuel vapors)

WBGT Index (F)	Six PHEL Curves (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

Appendix B2-B

HEAT STRESS TROUBLE-SHOOTING AND REPAIR ACTIONS

VENTILATION: If a ventilation problem is suspected, the WBGT meter should be positioned at the supply terminal/opening discharge such that the airflow is blowing into the left side of the WBGT meter. If the discharge air DB temperature is greater than 10 degrees Fahrenheit over the outside DB temperature, then a ventilation supply problem may be indicated. A reading of two terminals/openings per ventilation supply system serving the space is required. The below information may assist in determining the cause of the problem.

STANDARDS	HOW TO MEASURE DISCREPANCIES	CAUSES	RECOMMENDED ACTION
1. VENTILATION NSTM 510, Heating, Ventilation and Air Conditioning systems for Surface Ships			
a. Supply (1) Flow			
Duct velocity 2500 to 3500 fpm	Anemometer	Inlet obstructed	Remove obstructions
		Dirty screens	Clean Screens
Velocity of airflow at watchstander (NAVMED P-5010-3) about 250 fpm minimum		Wrong screen mesh (1-1/2 inches required	Replace with proper size mesh
		Toxic Gas Vent Dampers closed	Open and repair dampers
		Vent duct pressure losses due to dirty ductwork, leaks, unauthorized openings or missing access covers	Clean, repair or replace
		Supply terminal obstructed	Clean the terminal

STANDARDS	HOW TO MEASURE DISCREPANCIES	CAUSES	RECOMMENDED ACTION
(2) Flow (continued)		Terminal inoperable or missing	Replace terminal
		Supply fan not working properly:	Repair
		-Motor speed low (single phase or miswired)	Repair
		-Controller defective	Repair/Replace
		-Improper speed with exhaust fan	Repair fan interlock
		-Failed motor bearings	Repair
		Supply air short circuited by exhaust terminal	Relocate supply or exhaust terminal
At least one supply terminal at each watch-stander station without damper, which can be pointed at the watch-stander	Visual	Incorrect terminal type (should be corrosion resistant steel)	Replace terminal
		Terminal damper is not removed	Remove damper
High Efficiency Filters (HEPA) are dirty. (Ships equipped with a Collective Protection System)	HEPA filter differential pressure gauge. (See PMS)	Continuous use in a dirty environment such as an industrial availability or sand storm)	Replace filters

b. Exhaust			
Refer to specific HVAC Design Criteria Manual (DCM) for ship class. If no specific DCM exist for the ship class in question, refer to NAVSEA 0938-018-0010 (A/C & Ventilation DCM for Surface Ships). Exhaust ventilation is to be: -125% of supply ventilation for 1200 psi steam ships. -115% of supply ventilation for other ships except CPS ships -equal to supply ventilation on CPS ships plus sweep air from Type II airlocks	Anemometer	Exhaust fan not working properly: -Motor speed low (single phase or miss-wired) -Controller defective -Improper speed with exhaust fan -Failed motor bearings	Repair Repair Repair fan interlock Repair
Space pressure negative at ¼ to ½ inch of water is mandatory with supply and exhaust fans at the same speed (airflow should be into space when access is opened)	U-Tube Manometer	Exhaust inlet or outlet obstructed. Dirty screens. Wrong screen mesh (1-1/2 inches required.	Remove obstructions. Clean Screens. Replace with proper size mesh.
	Feel/visual	Vent duct pressure losses due to dirty ductwork, leaks, unauthorized openings or missing access covers. Toxic Gas Vent Dampers closed	Clean, repair or replace Open and repair dampers

Exhaust terminals in hot spots	Feel/Visual		Relocate terminal
2. INSULATION			
a. Piping & Machinery NSTM 635, Thermal, Fire and	Visual Check		
b. Acoustic Insulation Insulate all surfaces with temp. >125°F. Material/thickness IAW MIL-STD-769	Deteriorated cracked, worn, damaged	High traffic, walkway, standing, use of chain falls, etc.	Replace and install metal lagging/shielding
	Wet (water, oil, etc.)	Frequently occurring external leak Internal/ external one-time leak	Replace and cover with metal lagging/shielding Replace
	Missing insulation	Removed for access	Replace
		Replaceable pad missing Valve bonnets, etc	Install replaceable pad
c. After insulation is installed, surface temperature should not exceed 125°F. ***Note 1, 2**	Infrared handgun/ pyrometer-Note 1 Surface temp too high.	Insulation deteriorated/ compacted. Insulation too thin.	Increase insulation thickness. Paint surface with aluminum paint.

3. STEAM/WATER LEAKS

a. Turbine Shaft Seals NSTM 231, Propulsion and SSTG Steam Turbines			
Excessive shaft seal leakage, slight leakage is required to lubricate the shaft seals.	Visual	Shaft alignment	Align shaft
		Worn bearings	Replace bearings
		Improper or worn packing	Replace packing installation
Excessive shaft gland seal leakage, some turbine shaft seals are vented to a gland leak off system	Visual	Seal leaks beyond capacity of leak-off system	Repair Seal
		High exhaust steam Pressure	Rework exhaust dump Value
		Low vacuum in gland leak off system (less than 1/2 inch vacuum)	Secure unneeded auxiliary machinery. Check loop seals. Isolate idle equipment. Ensure gland exhaust fan operating
b. Mechanical Pump Seals NSTM 503, Pumps	Visual	Shaft alignment	Align shafting
		Worn bearings	Replace bearings
		Improper or worn package installation	Replace when leakage forms a stream

c. Pump Stuffing Boxes			
NSTM 503, Pumps	Visual	Packing not sufficiently tight	Tighten packing
Check for leakage for greater than 32 oz./min.	Measure	Gland bottomed out	Add packing
		Shaft alignment	Align shaft
		Worn bearings	Replace bearings
		Improper or worn packaging	Replace packing
d. Casing Joints			
NSTM 221, Boilers	Visual	Dirt on matting surfaces	Clean Surfaces
Check all areas of boiler casings for leakage	Feel	Improper bolt tightening	Retighten bolts
	Soap Suds	Warped doors/access	Replace doors/panels
		Cracked seams, fasteners missing or defective, faulty gaskets	Caulk seams, renew fasteners, replace/renew gaskets use tadpole gaskets
e. Piping			
NSTM 505, Piping	Visual	Pipe, valve or flange leaking	Repair or replace as necessary
Check for stained and wet lagging ***Notes 3, 4**		Pipe broken	Replace
f. Drains, Funnel			
No overflow	Visual	Check valve jammed	Repair check valve
		Drain funnel fouled	Clean drain funnel

4. BILGE

a. Dry Bilge Ships			
No water	Visual	Leaks Machinery Piping	Repair leaks
b. Wet Bilge Ships			
Minimize water (no quantitative standard)	Visual	Leaks Machinery Piping	Pump bilge water and/ or repair leaks

***Note 1** For ships designed to MIL-STD 769D or earlier revisions, the surface temperature after installing insulation was limited to 105°F.
***Note 2** Infrared Heat Gun Survey: Infrared heat guns may be borrowed from IMA or IMA requested to perform. (Heat gun should be used to detect hot spots. This equipment does not provide accurate temperatures).
***Note 3** Use extreme caution when inspecting pressurized or high temperature piping systems. Do not attempt repairs while system is pressurized.
***Note 4** Prior to removing lagging ensure that it does not contain asbestos

Appendix B2-C

USE OF THE WBGT METER

1. The basic instrument for assessing heat stress is the WBGT meter - a small, lightweight, portable instrument. The WBGT meter measures dry-bulb, wet-bulb, and globe temperature and electronically integrates these values into the WBGT Index. There are currently two meters available in the fleet: the RSS-220 meter and the Model 960. Each meter is assembled and operated per its technical manual, either NAVSEA SN000-AA-MMO-0010 for the RSS 220 meter, or NAVSEA S9491-AJ-MMO-010/0910/LP-464-1300 for the Model 960 meter, and the guidance contained within this instruction. Specific instructions for requisitioning and turn-in of units are available from Type Commanders. The Allowance Equipage List (AEL) for the meter is AEL 2-870003051. Experience has shown that the meter globe assembly may be damaged before the meter itself is damaged. Replacing the globe assembly, in the event of meter malfunction, may often eliminate the need to return the entire meter for repair. Similarly, the rechargeable batteries should also be checked before returning the entire meter for repair.

Supply information for the meter and accessories is:

a. Model RSS-220 (Note: No longer manufactured, but repair parts still available)

(1) WBGT meter. (NSN 7H-6685-01-055-5298)

(2) Globe assembly. (NSN 9G-6685-01-149-8635)

(3)Standard nickel cadmium rechargeable size AA batteries. (NSN 9G-6140-00-449-6001)

(4) WBGT meter accessories allowance parts list (APL) (100110001)

b. Model 960

(1) Heat stress monitor. (NSN 3H 6665-01-333-2590)

(2) Globe assembly. (Unavailable from SPCC at this time)

(3) Standard nickel cadmium rechargeable size AA batteries. (NSN 9G-6140-00-449-6001)

(4) Heat stress monitor allowance parts list (APL). (469990172)

2. **WBGT Index**. Environmental data displayed by the WBGT meter (heat stress monitor) are:

a. Shielded, ventilated dry-bulb temperature (DB).

b. Shielded, ventilated wet-bulb temperature (WB).

c. Globe temperature (GT). This temperature is an integration of radiant and convective (the heating or cooling effects of air movement) heat transfer (heat gained or lost).

d. WBGT Index. The meter calculates this value using the following mathematical equation:

$$WBGT = (0.1 \times DB) + (0.7 \times WB) + (0.2 \times GT)$$

e. Exposure Limit (Model 960 only). The calculated exposure limit can be read off the display for each of the PHEL curves (P1 through P6 positions). The heat stress monitor uses the data of appendix B2-A to perform this calculation.

3. **Use of the WBGT Meter (RSS-220)**

a. The procedure for turning on the WBGT meter readies it for operation. The turn-on procedure is:

(1) Install the globe sensor by pushing the phone jack on the base of the sensor into the receptacle on top of the meter. Hold the globe sensor by its phone jack end, not by the black sphere. The globe can easily be damaged by squeezing, bumping, or dropping.

(2) Fill the wet-bulb water reservoir. The reservoir is accessible through the end of the tunnel marked WATER FILL. When filled, water should completely cover the sponge and be well below the level of the tunnel. Excess water can be poured out of the tunnel end. Be careful to keep the dry-bulb sensor dry. If it becomes wet, dry it with tissue or a soft cloth before operating the meter.

(3) Turn the power switch to CHECK. Listen for the sound of the aspirating fan and see digits on the display.

(4) Turn the measurement function switch to DB, WB, GT, and WBGT. Wait five minutes for the initial reading (DB). Wait three minutes for subsequent readings. Each position will give a display reading of 100.0 $\pm$ 0.2 degrees Fahrenheit, if the meter is operating properly. If the proper reading cannot be obtained, do not use the meter.

(5) Turn the power switch to ON.

b. When taking measurements, the order in which the temperatures and WBGT Index are presented in paragraph 3a (DB, WB, GT, and WBGT Index) is the order in which data must be collected to ensure optimum reliability. This is the same order in which the meter will display data as the parameter selection switch is rotated clockwise from the DB position and is the order in which the individual sensors will stabilize (most to least quickly). As each value is obtained, it shall be recorded to the nearest 0.1 degrees Fahrenheit on a heat stress monitoring sheet (see paragraph B0204c(3)(a) for recording procedures). As the meter is moved from one site to another, the meter should be at each site for 5 minutes to allow for stabilization of the first reading (DB) in the series to be taken. To determine when each sensor has stabilized, the monitor should watch the 0.1 degrees Fahrenheit digit of the display. When the 0.1 degrees Fahrenheit digit stops changing or when it oscillates between a larger or smaller value, the sensor has stabilized and the value can be recorded. (If oscillating, always record the higher of the two values.)

c. While taking readings, hold the meter about chest high, one foot away from the body. If there is airflow at the reading location, the meter should be positioned to allow the airflow to enter the left side of the meter.

4. **Use of the Heat Stress Monitor (Model 960)**

a. The procedure for readying the heat stress monitor for operation is as follows:

(1) Fill the wet bulb reservoir. Flip up the top of the reservoir filler cap. Using the supplied filler bottle, fill the reservoir to the full mark. Push the cap cover down until

it snaps in place. The black O-ring that prevents excess water from spilling out of the reservoir may constrict the flow of water onto the WB wick. Feel the wick to ensure that the wick is properly wetted.

(2) Install the globe assembly by removing it from the carrying case and inserting the globe plug into the receptacle on the top of the monitor. Be careful not to get skin oils on the globe.

(3) Turn the monitor ON. Turn the TEST switch to TEST. The display will show either "EE.E" or "88.8." The "EE.E" means that the monitor has failed the test. The "88.8" means that the electronic portion of the unit is ready for use. If the monitor fails the test, check the battery charge level. If the level is low, charge the batteries. If the batteries are not low or the monitor fails the test after charging, the meter must be repaired.

(4) Turn the TEST switch to RUN. Check top of the bar in the Battery Charge Level window. If the top of the bar is in the green section, the batteries are well charged. If the top of the bar is in the yellow section, the batteries will need recharging soon. If the top of the bar is in the red section, the batteries must be recharged before use.

b. While taking readings, hold the meter about chest high, 18 inches away from the body. If there is airflow at the reading location, the monitor should be positioned to allow the airflow to enter the left side of the unit. When taking a measurement, the order in which the temperatures and WBGT index are taken are DB, WB, GT, and WBGT. Wait five minutes after turning the monitor on until taking the initial reading. Allow the temperature to stabilize before taking the subsequent readings. Following temperature readings, position the function switch to the PHEL curve (P position) from appendix B2-A which corresponds to the routine limit, the non-routine limit, the heavy work limit, and the drills limit. The exposure limits should be checked against table B2-B-2.

5. **Use of the Automated Heat Stress System (AHSS)**

a. Viewing/Printing AHSS Data:

(1) The AHSS PC workstation displays, stores and prints the heat stress information. The information on the monitor is updated each minute and stored each hour. A dry bulb (DB) log is available which displays the DB temperature values for each location. The AHSS software allows the workspace supervisor to review the DB log and enter the appropriate comments which will also record the time of the DB log review.

(2) A complete listing of all the WBGT and PHEL curve data are stored hourly and are available for review.

(3) The AHSS provides the ability to conduct a real-time and immediate heat stress survey. The heat stress survey printout includes the current WBGT and PHEL curve stay time information. Additionally, the AHSS software performs the comparison checks to verify that DB > WB, GT ≥ DB, and GT > WBGT > WB.

b. AHSS Operations:

(1) The AHSS unit has four sensor channels, from left to right, the first is capped, the second has the DB sensor, the third has the relative humidity (RH) sensor, the fourth has the GT (black globe) sensor. The WB value is calculated from the DB and RH values. The LED lights for the AHSS unit should be red, green, green, green indicating that the AHSS unit and the three sensors are operating correctly.

(2) A DB and GT value of 32 displayed on the AHSS workstation denotes a sensor failure and the LED light will be red. Follow the procedures in the AHSS technical manual to determine if the DB or GT sensor can become operational. If not, connect a spare sensor in the appropriate DB/GT channel, re-power the AHSS unit, and arrange to have the faulty sensor repaired.

(3) A RH value of either five or 98 displayed on the AHSS workstation denotes a sensor has drifted low or high and the LED light will be red. Follow the procedures in the AHSS technical manual to re-align low/high set points using the 33% and 75% RH salt solutions. If not, connect a spare sensor in the RH channel, re-power the AHSS unit, follow the RH sensor calibration procedures, and arrange to have the faulty sensor repaired. Note that the RH salts are a disposable item with a

one-year shelf life and must be replaced each year. Ordering information is provided in the AHSS technical manual.

Refer to the AHSS technical manual for a comprehensive review of the AHSS procedures.

6. **Periodic WBGT Meter Validation**

a. Each series of WBGT meter readings shall be validated by manually calculating the highest WBGT Index obtained using the equation of paragraph 2d above. This calculation shall be performed in the remarks section of the Heat Stress Monitoring Sheet. The reported WBGT Index value from the meter reading should agree within plus or minus 0.2 degrees Fahrenheit of the calculated WBGT Index value. If such agreement is not obtained, the following causes of error shall be considered:

(1) The operator may have rushed through the measurement procedures not allowing the sensors to stabilize.

(2) The operator may have misread or recorded the values incorrectly.

(3) The meter may not be functioning properly.

If agreement is not obtained, the operator shall conduct a meter check per the appropriate technical manual. If the meter check is satisfactory, the operator shall retake the meter readings, ensuring that the meter is allowed to stabilize properly prior to obtaining readings and ensuring that values are recorded properly. If the meter check is unsatisfactory, the operator shall obtain another WBGT meter and retake the readings.

b. During reviews of heat stress monitoring sheets by the MDR, the department head, and other supervisors, the temperature and WBGT Index values should be spot-checked to determine obvious errors. The following rules of thumb should be applied:

(1) WB temperatures must be less than DB temperatures (WB < DB).

NOTE:

If the WB temperature equals the DB temperature, the wick over the WB sensor is probably dried out. Check that there is water in the WB reservoir.

(2) GT for each set of readings should be greater than or equal to DB temperature for the same set of readings (GT $\geq$ DB).

(3) WBGT Index must be greater than WB temperature and less than the GT (WB <WBGT < GT).

(4) The higher the overall heat stress, the more important it is to periodically check the meter's WBGT Index value by manually calculating the WBGT Index. It is the reliability of the individual data and WBGT Index which determines the reliability of the exposure limit from the PHEL chart or table.

7. **Emergency Environmental Monitoring Equipment Method.**

The emergency environmental monitoring equipment method discussed here will almost always significantly underestimate the level of heat stress; this shortfall will result in an increased risk of personnel suffering 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 psychrometric 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 under similar plant operating conditions (power level, number of operating boilers, and approximately the same load on the propulsion plant) when a full set of WBGT meter measurements were obtained. This difference (ΔT) should be added to the DB temperature measured with the psychrometer. For example:

Previous DB	-	Previous GT	=	ΔT
98.3	-	110.4	=	12.1

Psychrometer DB	-	Psychrometer WB	=	Estimated GT(DB+ ΔT)
99.1	-	83.6	=	99.1 + 12.1 = 111.2

Using the formula:

WBGT = (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)

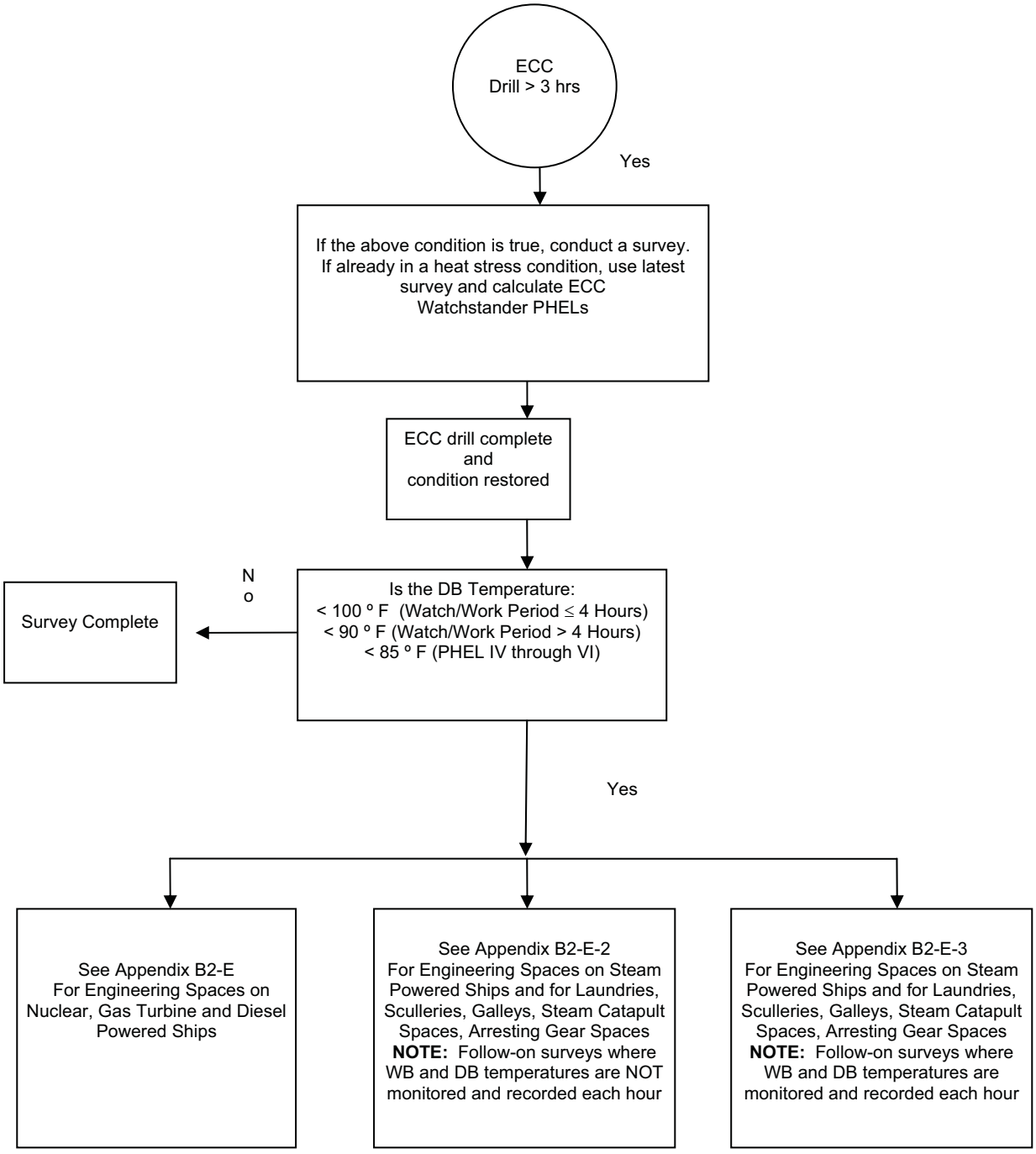
WBGT = 90.7

The WBGT Index values obtained by this strictly emergency monitoring method should be used with the PHEL chart (figure B2-B-1) or tables (tables B2-B-2 and B2-B-3). The resultant exposure limits will be approximations only.

Records should indicate whenever the emergency environmental monitoring equipment method was used. A casualty report shall be submitted. When reporting meter failure, give the serial and model numbers and describe the problems encountered.

Appendix B2-D

HEAT STRESS DECISION DIAGRAM



Appendix B2-E

TIME WEIGHTED MEAN (TWM) WBGT VALUES

Time Weighted Mean (TWM) WBGT Values. The TWM WBGT is intended for use in especially hot environments where reduced stay times have been imposed on watchstanders. The TWM WBGT is an optional provision, for use if an air-conditioned booth or cooler space is available for personnel to spend time in the cooler climate and afford some relief from the heat in the space. When the TWM is used it changes the WBGT value for that individual and increases the length of time spent at watch station. Ships that have this ability may properly calculate the new WBGT value using the following equation:

$$\text{Time (booth)} = \frac{[\text{WBGT (WATCH STATION)} - [\text{WBGT (desired)}] \times 60}{[\text{WBGT (watch station)} - \text{WBGT (booth)}]}$$

For example: Engineering spaces on a steam-powered ship in the Indian Ocean are on a four-hour watch rotation. The temperature on a hanging DB thermometer in a main space measured 101°F during the latest heat-stress survey:

Burnerman WBGT = 92, PHEL = II, Stay time = 4:10
Lower Levelman BGT = 92; PHEL = III; Stay time = 3:30
Console Booth WBGT = 80; PHEL = I; Stay time = 8:00

The lower levelman has a stay time less than four hours while other watch stations have stay times that are equal to greater than four hours. The engineering office decides to incorporate a TWM WBGT for the lower levelman to maintain a four-hour watch for all watchspace personnel. He/she looks up the WBGT value (in the PHEL Time Table in appendix B2-A) to achieve a four-hour stay time (90 WBGT = stay time of four hours) and does the calculation. The time that the lower levelman must spend in the cool booth each hour to achieve a four-hour watch would be calculated as follows:

For the Lower Levelman:

$$\text{Time (booth)} = \frac{[\text{WBGT (watch station)} - [\text{WBGT (desired)}] \times 60}{[\text{WBGT (watch station)} - \text{WBGT (booth)}]}$$

The 90 WBGT value is from the PHEL Table in appendix B2-A.

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

TWM WBGT information shall be documented on the heat stress survey sheet.