**DEPARTMENT OF THE AIR FORCE**
**Headquarters US Air Force**
**Washington, DC 20330-1030**

**QTP 4B051-17**
**2 April 2015**
***Certified Current, 15 July 2022***

# AIR FORCE SPECIALTY CODE 4B051
# BIOENVIRONMENTAL ENGINEERING

## Thermal Stress

# QUALIFICATION TRAINING PACKAGE

**Accessibility:** ***Publications and forms are available on the e-publishing website at http://www.e-publishing.af.mil for downloading or ordering.***

**Realeasability:** ***There are no releasability restrictions on this publication.***

# Table of Contents

# STS Line Item 4.12.3: Analyze thermal stress hazards (i.e. WBGT)

## TRAINER GUIDANCE

| | |
|---|---|
| **Proficiency Code:** | 3c |
| **PC Definition:** | Can do all parts of the task. Needs only a spot check of completed work. Can identify why and when the task must be done and why each step is needed. |
| **Prerequisites:** | None |
| **Training References:** | • AFPAM 48-151, *Thermal Injury*, Nov 02 (Update 7 May 2013), Chapter 3& 4, Attachments 2 thru 5. May differ as publication is updated periodically.<br>• ACGIH TLV Booklet<br>• Fundamentals of Industrial Hygiene, Current edition |
| **Additional Supporting References:** | None |
| **CDC Reference:** | 4B051 |
| **Training Support Material:** | • Wet Bulb Globe Thermometer (WBGT) apparatus<br>• Tripod<br>• Distilled water<br>• Equipment Instructions (if digital WBGT kit)<br>• Calculator<br>• Tables A2.1, A2.2, from attachment 2 of AFPAM 48-151<br>• Tables A4.1, A4.2, from attachment 4 of AFPAM 48-151<br>• Tables A5.1, A5.2, from attachment 5 of AFPAM 48-151 |
| **Specific Techniques:** | Conduct hands-on training and evaluation. Have the trainee calculate both an outdoor and indoor WBGT index manually and also using the slide calculator (if available). Also have the trainee consider effects of specialist-clothing ensembles when analyzing results. Finally, have the trainee calculate a time-weighted average. |
| **Criterion Objective:** | Given a WBGT apparatus and calculator, perform indoor and outdoor WBGT measurements and properly calculate the WBGT successfully completing all checklist items with NO trainer assistance. |
| **Notes:**<br>WBGT measurements can be taken with manual and electronic units. This training module focuses on the manual method. | |

## TASK STEPS

***Heat Stress:***

1. Select a suitable location[1].
2. Extend the legs of the tripod so the mounting device is at a height of 3-5 feet.
3. Mount the WBGT apparatus to the tripod by securing with the mounting screw.
4. Open the WBGT kit.
5. Lift the thermometer assembly up and out using the "lift here" tab.
6. Wet the wet bulb wick thoroughly with distilled water.
7. Position the kit with the thermometers toward the sun[2].
8. Allow the black globe to be exposed to the sun at least 25 minutes before recording readings.
9. Record the temperatures wet bulb (WB), dry bulb (DB), and black globe (GT) temperatures.
10. Calculate the WBGT index[3].
11. Determine the correct metabolic rate class (see AFPAM 48-151, Table A2.1).
12. Determine the correct reference value (see AFPAM 48-151, Table A2.1).
13. Determine correct stage (see AFPAM 48-151, Table A2.2)[4].

***Cold Stress:***

14. Determine the wind chill temperature (see AFPAM 48-151, Table A4.1).
15. Determine proper wind chill condition (see AFPAM 48-151, Table A4.2).

**LOCAL REQUIREMENTS: None**

**NOTES:**

1. Readings should be taken at a location representative of the conditions to which workers are exposed.

2. Ensure the dry bulb is shielded from direct sunlight. Expose the black globe to direct sunlight.

3. To calculate the outdoor WBGT with direct sunlight, all three temperatures (WB, DB, and GT) are needed. To calculate an indoor or outdoor WBGT without direct sunlight, only the wet bulb temperature and black globe temperature are needed. Equation is available below.

**<u>Equations</u>**:

$WBGT = 0.7T_{nwb} + 0.2T_{bg} + 0.1T_{db}$ (Outdoors)
$WBGT = 0.7T_{nwb} + 0.3T_{bg}$ (Absent Solar Load or Indoors)

Where:
$T_{nwb}$ = natural wet bulb
Tbg = black globe
Tdb = dry bulb temperatures

$$TWA = \frac{WBGT_1 \times T_1 + WBGT_2 \times T_2}{T}$$

Where T = Time

(Source: 4B051 CDC)

4. AFMAN 48-151 states for specialist-clothing ensembles (individuals are working in ground crew ensemble, firefighting gear or other similar restrictive or impermeable clothing) 10 degrees F is to be added to the WBGT measurement before applying the work schedule guidelines at Tables A5-1 and A5-2 of Attachment 5. A further 5 degrees WBGT should be added if individuals are wearing combat armor.

**TRAINEE REVIEW QUESTIONS**

## STS Line Item 4.12.3: Analyze thermal stress hazards (i.e. WBGT)

| |
|---|
| 1. What precaution should be taken with the dry bulb thermometer when the measurements are taken outside? |
| 2. When must BE begin monitoring the wet bulb globe temperature? |
| 3. Given the WBGT readings below, calculate an outdoor (with full sun) WBGT index.<br>• Wet bulb = 78$^{o}$ F<br>• Black globe = 100 $^{o}$ F<br>• Dry bulb = 82 $^{o}$ F |

| |
|---|
| 4. Given the same WBGT readings from question #5, calculate an indoor WBGT index. |
| 5. Applying the answer to question #5, what is the proper WBGT stage? |
| 6. What type of adjustment is made to a WBGT index when specialist-clothing ensembles are worn? |

## PERFORMANCE CHECKLIST

## STS Line Item 4.12.3: Analyze thermal stress hazards (i.e. WBGT)

| | |
|---|---|
| **Proficiency Code:** | 3c |
| **PC Definition:** | Can do all parts of the task. Needs only a spot check of completed work. Can identify why and when the task must be done and why each step is needed. |

| DID THE TRAINEE… | YES | NO |
|---|---|---|
| ***HEAT STRESS*** | | |
| 1. Select a suitable location? | | |
| 2. Extend the legs of the tripod so the mounting device is at a height of 3-5 feet? | | |
| 3. Mount the WBGT apparatus to the tripod by securing with the mounting screw? | | |
| 4. Open the WBGT kit? | | |
| 5. Lift the thermometer assembly up and out using the “lift here” tab? | | |
| 6. Wet the wet bulb wick thoroughly with distilled water? | | |
| 7. Position the kit with the thermometers toward the sun? | | |
| 8. Allow the black globe to be exposed to the sun at least 25 minutes before recording readings? | | |
| 9. Record the temperatures wet bulb (WB), dry bulb (DB), and black globe (GT) temperatures? | | |
| 10. Calculate the WBGT index? | | |
| 11. Determine the correct metabolic rate class? | | |
| 12. Determine the correct reference value? | | |
| 13. Determine correct stage? | | |
| ***COLD STRESS*** | | |
| 14. Determine the wind chill temperature? | | |
| 15. Determine proper wind chill condition? | | |
| **Did the trainee successfully complete the task?** | | |

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

## ANSWERS

1. What precaution should be taken with the dry bulb thermometer when the measurements are taken outside?

   A: The dry bulb must be shielded from radiant heat.

   (Source: 4B051 CDC)

2. When must BE begin monitoring the wet bulb globe temperature?

   A: When the temperature is forecasted to exceed 85$^{o}$F.

   (Source: 4B051 CDC)

1. Given the WBGT readings below, calculate an outdoor (with full sun) WBGT index.

   - Wet bulb = 78$^{o}$ F
   - Black globe = 100 $^{o}$ F
   - Dry bulb = 82 $^{o}$ F

   A:
   WBGT = 0.7Tnwb + 0.2Tbg + 0.1Tdb (Outdoors)
   = (78)(0.7) + (100)(0.2) + (82)(0.1)
   = 54.6 + 20 + 8.2
   = 82.8$^{o}$ F

   (Source: 4B051 CDC)

4. Given the same WBGT readings from question #5, calculate an indoor WBGT index.

   A:
   WBGT = 0.7Tnwb + 0.3Tbg (Absent Solar Load or Indoors)
   = (78)(0.7) + (100)(0.3)
   = 54.6 + 30
   = 84.6$^{o}$ F

   (Source: 4B051 CDC)

5. Applying the answer to question #5, what is the proper WBGT stage?

   A: Stage 2 (82 - 84.9$^{o}$ F)

   (Source: AFMAN 48-151, *Thermal Injury*, Table A2.2)

6. What type of adjustment is made to a WBGT index when specialist-clothing ensembles are worn?

   A: 10 degrees F is to be added to the WBGT measurement before applying the work schedule guidelines.

   (Source: AFMAN 48-151, *Thermal Injury*, Table A5.2, sub-paragraph B)

# STS Line Item 4.12.4: Recommend thermal stress controls

## TRAINER GUIDANCE

| | |
|---|---|
| **Proficiency Code:** | 2b |
| **PC Definition:** | Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task. |
| **Prerequisites:** | None |
| **Training References:** | • AFPAM 48-151, *Thermal Injury*, Nov 02 (Update 7 May 2013), Chapter 4. May differ as publication is updated periodically.<br>• ACGIH TLV Booklet<br>• Fundamentals of Industrial Hygiene, Current Edition. |
| **Additional Supporting References:** | None |
| **CDC Reference:** | 4B051 |
| **Training Support Material:** | None |
| **Specific Techniques:** | Conduct hands-on training and evaluation. Have the trainee use Table A5.1 located in AFPAM 48-151 to correctly decide work/rest cycles for given flag condition information. |
| **Criterion Objective:** | When provided with relevant thermal stress conditions state the appropriate controls for the situation with limited trainer assistance. |
| **Notes:**<br>WBGT measurements as laid out in QTP 4.12.3 are needed to identify WBGT Stages and Flag Colors that help to justify appropriate controls. | |

## TASK STEPS

***Heat Stress:***

1. Determine source of heat stress and appropriate WGBT conditions as laid out in Training Module 4.12.3.[1]
2. If feasible, determine appropriate engineering controls.[2]
3. If feasible, determine appropriate administrative controls.[3]
4. If feasible, determine appropriate PPE.[4]
5. Communicate (i.e. email, face-to-face, MFRs) recommendations to affected units/individuals.

***Cold Stress:***

1. If feasible, determine appropriate engineering controls.[5]
2. If feasible, determine appropriate administrative controls.[6]
3. If feasible, determine appropriate PPE.[7]
4. Communicate (i.e. email, face-to-face, MFRRs) recommendations to affected units/individuals.

**LOCAL REQUIREMENTS:** None

**NOTES:**

1. Hot environment, heat generating sources such as welding, increased levels of PPE that elevate heat stress levels.

2. **Engineering Controls for Heat Stress** are directed toward reducing physical work demands, reducing external heat gain from the air and hot surfaces, and enhancing external heat loss by increasing sweat evaporation and decreasing air temperature. Examples include: dilution ventilation, active cooling, shielding and etc.

3. **Administrative Controls for Heat Stress** change the way work is performed in order to limit exposures or risks. For heat stress, they are directed toward limiting exposures so that increases in heart rate and core temperature do not exceed accepted limits. Administrative controls include: acclimatization, work/rest cycles, pace of work, sharing work, fluid intake, scheduling of work and etc.

4. **PPE Controls for Heat Stress** provides protection for individual workers. For heat stress, PPE is primarily in the form of personal cooling, but can include reflective clothing for high-radiant heat conditions. Keep in mind that PPE is used as a last resort, when other control measures are not feasible or available. Examples include: ice garments/vests, reflective clothing, personal air cooling systems and etc.

5. **Engineering Controls for Cold Stress** reduce heat loss from the person as a whole or from exposed skin. They include the following: general/spot heating such as heaters, temporary shelters, shielding and etc.

6. **Administrative Controls for Cold Stress** that help reduce the exposure time, allow individual control over the work, and provide for mutual observation include the following: Example: work/warm cycles, work scheduling practices, moving work to warmer areas, buddy system and etc.

7. **PPE Controls for Cold Stress** are fundamental in managing cold stress. Personal protective equipment includes the following: properly selected insulating clothing, layer clothing, active warming systems such as hand/foot warmers and etc.

**TRAINEE REVIEW QUESTIONS**

## STS Line Item 4.12.4: Recommend thermal stress controls

| |
|---|
| 1. How long does it take for someone to become adapted (acclimated) to a new climate? |
| 2. What is an appropriate example for an engineering control for heat stress? |
| 3. What is an appropriate example for an administrative control for cold stress? |

## PERFORMANCE CHECKLIST

# STS Line Item 4.12.4: Recommend thermal stress controls

| | |
|---|---|
| **Proficiency Code:** | 2b |
| **PC Definition:** | Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task. |

| DID THE TRAINEE… | YES | NO |
|---|---|---|
| **HEAT STRESS:** | | |
| 1. Determine source heat stress and appropriate WGBT conditions as laid out in QTP 4.12.3? | | |
| 2. If feasible, determine appropriate engineering controls? | | |
| 3. If feasible, determine appropriate administrative controls? | | |
| 4. If feasible, determine appropriate PPE? | | |
| 5. Communicate (i.e. email, face-to-face, MFRs) recommendations to affected units/individuals? | | |
| **COLD STRESS:** | | |
| 1. If feasible, determine appropriate engineering controls? | | |
| 2. If feasible, determine appropriate administrative controls? | | |
| 3. If feasible, determine appropriate PPE? | | |
| 4. Communicate (i.e. email, face-to-face, MFRRs) recommendations to affected units/individuals? | | |
| **Did the trainee successfully complete the task?** | | |

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

## ANSWERS

1. How long does it take for someone to become adapted (acclimated) to a new climate?

   A: 10 to 14 days

   (Source: AFPAM 48-151, *Thermal Injury*, Nov 02 (Update 7 May 2013), Chapter 4, paragraph 2.3)

2. What is an appropriate example for an engineering control for heat stress?

   A: Air conditioning, fans, shielding

   (Source: AFPAM 48-151, *Thermal Injury*, Nov 02 (Update 7 May 2013), Chapter 4.)

3. What is an appropriate example for an administrative control for cold stress?

   A: Worker rotation, move work indoors, training.

   (Source: AFPAM 48-151, *Thermal Injury*, Nov 02 (Update 7 May 2013), Chapter 4.)