TSI | QUEST™

QUESTemp°
Heat Stress
Monitor

Model 48N

User Manual

Start Seeing the Benefits of Registering Today!

Thank you for your TSI® instrument purchase. Occasionally, TSI® releases information on software updates, product enhancements and new products. By registering your instrument, TSI® will be able to send this important information to you.

http://register.tsi.com

As part of the registration process, you will be asked for your comments on TSI products and services. TSI's customer feedback program gives customers like you a way to tell us how we are doing.

Warranty

(For country-specific terms and conditions outside of the USA, please visit www.tsi.com.)

Seller warrants the goods, excluding software, sold hereunder, under normal use and service as described in the operator's manual, to be free from defects in workmanship and material for the longer period of either **12 months**, or **the length of time specified in the operator's manual/warranty statement provided with the goods or made available electronically (version published at the time of sale)**, from the date of shipment to the customer. This warranty period is inclusive of any statutory warranty. **This limited warranty is subject to the following exclusions and exceptions:**

   a. Hot-wire or hot-film sensors used with research anemometers, and certain other components when indicated in specifications, are warranted for 90 days from the date of shipment;

   b. Pumps are warranted for hours of operation as set forth in product or operator's manuals;

   c. Parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment;

   d. Seller does not provide any warranty on finished goods manufactured by others or on any fuses, batteries or other consumable materials. Only the original manufacturer's warranty applies;

   e. This warranty does not cover calibration requirements, and seller warrants only that the instrument or product is properly calibrated at the time of its manufacture. Instruments returned for calibration are not covered by this warranty;

   f. This warranty is **VOID** if the instrument is opened by anyone other than a factory authorized service center with the one exception where requirements set forth in the manual allow an operator to replace consumables or perform recommended cleaning;

   g. This warranty is **VOID** if the product has been misused, neglected, subjected to accidental or intentional damage, or is not properly installed, maintained, or cleaned according to the requirements of the manual. Unless specifically authorized in a separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, goods which are incorporated into other products or equipment, or which are modified by any person other than Seller.

   h. New parts or components purchased are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment.

The foregoing is **IN LIEU OF** all other warranties and is subject to the LIMITATIONS stated herein. **NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. WITH RESPECT TO SELLER'S BREACH OF THE IMPLIED WARRANTY AGAINST INFRINGEMENT, SAID WARRANTY IS LIMITED TO CLAIMS OF DIRECT INFRINGEMENT AND EXCLUDES CLAIMS OF CONTRIBUTORY OR INDUCED INFRINGEMENTS. BUYER'S EXCLUSIVE REMEDY SHALL BE THE RETURN OF THE PURCHASE PRICE DISCOUNTED FOR REASONABLE WEAR AND TEAR OR AT SELLER'S OPTION REPLACEMENT OF THE GOODS WITH NON-INFRINGING GOODS**.

TO THE EXTENT PERMITTED BY LAW, THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF SELLER'S LIABILITY FOR ANY AND ALL LOSSES, INJURIES, OR DAMAGES CONCERNING THE GOODS (INCLUDING CLAIMS BASED ON CONTRACT, NEGLIGENCE, TORT, STRICT LIABILITY OR OTHERWISE) SHALL BE THE RETURN OF GOODS TO SELLER AND THE REFUND OF THE PURCHASE PRICE, OR, AT THE OPTION OF SELLER, THE REPAIR OR REPLACEMENT OF THE GOODS. IN THE CASE OF SOFTWARE, SELLER WILL REPAIR OR REPLACE DEFECTIVE SOFTWARE OR IF UNABLE TO DO SO, WILL REFUND THE PURCHASE PRICE OF THE SOFTWARE. IN NO EVENT SHALL SELLER BE LIABLE FOR LOST PROFITS, BUSINESS INTERRUPTION, OR ANY SPECIAL, INDIRECT, CONSEQUENTIAL OR INCIDENTAL DAMAGES. SELLER SHALL NOT BE RESPONSIBLE FOR INSTALLATION, DISMANTLING OR REINSTALLATION COSTS OR CHARGES. No Action, regardless of form, may be brought against Seller more than 12 months after a cause of action has accrued. The goods returned under warranty to Seller's factory shall be at Buyer's risk of loss, and will be returned, if at all, at Seller's risk of loss.

Buyer and all users are deemed to have accepted this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of Seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended, modified or its terms waived, except by writing signed by an Officer of Seller.

Service Policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI's Customer Service department at 1-800-874-2811 (USA) or +001 (651) 490-2811 (International).

Contents

List of Figures

List of Tables

Introduction

The QUESTemp⁰ 48N offers traditional heat stress monitoring without the aggravation of maintaining a wet bulb. Through collaboration with Professor Dr. Thomas Bernard, from the College of Public Health at the University of South Florida, mathematical models were implemented to create a *Waterless Wet Bulb calculation* through a combination of dry bulb temperature, globe temperature, relative humidity, and air flow.

Figure 1: QUESTemp⁰ 48N

QUESTemp⁰ 48N Model

The QUESTemp⁰ 48N model was specifically engineered for the Department of Defense Ashore and Afloat Operations in which conditions require hand's free monitoring, in-the-field user RH/WBGT sensor alignments, and snapshot measurement logging (called "event logging mode").

The QT48N measures and calculates the dry bulb, wet bulb, globe, WBGT outdoors, and relative humidity with two different types of data logging modes – as a time history session or an event logging mode.

You also have the capability to measure stay times in order to manage work/rest regimens. Guidance is based on the screening criteria for heat stress as defined in the ACGIH TLV Handbook, U.S. Navy PHEL charts, and Flag Conditions for U.S. Navy / Marine Corp. Ashore.

Getting Started

Up and Running Overview

1. Place the QUESTemp° 48N in the work area in a safe location approximately 3.5 feet off the ground.

2. Turn the unit **On**. If the battery voltage displayed during the power-on sequence is less than or equal to 6.4 volts, replace or recharge the batteries.

3. Be aware that the sensors require 10 minutes to stabilize to a new environment.

4. In the main menu, **View** will be selected (an indicator arrow denotes the selected menu). Press the **I/O Enter** key and the measurement screen will appear.

5. Press the **Run/Stop** key to begin datalogging. Use the **Arrow keys** to set the display to the desired items.

Placing the QUESTemp° 48N on the Job Site

The QUESTemp° 48N should be placed at a height of 3.5 feet (1.1 m) for standing individuals or 2 feet (.6 m) for seated individuals. Tripod mounting is recommended to get the unit away from anything that might block radiant heat or air flow. A 1/4" x 20 threaded bushing on the bottom of the instrument allows mounting to a standard photographic tripod. **DO NOT** stand close to the unit during sampling.

Before data logging, allow ten minutes for the sensors readings to stabilize.

Keypad Operation

The unit operates using a keypad with four keys. The **I/O Enter key** responds when the key is released while all other keys respond when the key is pressed.

Table 1: Keypad explained

| Keys	Explanation
I/O Enter key	The unit turns on with a single key press. The unit turns off by holding the key down while a countdown of 3-2-1 occurs in the lower right corner of the display. This key is also used to select a mode (such as **Setup** or **View**) or enter setup changes.
	Pressing and releasing the key while viewing temperatures causes the display to view the next available sensor bar (indicated in the upper right corner of the display).
Up Arrow key	Changes items appearing in the display. Scrolls up.
Down Arrow key	Changes items appearing in the display. Scrolls down.
Run/Stop key	From the menu or view modes, pressing this key starts or stops the run mode. Pressing this key will exit the setup, print or reset modes.
Escaping or moving back one screen	If you are in the setup, print, reset, or sensor alignment screens, you can press **Run/Stop** key to escape or move back one screen.

Figure 2: Keypad Keys identified

Turning on, Logging/Capture an Event, and Turning Off

To quickly get you started with the QUESTemp⁰ 48N, the following section explains turning on the instrument, data logging/event logging, and stopping.

1. Press the **I/O Enter** key to turn on.

   ▪ The first two start-up screens detail the name, type of instrument, and then a revision and battery power screen appears. (Ensure the battery level does not fall below 6.4V or you will want to replace the battery. See "Powering" for more details.)

NOTICE
If you have data saved on the instrument, an additional screen stating "data in memory" will appear prompting you to reset the instrument, if desired.

   A

QUEST	
QT-48N	WWB

   B

REVISION	1.25
BATTERY	8.3V
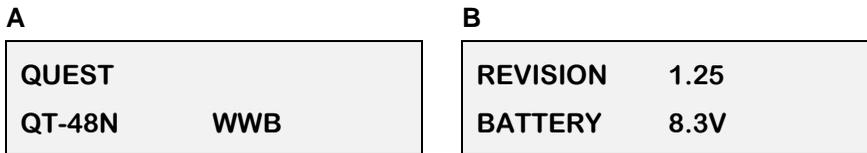
   **Figure 3: Start-up screens (A – indicates model and type
   B- indicates revision and battery power)**

2. In the **Index Start-Up** screen, press **I/O Enter** key.

NOTICE
If an index is selected from the Setup menu, this will appear on this screen.

Index: - - - -
<ENTER>

   Figure 4: Index start-up screen

3. A **Log Rate Start-Up** screen will appear, press **I/O Enter** key. (This screen details your log rate time or event logging setup option and the last saved logged session or event.) (See Setup for more information on event logging.)

Log Rate: 1 min
Nxt 01 <ENTER>

   Figure 5: Log rate start-up screen

4. The **main menu** (navigational screen) will appear after the start-up screens. Press **I/O Enter** key. (This will open to the measurement screens.)

		Indicator arrow
▸ VIEW	PRINT	Indicates the selected menu option. Either press up/down arrows to select a new menu
SETUP	RESET	or press **I/O Enter** key to select.

Figure 6: Main menu of the QT48N

5. Press **Run/Stop** key to either Data Log or log/record an Event and an asterisk will appear in far right corner.

NOTICE
Data logging or an Event is selected via the Setup menu.

- ▪ **Numeric counter**

    - – *Event logging/recording:* As you record events, the numeric counter will increase by one displaying the number of saved events.

    - – *Data logging mode***:** This will display the number of saved data logged sessions instead of Events. (The process is identical to event mode.)
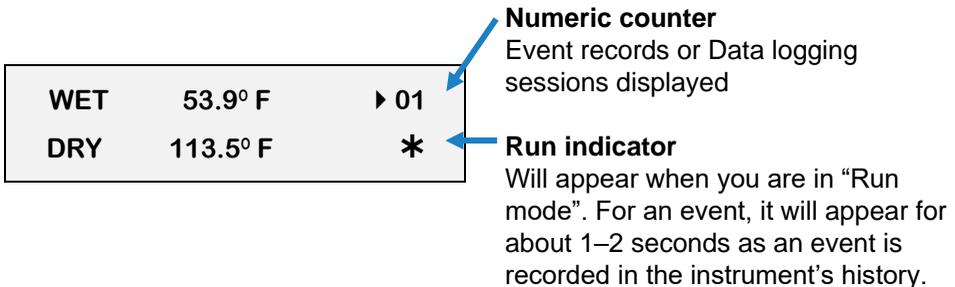
		Numeric counter
		Event records or Data logging sessions displayed
WET	53.9° F	▸ 01
DRY	113.5° F	✱

Numeric counter
Event records or Data logging sessions displayed

Run indicator
Will appear when you are in "Run mode". For an event, it will appear for about 1–2 seconds as an event is recorded in the instrument's history.

Figure 7: Measurement screen (example)

6. To stop data logging, press and hold **Run/Stop** key.

NOTICE
Skip this step for an Event log. An event log will capture the measurements with the initial run/stop key press.)

7. To view different measurements, press the **Up** or **Down Arrow** key to toggle through the views.

8. To return to the **main menu**, press and hold the **I/O Enter** key (3, 2, 1 countdown will appear) and the main menu will display.

   ▪ To select an option on the main menu, press the **Up or Down Arrow** until an arrow appears directly in front of the appropriate menu selection and then press **I/O enter** key.

9. To **power off**, press and hold the **I/O Enter key** from the main menu.

Sensors

Globe Thermometer

The globe thermometer (left position) gives an indication of the radiant heat exposure on an individual due to either direct sunlight or hot objects in the environment. This is accomplished by placing a temperature sensor inside a blackened copper sphere and measuring the temperature rise. The WBGT index is based on the response of a 6-inch diameter globe. The QUESTemp° uses a 2-inch diameter globe for a faster response time. The temperature of the 2-inch globe is correlated to match that of a 6-inch globe.

Waterless Wetbulb & Relative Humidity Sensor

The relative humidity sensor (middle position) is used to calculate the Waterless Wetbulb from a combination of dry bulb temperature, humidity and wind speed measurements. The waterless wetbulb is used to calculate an estimated WBGT value.

Dry Bulb Thermometer

The dry bulb thermometer (right position) measures the ambient air temperature. This measurement is used in the outdoor WBGT calculation when a high solar radiant heat load may be present. The series of white plates surrounding the sensor shield it from radiant heat.
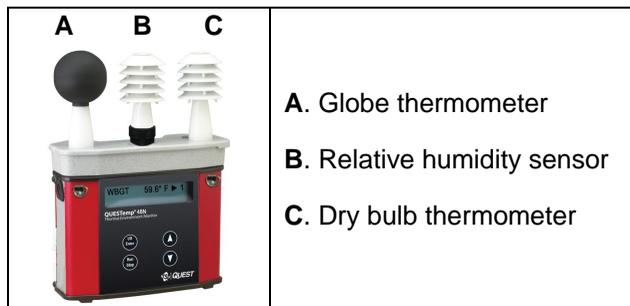

A. Globe thermometer

B. Relative humidity sensor

C. Dry bulb thermometer

Figure 8: Sensors identified

Measurements

The QUESTemp° 48N data logging, with an event logging mode, heat stress monitor directly senses three parameters: dry bulb temperature (DB), globe temperature (G), and relative humidity (RH).

It computes the Wet Bulb (WB), the Wet Bulb Globe Temperature (WBGT), and the Stay Times Indices for ACGIH, U.S. Navy PHEL charts, and Flag Conditions for U.S. Navy/ Marine Corp. Ashore.

WetBulb Globe Temperature (WBGT)

The WBGT is a type of temperature index which combines the effects of temperature, humidity, radiant heat, and air flow and provides a relatively simplistic tool to analyze thermal comfort. The resulting WBGT values can then be compared to indices of work-rest regimens (stay times) based upon workloads.

The WBGT calculation is a weighted average of the three temperature sensors using the following formulas:

NOTICE
Navy and Marine calculations are all based on the outdoor computation.
WBGT (outdoor) = 0.7WB + 0.2G + 0.1DB (denoted as "WBGT" on the display)

Stay Times/Rest Times (Indicies)

Stay Times Indices represent how long a worker should be able to safely work under heat stress conditions. Select one of four indices for displaying and printing from the unit: ACGIH Stay Times, NAVY PHEL's, or Flag Conditions for U.S. Navy/Marine Corp. Ashore. Refer to Appendix B for more information on the indices.

NOTICE
It will appear as "Index" on the measurement screen.

Remote Measurements

The top sensor bar may be removed from the instrument and used through a remote cable. (Refer to Appendix C for remote cable options.) Shelter the instrument and remote the sensor bar if the measured environment is expecting heavy rain or if temperatures are above 60°C.

Operating QUESTemp⁰ 48N

From a powered on mode, the main menu
will appear (after the start-up screens are
displayed.) Use the **Up Arrow** and **Down
Arrow** keys to move the marker in the
display in front of the desired mode. Pressing
the **I/O Enter** key will select the mode.

VIEW	PRINT
▶ SETUP	RESET

Figure 9: Main menu example

View

Displays the measured data but does not log it. If more than one set of sensors is
plugged into the unit, they can be displayed by pressing and releasing the **I/O Enter** key.
The displayed **sensor set** is shown in the **upper right corner**.

WET	53.9⁰ F	▶ 01
DRY	113.5⁰ F	

View mode
Arrow icon Indicates you are in view mode

Event #
Last logged event/session

Figure 10: Viewing measured data

NOTICE
To return to the main menu, hold down the **I/O Enter** key while a 3, 2, 1 countdown is shown in the lower-right corner of the display.

Setup

The setup options are from the main menu when Setup is selected. At any time, to exit (or escape) a screen, press the **Run/Stop** key. Table 2 identifies the setup parameters.

Table 2: Settings identified

Settings	Explanation
Temperature units	▪ Selectable: ºF/ºC
Language setting	▪ Selectable: English, Spanish, French, Italian, and German
Time and Date	▪ Time settings: 24-hour clock ▪ Day-month-year format
Log Rate	▪ 1, 2, 5, 10, 15, 30, 60 minutes log rate options ▪ Event Log: When run/stop is pressed, an event or snapshot of the current conditions is logged into memory. The events range from 0–99.
Index/Stay Times	▪ ACGIH, PHEL, FLAG, or none (denoted "----")

Selecting Setup Parameters

1. From the main menu, select **Setup** by pressing the **I/O Enter** key. Using the **Up/Down Arrow** keys, select the settings in steps <u>2</u>–<u>6</u>.

```
VIEW        PRINT

▸ SETUP     RESET
```

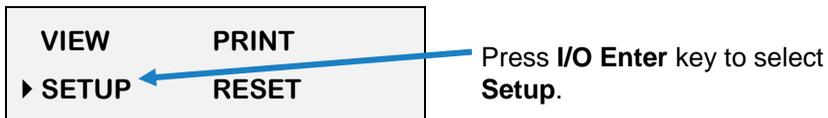Press **I/O Enter** key to select **Setup**.

Figure 11: Selecting temperature setting and setup

2. For the **Time and Date** settings, once selected, press **I/O Enter** key to move to the update field. (An underline will appear under the first field.)

   ▪ Press **Up/Down Arrows** to change the number/month. Press **I/O Enter** key to toggle through each field. Repeat as necessary until all values are selected.

3. For the **Temperature setting,** either **Fahrenheit or Celsius** will appear. Press the **Up/Down Arrow** to select and **I/O Enter** key to change.

```
▸ Fahrenheit
  English
```

Temperature setting – press **I/O Enter** key to switch between values.

Figure 12: Selecting temperature setting

4. For the **Language** setting, once selected, press **I/O Enter** key. To select a language, press **Up/Down Arrow** keys. Once selected, press **Run/Stop** key to return to setup parameters.

5. For the **Log Rate,** once selected, press **I/O Enter** key.

    ▪ Repeatedly press **I/O Enter** keys to select either the Log Rate Event or a Log Rate interval (for data logging; e.g. "5").

    ▪ *Optional*: changing **Next Event field**. Events are numbered starting at 1 and incrementing. The number may be increased to simulate skipping events. This may be useful if the events represent locations and the starting location is somewhere other than 1.
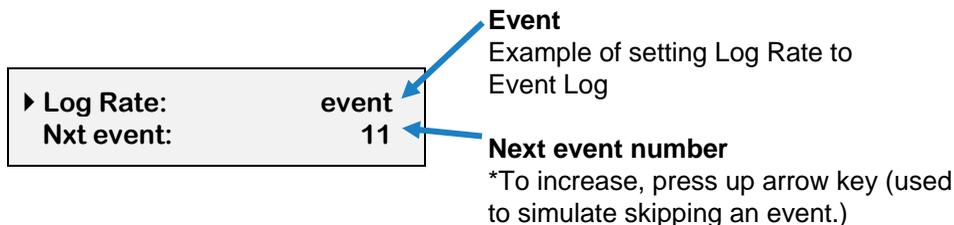
Event
Example of setting Log Rate to Event Log

```
▶ Log Rate:           event
  Nxt event:             11
```

Next event number
*To increase, press up arrow key (used to simulate skipping an event.)

Figure 13: Selecting log rate with event log

6. For the **Index** setting, once selected, press **I/O Enter** key. Press **Up/Down Arrow** keys to select: "---" (which is equivalent for no index), ACGIH, PHEL, or Flag.

7. Exit Setup by pressing the **Run/Stop** key.

Print

Allows printing to a parallel or serial printer or to a computer. The QUESTemp° 48N Heat Stress Monitor will recognize the cable plugged in and configure itself for serial or parallel. If no cable is plugged in, it will default to serial. Press **I/O Enter** key to begin printing. Press **Run/Stop** key to return to the menu.

NOTICE
To stop the printing, press **I/O Enter** key until you return to the main menu. When the printer has stopped printing, remove the cable from the printer to the instrument.

Reset

Resetting enables you to clear the logged data from memory. Press the **I/O Enter key** to enter the **Reset mode**. Clear the memory by holding down the **I/O Enter key** while the display counts down from three.

Run

For Data Logging setup, the run mode begins a session in memory and logs the data. For Event Logging, each run/stop is stored as an event and a numeric counter displays the number of saved events.

- Begin a session by pressing the **Run/Stop key** from the view mode (or measurement view). An asterisk in the lower right corner indicates the run mode.

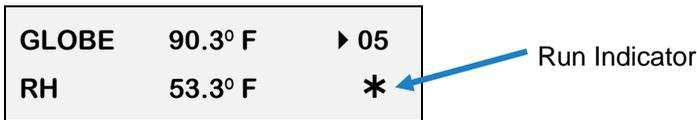 – To toggle through the views, press the **Up or Down Arrow**.

GLOBE	90.3° F	▶ 05
RH	53.3° F	✱

Run Indicator

Figure 14: Run mode indicator

- End the session by pressing the **Run/Stop key** again. (The session will stop recording when the asterisk is no longer displayed.)

NOTICE
If the logging memory is full or if there are no sensors plugged into the unit, attempting to enter the Run mode will result in an error message. If the memory capacity is exceeded, the asterisk in the lower-right corner of the display will turn into an "F" and the memory remaining screen will show "0.0".

Displayed Items

For the QUESTemp° 48N Heat Stress Monitor, the number in the upper-right corner indicates the saved session or the saved event log.

- "**1**" indicates the sensor bar placed on (or attached to) the top of the instrument. Sensors 2 and 3 are labeled on the side of the unit as "Sensor 2", and "Sensor 3".

- An "*****" asterisk in the lower right corner indicates that the unit is in the run mode and is logging data or saves an event.

The following measurements can be accessed on the display:

Screen 1: WET (Wet bulb)
DRY (Dry bulb)

WET	80.5° F	▶ 01
DRY	92.2° F	✱

Figure 15: Wet and Dry screen

Screen 2: GLOBE and RH

GLOBE	40.4°C	▶ 03
RH	52.5%	✱

Figure 16: Globe and RH screen

Screen 3: WBGT

WBGT	30.7°C	▸ 3
		✳

Figure 17: WBGT screen

Screen 4: Time (24 hour format)
Date (day, month, year)

TIME	11:04:13	▸ 04
DATE	14-MAY-18	✳

Figure 18: Time and Date screen

Screen 5: BAT (Battery voltage)
MEM (Logging memory
available in days)

BAT	09:04:13	▸ 05
DATE	10.4 dy	✳

Figure 19: Battery & memory screen

Screen 6: Index
(Navy PHEL stay times)

PHEL_5	3:10	▸ 05
PHEL_6	8:03	✳

Figure 20: Navy PHEL stay times

NOTICE
A series of dashes appear in the display if one of the following occur:
▪ The temperature is outside of its allowable range
▪ A temperature sensor has failed
▪ Stay times temperatures are outside of their defined range

Stay Time/Index

The screen(s) displaying stay time data appear different for each of the possible indices.

If **ACGIH** is selected, the recommended working minutes per hour are shown for each of the workload categories Light (L), Moderate (M), Heavy (H), and Very Heavy (VH).

L	M	H	VH	▸ 04
60	45	30	15	✳

Figure 21: Index for ACGIH

QUESTemp°Heat Stress Monitor Model 48N

If the **Navy PHELs** are selected, the recommended working hours are shown based on a maximum of eight hours. Three screens are used to display the PHELs two at time.

NOTICE
"8:01" following one of the PHELs indicates greater than eight hours.

PHEL_5   3:10   ▸ 05
PHEL_6   8:03   ✳

PHELs stay time is greater than 8 hours.

Figure 22: Navy PHELs screen

If **Flag** is selected, the Flag Conditions for Navy/Marines Corp. Ashore warning system screen will appear. There are five flag systems, no flag, yellow, green, red, and black, which provide heat exposure guidelines for acclimated individuals. (For more information, refer to the "Flag Conditions US Navy/Marine Corp. Ashore".)

HEAT CATEGORY   ▸ 05
YELLOW FLAG   ✳

Navy/Marine Corp's heat condition flag warning example

Figure 23: Flag Conditions Navy/Marine Corp. Ashore

Data Logging

Data from each sensor is recorded at the interval set by the logging rate. Every time **Run/Stop** is pressed, a session is either started or ended in memory. Each session contains a header with time, date, and summary information.

Table 3: Example of a Memory table

Memory Table: Gives the number of logging DAYS.

Log Rate	1 min	2 min	5 min	10 min	15 min	30 min	60 min
1 sensor	11.2	22.5	56.2	112.4	168.6	337.3	674.5
2 sensors	5.6	11.2	28.1	56.2	84.3	168.6	337.3
3 sensors	3.7	7.5	18.7	37.5	56.2	112.4	224.8

Electronic Sensor Check

A verification module, TSI® model 053-923, may be used to check the operation of the QUESTemp monitor's wet bulb, dry bulb, and globe. The purpose is to verify that the electronic components are within a specific range with known values and a known source. The temperature tolerances should be within ±0.5ºC.

Example of Verification module

<table>
<tr><td align="center">**NOTICE**</td></tr>
<tr><td>If the sensors are outside of the tolerances, this indicates the sensor alignment should be serviced off-site for calibration.</td></tr>
</table>

Performing an Electronic Sensor Check

1. Ensure the instrument is reading in Celsius prior to your electronic sensor check.

   - To change the temperature setting, select **Setup** from the main menu. Then, either Fahrenheit or Celsius will appear on the screen. When selected, press **I/O enter** key to switch between settings. For more information, refer to step 3.

2. Remove the top sensor bar, place to the side, and plug in the verification module into the center pins of the sensor housing.

3. Verify the measurement readings on the screen are within ±0.5°C tolerance to the readings printed on the verification module label. Example below:

   a. Wet Bulb (WB): 11.1°C   b. Dry Bulb (DB): 45.3°C

   c. Globe (G): 69.2°C

<table>
<tr><td align="center">**NOTICE**</td></tr>
<tr><td align="center">Relative humidity (RH) is not valid on this instrument.</td></tr>
</table>

4. Once completed, remove verification module and place sensor bar back on the instrument (tighten down the two bolts). Change the Celsius reading back to Fahrenheit (refer to step 1).

Sensor Alignment

For highly accurate measurement readings, you should align your QUESTemp⁰ 48N prior to data logging or event logging/recording. For the RH sensor, it is recommended to align with a High concentration level using the 75% sensor salt, NaCl (sodium chloride), or a Low concentration level using the 33% sensor salt, MgCl (magnesium chloride). (To order sensor alignment salts, refer to an online vendor, such as, colepalmer.com.)

RH Sensor Alignment

1. To open, navigate to the main menu and select **View** by pressing **I/O Enter** key (see **A**). A measurement screen will appear (see **B**).

A			B	
▶ **VIEW**	**PRINT**		**WET**	**50.7° F**
SETUP	**RESET**		**DRY**	**70.6° F**

Figure 24: Main menu with view selected (A) & measurement screen (B)

2. Press and hold **I/O Enter** key and then press **Down Arrow** key from the **View** menu. The **Alignment** screen will appear.

(RH Sensor) Alignment menu

"High" is selected when the arrow appears in front of the text.

NOTE: WBGT is not used in sensor alignment.
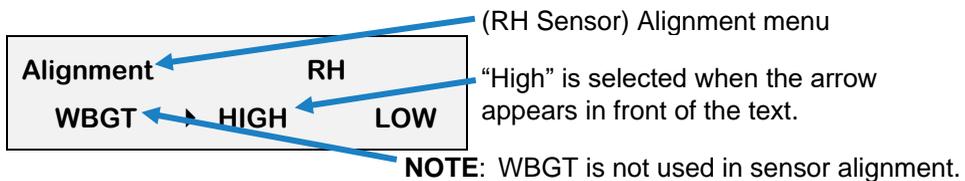
Figure 25: Alignment screen

3. Press **Up/Down Arrow** key to select either **High** or **Low**. Then press **I/O Enter** key.

4. **Remove** (or slide) the **Sunshield** (white globe) from the **RH sensor** and place it to the side (see Figure 26).

5. **Place a latex finger cot** (user-supplied) over the humidity sensor in order for the sensor to stabilize quicker about 15 minutes (or up to 60 minutes without).

> **NOTICE**
>
> Latex finger cots can be found at various hardware stores or online such as colepalmer.com.

Sunshield: Slide off RH sensor to remove.

Place unrolled finger cot, with a small hole cut in the top, so it is completely stretched over the humidity sensor.

Figure 26: Sunshield and placement of finger cot prior to RH alignment

6. **Place** the **Salt container**, with the salt alignment cap removed, over the **RH sensor** (middle sensor). Allow level to **stabilize** for at least **15 minutes** (refer to Figure 25.)

   ▪ About sensor alignment: If readings are within ±0.5%, a change in sensor alignment is not required. Skip to step 7 to return to main menu.

NOTICE
For a High alignment, use the 75% sensor alignment salt (NaCL) and for a Low alignment, use the 33% alignment salt (MgCl).

Alignment salt (remove rubber cap and place over RH sensor with the sunshield removed)

Once Alignment salt is placed, allow levels to stabilize (about 15 mins).

Low RH Alignment screen
Adjust % to 33% (using up/down arrow keys) and press **Enter** (after level has stabilized) to store sensor alignment level.
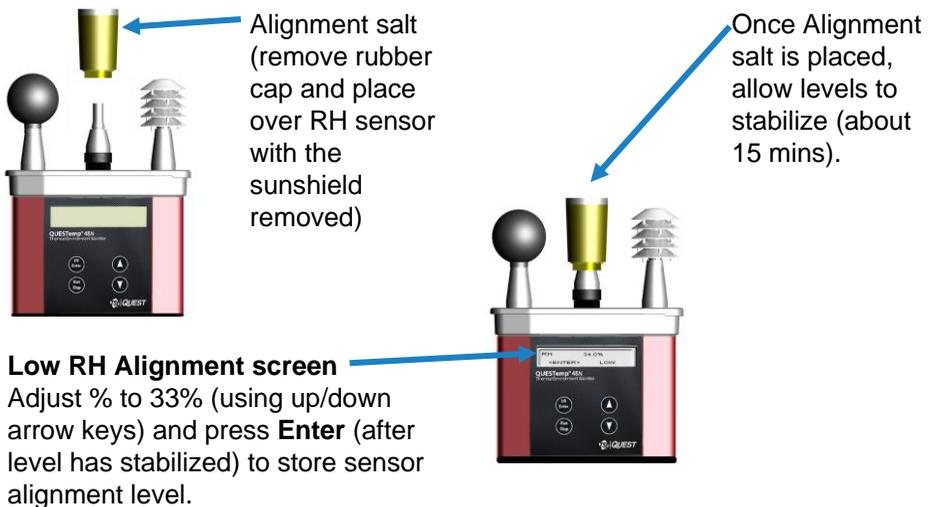
Figure 27: RH alignment with Low % example

7. In either the High/Low RH alignment screen, adjust the level to the percentage displayed on the salt container by using the **Up/Down Arrow** keys. Press **I/O Enter** key to save. (The instrument will state either "Successful" or "Failure" if it passed/did not pass. For "Failure" repeat the steps above.)

Press **Enter** to save the alignment.

Example of high RH percentage prior to sensor alignment. Press up/down arrows to adjust level after salt has stabilized.

RH	51.2%
<ENTER>	**HIGH**

Sensor alignment with High % RH level
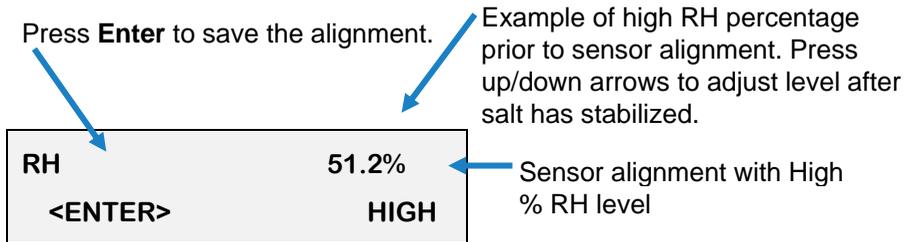
NOTE: WBGT is not used in sensor alignment

Figure 28: RH alignment with High% screen

8. To return to the main menu, press **Run/Stop** key.

9. Verify the RH sensor is ±0.5% of the specific percentage. If not, repeat the steps above.

10. Remove the alignment salt and finger cot. Replace the Sunshield over the RH sensor when completed with the sensor alignment.

Printing

Printing options include to a RS-232 port or to a parallel printer. Serial transmission requires TSI® cable #54-715. Parallel transmission requires TSI® cable #56-875. With the applicable cable plugged in, select **PRINT** from the menu and press the **I/O Enter key** to enter the **PRINT** mode. Begin printing by pressing the **I/O Enter key**. Press the key again to abort the printing.

Data/Communications

TSI® Detection Management Software DMS is recommended for downloading, storing, graphing, and printing reports (see below). Communications programs, such as Windows® HyperTerminal® may also be used to capture the printout into a file. The baud rate is fixed at 9600.

Heat Stress Report (Event Summary Data)

2/21/2013

Event Log 1: Summary Data Panel

Description	Meter	Value	Description	Meter	Value
Dry Bulb Max	SensorBar 1	25.15 ºC	Dry Bulb Max Time	SensorBar 1	9/9/2011 8:25:30 AM
Globe Max	SensorBar 1	25.15 ºC	Globe Max Time	SensorBar 1	9/9/2011 8:25:30 AM
Heat Index Max	SensorBar 1	24.37 ºC	Heat Index Max Time	SensorBar 1	9/9/2011 8:25:30 AM
Humidex Max	SensorBar 1	--	Humidity Max	SensorBar 1	50.7 %
Humidity Max Time	SensorBar 1	9/9/2011 8:25:30 AM			

Event Log 2: Summary Data Panel

Description	Meter	Value	Description	Meter	Value
Dry Bulb Max	SensorBar 1	26.65 ºC	Dry Bulb Max Time	SensorBar 1	1/11/2012 11:27:14 AM
Globe Max	SensorBar 1	27.84 ºC	Globe Max Time	SensorBar 1	1/11/2012 11:24:40 AM
Heat Index Max	SensorBar 1	26.74 ºC	Heat Index Max Time	SensorBar 1	1/11/2012 11:26:29 AM
Humidex Max	SensorBar 1	--	Humidity Max Time	SensorBar 1	1/11/2012 11:26:30 AM

Event Log 3: Summary Data Panel

Description	Meter	Value	Description	Meter	Value
Dry Bulb Max	SensorBar 1	25.37 ºC	Dry Bulb Max Time	SensorBar 1	1/13/2012 9:17:43 AM
Globe Max	SensorBar 1	25.86 ºC	Globe Max Time	SensorBar 1	1/13/2012 9:17:43 AM
Heat Index Max	SensorBar 1	--	Heat Index Max Time	SensorBar 1	--

Figure 29: Sample DMS event data report

Parallel

Data can be sent directly to parallel printers that accept direct ASCII test input without special drivers. Make sure the **printer** is **powered on** and is **online**, ready to accept data, prior to printing.

TSI QUEST TECHNOLOGIES **Page 1** **HEAT STRESS REPORT** File Name _____ **QUESTemp°48N Rev 1.00** **Serial # TK09090909**	**EVENT: 1** **Page 2** **Sensor: 1**

```
TSI QUEST TECHNOLOGIES               Page 1
         HEAT STRESS REPORT

File Name _____  QUESTemp°48N  Rev 1.00
                               Serial # TK09090909
Employee _____

Facility _____  Session (3)
                                 Start: 21-NOV-09  11:07:32
Department _____  Stop: 21-NOV-09  11:10:15

Job _____  Printed: 21-NOV-09  11:16:00

Comments/NOTEs_____
_____

Logging Interval:  1 minutes
Degrees Fahrenheit

MAXIMUM LEVELS, Sensor 1
  WBGT          68.3   21-NOV-09  11:10:08
  DRY BULB      82.7   21-NOV-09  11:09:56
  GLOBE         91.4   21-NOV-09  11:10:12
  REL HUMIDITY  14%    21-FEB-08  11:07:32
  FLOW (m/s)    0.6    21-FEB-08  11:09:08

MAXIMUM LEVELS, Sensor 2
  WBGT          80.5   21-FEB-08  11:10:11
  DRY BULB      99.2   21-FEB-08  11:09:07
  GLOBE         106.1  21-FEB-08  11:10:06
  HEAT INDEX    0      00-XXX-00  00:00:00
  REL HUMIDITY  15%    21-FEB-08  11:07:32

MAXIMUM LEVELS, Sensor 3
  WBGT          68.6   21-FEB-08  11:09:56
  DRY BULB      88.6   21-FEB-08  11:10:08
  GLOBE         93.0   21-FEB-08  11:10:03
  HEAT INDEX    0      00-XXX-00  00:00:00
  REL HUMIDITY  11%    21-FEB-08  11:07:32

MAXIMUM LEVELS,  Sensor(WEIGHTED AVERAGE)
  WBGT          71.4   21-FEB-08  11:10:14
```

```
EVENT: 1                              Page 2
Sensor: 1
Degrees Fahrenheit
Stay Times: ACGIH, Acclimated, WBGT, clo correction = 1.0 °C

TIME  WBGT   DRY  GLOBE  RH  HI FLOW  L  M  H  VH
11:08 67.9   82.4  90.7  13  0  0.5   60 60 60 60
11:09 68.1   82.6  91.3  12  0  0.5   60 60 60 60

EVENT: 2                              Page 3
Sensor: 1
Degrees Fahrenheit
Stay Times: ACGIH, Acclimated, WBGT, clo correction = 1.0 °C

TIME  WBGT   DRY  GLOBE  RH  HI  L  M  H  VH
11:08 79.3   98.9 104.5  15  0  60 45 30 15
11:09 80.2   99.2 105.6  15  0  60 45 30 15

EVENT: 3                              Page 4
Sensor: 1
Degrees Fahrenheit
Stay Times: ACGIH, Acclimated, WBGTi, clo correction = 1.0 °C

TIME  WBGT   DRY  GLOBE  RH  HI  L  M  H  VH
11:08 68.1   88.0  92.7  11  0  60 60 60 60
11:09 68.4   88.3  92.9  11  0  60 60 60 60

EVENT: 4                              Page 5
Sensor: WBGT(W-AVG) = .50*WBGT(1) + .25*WBGT(2) +
.25*WBGT(3)
Degrees Fahrenheit

Stay Times: ACGIH, Acclimated, WBGT, clo correction = 1.0 C
WBGT WBGTo


TIME     W-AVG    W-AVG    L   M   H   VH
-----    -----    -----   --- --- --- ---
11:08    71.5     70.8     60  60  60  60
11:09    71.8     71.1     60  60  60  45
```

Figure 30: Sample printouts

Powering

The QUESTemp° 48N Heat Stress Monitor uses a 9-volt alkaline battery. A door on the back of the instrument allows the user access to the 9-volt battery.

The 2-position switch located in the battery compartment is set by the user to the 9-volt battery.

Figure 31: 9-volt battery
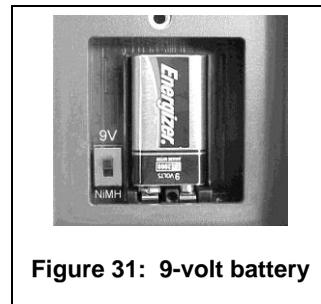
9-Volt Alkaline Battery Replacement

⚠️	**W A R N I N G**
	Replace batteries only in a non-hazardous environment.

The 9-volt battery should be replaced and recharged when the voltage drops below 6.4 volts. The battery voltage is displayed when the instrument is turned on. While turned on, the battery voltage can be displayed at any time by pressing the up or down arrow keys to move through the display until the battery voltage screen appears. If while operating the battery voltage drops below 6.4 volts, the display will automatically switch to the display showing the battery voltage along with a low battery message. After a low battery occurs, the unit will continue to operate for approximately 8 hours. When the battery voltage falls to 6.2 volts or below, the unit will automatically turn off.

Replace only with an approved 9-volt alkaline battery.

Approved 9-Volt Batteries

Eveready®:.......... Energizer® 522, EN22, 6LR61
Duracell®: MN1604
Panasonic®: 6LR61, 6AM6X
Rayovac®: A1604
UltraLife®:........... U9V

®Eveready, Energizer and Rayovac are registered trademarks of Energizer Brands, LLC. Duracell is a registered trademark of Duracell U.S. Operations, Inc. Panasonic is a registered trademark of Panasonic Holdings Corporation. UltraLife is a registered trademark of Ultralife Corporation.

Contact/Service Information

This section gives directions for contacting TSI® Incorporated for technical information and directions for returning the QUESTemp° 48N Heat Stress Monitor for service.

Technical Support Contacts

If you have any difficulty setting or operating the instrument, or if you have technical or application questions about this system, contact TSI® Incorporated's Technical Support.

North America and Asia Pacific	Europe, Middle East, and Africa
Telephone: 1-800-680-1220 (USA); +1 651-490-2860 (outside USA) **Fax:** +1 651-490-3824 **E-mail:** technical.services@tsi.com	**Telephone**: +49 241-52303-0 **E-mail:** tsigmbh@tsi.com

Service Contact Information

If your instrument does not operate properly, or if you are returning the instrument for service, visit our website at tsi.com/service for a Service Request form, or contact Customer Service.

North America and Asia Pacific	Europe, Middle East, and Africa
TSI Incorporated 1060 Corporate Center Drive Oconomowoc, WI 53006-4828 **Telephone:** 1-800-680-1220 (USA); +1 651-490-2860 (outside USA) **E-mail:** technical.services@tsi.com	**TSI Instruments Ltd.** Stirling Road Cressex Business Park High Wycombe, Bucks HP12 3ST United Kingdom **Telephone:** +44 (0) 149 4 459200 **E-mail:** tsiuk@tsi.com

Returning for Service

Visit our website at tsi.com/service and complete the on-line "Service Request" form or call TSI® at 1-800-680-1220 (USA) or (651) 490-2860, or 001 651 490-2860 (International) for specific return instructions.

Customer Service will need the following information:

- The instrument model number
- The instrument serial number
- A purchase order number (unless under warranty)
- A billing address
- A shipping address

Use the original packing material to return the instrument to TSI® Incorporated. If you no longer have the original packing material, seal off any ports to prevent debris from entering the instrument and ensure that the display and the connectors on the instrument front and back panels are protected. This instrument is very fragile and must be packed in a manner appropriate for a precision instrument.

Calibration

The QUESTemp^0 48N Heat Stress Monitor and TSI® field calibrator devices should be examined regularly by the factory. An annual calibration is recommended. (See Service Information above.)

Appendix A: Specifications

Measurements
- Globe Temperature, Dry Bulb Temperature, Wet Bulb Temperature, % Relative Humidity, and WBGT Index
- Temperatures given in Celsius or Fahrenheit
- Index (displayed stay time with selected index): ACGIH TLV, U.S. Navy PHEL Charts, Flag Conditions for U.S. Navy/Marine Corp. Ashore

Data Logging mode and Event logging mode
- Data logging mode records and prints all measurements at user selected interval of 1, 2, 5, 10, 15, 30, or 60 minutes.
- Event logging mode (1 second record) 128K bytes of data memory.

Languages
- English, French, Spanish, Italian, German

Sensors
- Dry Bulb Sensor- 1000 Ohm Platinum RTD
  - **Accuracy and Ranges**: ±0.5 from 0°C to 120°C (±0.9°F from 32°F to 248°F)
- Waterless Wet Bulb (Humidity) Sensor
  - **Accuracy and Ranges: Expanded** measurement uncertainty of 1.1°C (k=2) between 0°C and 80°C (32°F and 176°F)
- Globe Sensor- 1000 Ohm Platinum RTD
  - **Accuracy and Ranges:** ±0.5 from 0°C to 120°C (±0.9°F from 32°F to 248°F)
- Relative Humidity Sensor - Integrated circuit with capacitive polymer sensor
  - **Accuracy and Ranges:** ±5% from 20 to 95% (non-condensing)

Operating Temperature Range
- Sensor Assembly: -5°C to +100°C
- Electronics: -5°C to 60°C

Housing
- Designed water resistant to a light rain or mist. If rain is frequent, best practice would be to remote the sensor bar and keep the instrument sheltered.

Size

- Height 9.2 in. (23.5 cm); Width 7.2 in. (18.3 mm); Depth 3.0 in. (7.5 mm)
- Dimensions include mounted sensor assembly

Weight

- 2.6 lbs. (1.2 kg) with mounted sensor assembly

Remote Sensor Bar

- Using a cable, the top sensor bar can be setup for remote measurements, up to 200 feet (61 m).

Power

- 9V alkaline

Battery Life

- 9V alkaline: 80 hours

QUESTemp° 48N Block Model
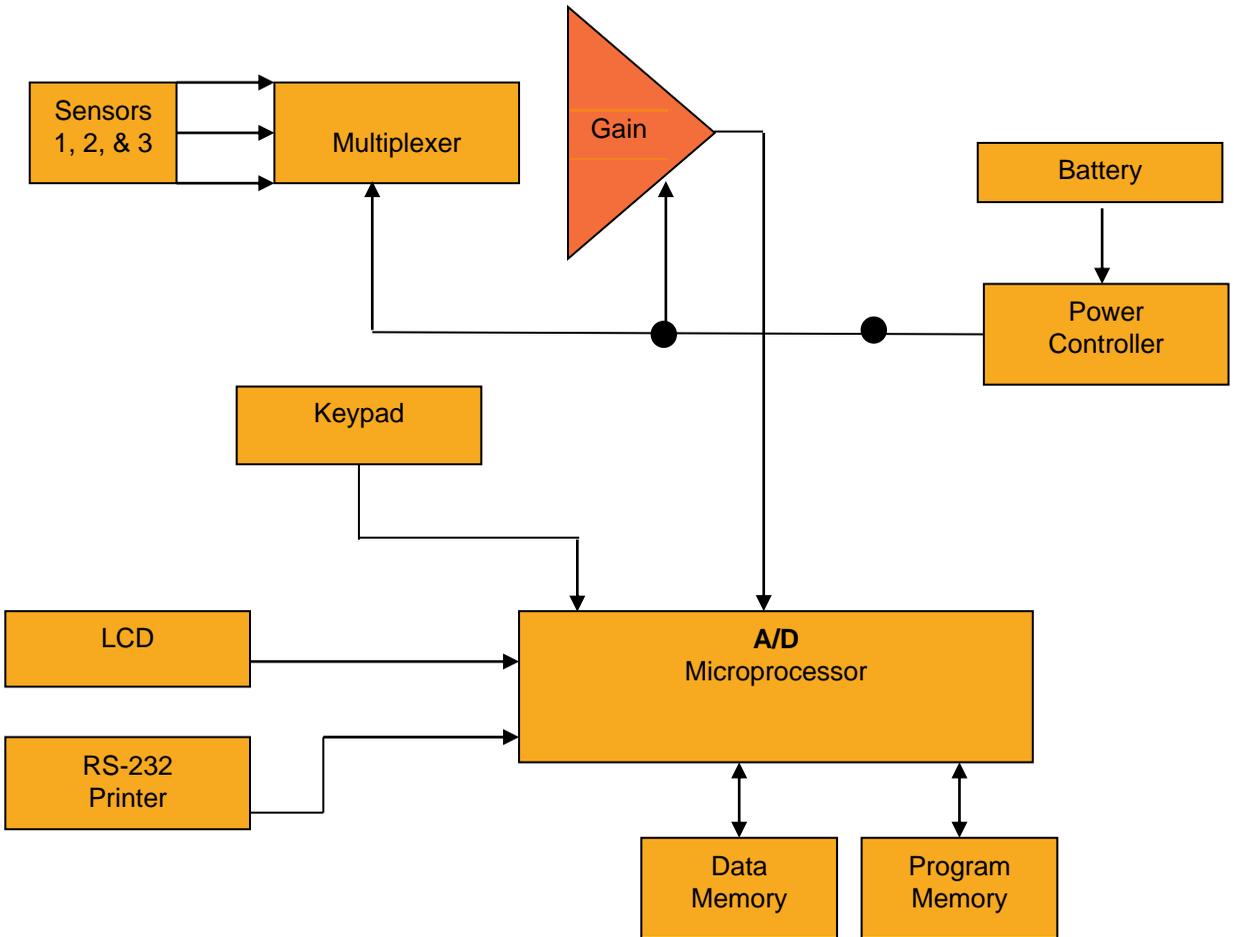
Appendix B: Heat Exposure Tables

ACGIH

Screening Criteria for Heat Stress Exposure. WBGT values in °C.

NOTICE
According to the ACGIH's guidelines, the temperature values represent a work and rest process which is explained in the standards. Refer to the ACGIH TLVs and BEIs for specific details.

Work and recovery (TLV)	Light	Moderate	Heavy	Very Heavy
75% to 100%	31.0	28.0	26.0*	23.5*
50% to 75%	31.0	29.0	27.5	25.5*
25% to 50%	32.0	30.0	29.0	28.0
0% to 25%	32.5	31.5	30.5	30.0

Work and recovery (Action Limit)	Light	Moderate	Heavy	Very Heavy
75% to 100%	28.0	25.0	22.5*	20.0*
50% to 75%	28.5	26.0	24.0	22.5*
25% to 50%	29.5	27.0	25.5	24.5
0% to 25%	30.0	29.0	28.0	27.0

*Values not specified by ACGIH have been estimated for continuity.

ACGIH Clothing Corrections

The following clothing corrections are in degrees Celsius. When a clothing correction is entered into the setup portion of the QUESTemp° 48N Heat Stress Monitor, the value is added to the WBGT only for looking up the stay times. The WBGT value displayed by the unit does not reflect corrections.

Clothing type	Clothing correction (Addition to WBGT (ºC)
Work clothes (long sleeve shirt and pants)	0º
Cloth (woven material) coveralls	0º
Double-layer woven clothing	3º
SMS polypropylene coveralls	0.5º
Polyolefin coveralls	1º
Limited-use vapor-barrier coveralls	11º

Cited from American Conference of Governmental Industrial Hygienists, *Threshold Limit Values and Biological Exposure Indices for 2008.* Reprinted with permission.

United States Navy

Physiological Heat Exposure Limits (PHEL) Time Table
(Without the presence of fuel combustion gases/fuel vapors)

The recommended working hours are shown based on a maximum of eight hours. Naval personnel will follow a category, I - VI, based upon their function.

PHEL Curves (Total Exposure Time in Hours: Minutes)

WBGT(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	8:00	6:35	4:30
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

WBGT(F)	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

QUESTemp°Heat Stress Monitor Model 48N

WBGT(F)	I	II	III	IV	V	VI
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

Flag Conditions for U.S. Navy/Marine Corp. Ashore

The following chart details the heat stress monitoring Flag Conditions for U.S. Navy/Marine Corp. Ashore in Degrees Fahrenheit and Celsius.

	No Flag	Green	Yellow	Red	Black
Flag Degrees F	<80.0	80.0–84.9	85.0–87.9	88.0–89.9	>90
Flag Degrees C	<26.7	26.7–29.4	29.4–31.1	31.1–32.2	>32.2

*Rest means minimal physical activity (sitting or standing) and should be accomplished in the shade if possible.

Appendix C: Accessories (sold separately)

Replacement Relative humidity sensor...057-317
Sensor array with 2-inch Globe and removable RH sensor 057-909
Sensor alignment salt at 75% [NaCl (sodium chloride)].....................100-452
Sensor alignment salt at 33% [MgCl (magnesium chloride)]............100-451
Verification module (one included)...053-923
Neck Strap (one included) 0057-333
QT-3X series replacement battery cover QT3X-BC
QT-3X series replacement dry bulb shield assembly–consists of
   (5) shields and (1) cap/cover. QT3X-DBS
Remote sensor cable - 6 Foot 053-924
Remote sensor cable - 25 Foot 053-925
Remote sensor cable - 100 Foot...053-926
Remote sensor cable - 200 Foot 053-927
Serial/Computer interface cable (RS-232 to PC) 9 Pin.....................054-715
RS-232 to USB converter (one included) 053-810
Parallel printer interface cable 056-875
Storage case (one included)..053-922
QT48N User Manual (one included) 057-330

Appendix D: Software

The QUESTemp° 48N Heat Stress Monitor has the flexibility to be set up and controlled through computer software. The programmable start and stop time feature is only accessible through the computer. The instrument also has the capability of sending *live data* while measuring. These features are best utilized using TSI® Detection Management Software DMS.

DMS Quick Overview

The focus of this section is to briefly introduce the following QSP-II topics: Downloading your data, setting up parameters, and viewing your data in charts, graphs, and reports. (For further details on DMS, refer to the online **Help** and select **Contents**.)

Communicating and Downloading in DMS

In order to download, review the data, and setup parameters in DMS software, this will require connecting the QT°48N to a computer. The steps below explain connecting and communicating to DMS.

1. Using a TSI® cable, part number 054-715, plug the cable into the computer and plug the opposite end into the side jack of the QT° 48 data port.

   QT⁰ 48 data port
   Connected and powered on

   Connected to serial port

   Figure 32: Communicating with the QT⁰ 48N and DMS

2. From the start page of DMS, select [Download] button and the instrument communication panel will appear.

3. Select **Heat Stress** and then select **the Model Type** by clicking on **QT⁰48N** (see Figure 34).

4. Click on the ⬛ Download button in the Instrument Communications page while **Data Finder** checkbox is checked (see ❶ below).

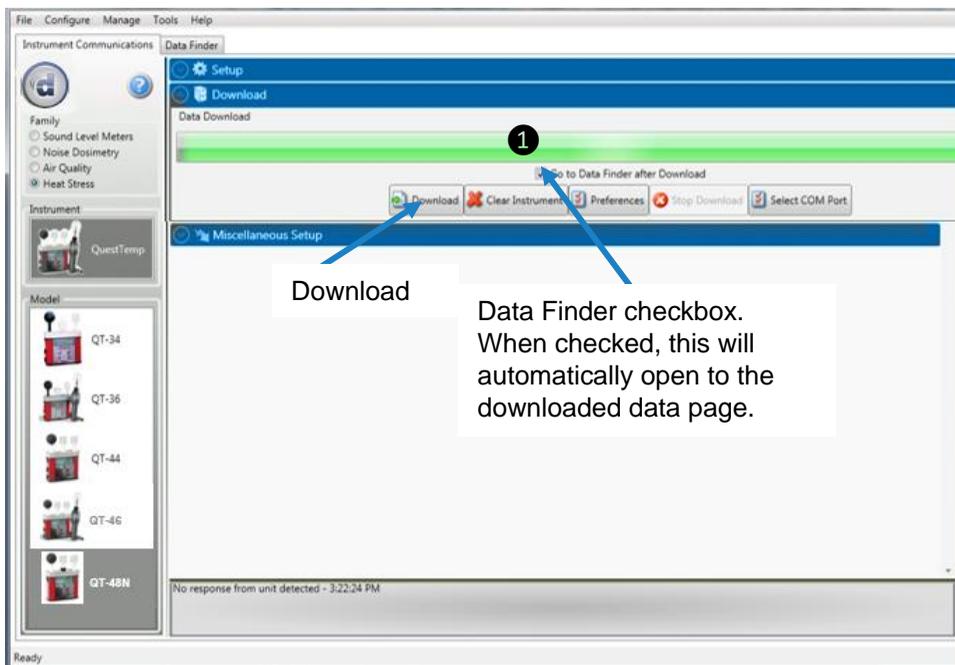| **N O T I C E** |
|---|
| The **Data Finder** page will appear. See next section. |

Figure 33: Communicating with the QT⁰ 48N and DMS

Data Finder and Quick Reports

In the Data finder page, the data you downloaded is stored by instrument family and then organized by models.

NOTICE
When working in this page, click on the **Most Recent** button if you are looking for your recently downloaded data.

1. In the **Data Finder** page, click on the downloaded data and select either **Analyze** or **Print Report**.

Double-click to select/view QT°48N data in charts and graphs
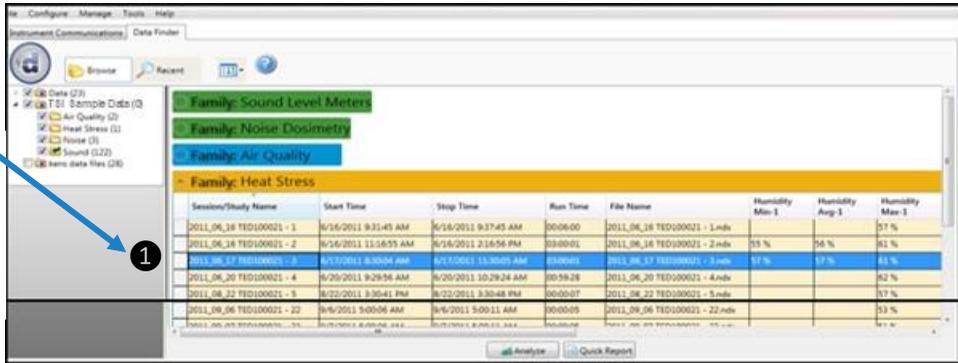
Figure 34: Data Finder Page

2. **Quick Report:** Select the [📄 Quick Report] button to generate a report with basic information and a summary table of your downloaded data.

Figure 35: Quick Report

3. **Analyze:** Allows you to add charts/graphs and customize how they appear in a report.

TIP
Add the panels by using the add a panel and dragging them into the appropriate location.

4. Press [Report View] button and it will generate a report based on the where the charts/graphs (panels) are placed.
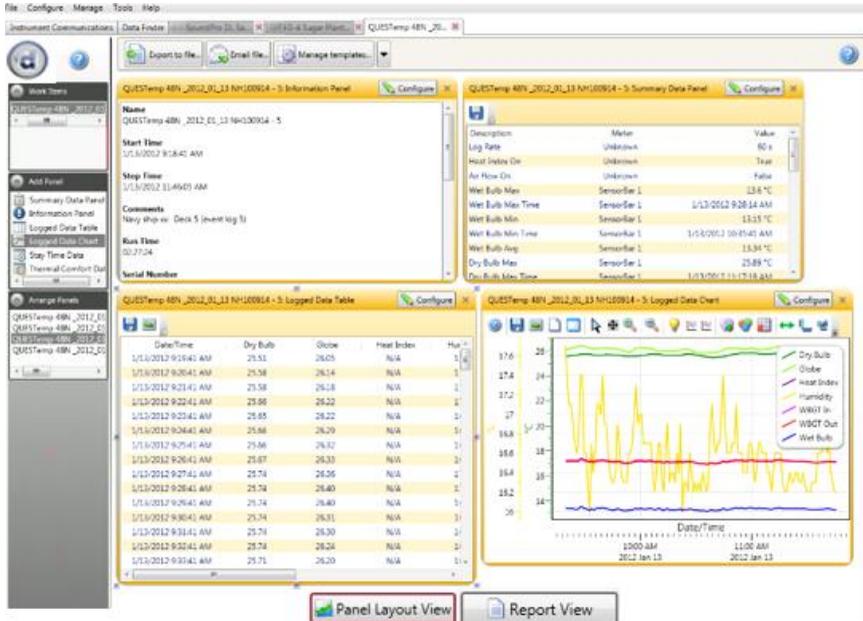

Figure 36: Analyze button opens to the panel layout page

TSI | **QUEST**™