# Kestrel®
## Heat Stress Trackers
by NK

**KESTREL 4400 & 4600**
**INSTRUCTIONAL MANUAL**


AVAILABLE WITH Bluetooth® WIRELESS DATA TRANSFER

NKhome.com | 800.784.4221

## ⚠ CAUTION

**Your Kestrel brand Weather & Environmental Meter is designed to provide accurate measurement of current conditions only. Depending on your location and environment, conditions may change rapidly.**

*Rapid temperature and humidity changes (ie moving your meter from indoors to outdoors) may cause inaccurate readings of temperature and humidity as well as all readings that rely on either of these values. Before relying on a Kestrel Meter's readings, use care to either a) force air flow over the sensors by waving or slinging your meter through the air; or b) wait until your unit's readings have stabilized, indicating it has equilibrated to its new environment.*

**To maximize the accuracy and reliability of your readings:**

- ***Ensure that your Kestrel Meter is in good repair and within factory calibration.***
- ***Take readings frequently and carefully according to the guidelines above.***
- ***Allow your meter's readings to stabilize after significant changes in temperature or humidity (ie changing location from indoors to outdoors).***
- ***Allow a margin of safety for changing conditions and reading errors (2-3% of reading is recommended).***

***Use extra care and good judgment when referring to your Kestrel Meter to make any decisions regarding safety, health or property protection.***

## ⚠ WARNING

**To reduce the risk of injury or death to persons, read and follow these guidelines!**

*The Heat Stress, Wind Chill and Thermal Work Limit indices are published indices developed by the National Weather Service to provide decision guidance based on average human physiological response. Certain individuals, animals, equipment or property may be more susceptible to harm relating to environmental conditions, requiring additional precautions. For example, very young or elderly individuals, individuals with asthma or sickling trait, and individuals who have not become acclimated to hot conditions are likely to be more prone to heat illness, heat exhaustion, heat stroke or death.*

- ***Know yourself and the individuals and items you are responsible for.***
- ***Where appropriate, seek the guidance of a medical professional.***
- ***Know what to do in the event of heat illness.***
- ***Be prepared with supplies to treat heat illness.***
- ***Have and practice a heat illness action plan.***

**Your Kestrel Heat Stress Tracker is an environmental meter, not a medical device. It is only one source of information and must be employed with care and good judgment.**



## OVERVIEW




NK, manufacturer of Kestrel Weather & Environmental Meters, is available to answer questions and provide support.
Contact NK by phone: 610.447.1555; fax: 610.447.1577; email: info@NKhome.com; or NKhome.com

## FEATURES & OPTIONS

| Measurement | Icon | Units of Measure | 4400 | 4600 |
|---|---|---|---|---|
| Wind Speed \| Air Speed | | mph \| fpm \| Bft \| m/s \| km/h \| kt | • | • |
| Wind Direction | | Cardinal Points, Degrees | | |
| Crosswind Calculation | | mph \| fpm \| Bft \| m/s \| km/h \| kt | | |
| Headwind \| Tailwind | | mph \| fpm \| Bft \| m/s \| km/h \| kt | | |
| Temperature* | | °F \| °C | • | • |
| Wind Chill | | °F \| °C | • | • |
| Relative Humidity | | Gpp \| G/kg | • | • |
| Heat Stress Index | | °F \| °C | • | • |
| Globe Temp | | °F \| °C | • | • |
| Naturally Aspirated Wet Bulb Temp | | °F \| °C | • | • |
| Wet Bulb Globe Temp (WBGT) | | °F \| °C | • | • |
| Thermal Work Limit (TWL) | | w/m² | • | • |
| Dewpoint Temp | | °F \| °C | • | • |
| Wet Bulb Temp | | °F \| °C | • | • |
| Humidity Ratio | | Gpp \| G/kg | • | • |
| Relative Air Density | | lb/ft³ \| kg/m³ | • | • |
| Barometric Pressure | | inHg \| hPA \| psi \| mb | • | • |
| Absolute Pressure | | inHg \| hPA \| psi \| mb | • | • |
| Altitude | | m \| ft | • | • |
| Density Altitude | | m \| ft | • | • |
| Pressure Trend | | | • | • |
| Backlit Display | | | • | • |
| NV Backlight | | | o | o |
| *Bluetooth*® Data Transfer | | | o | o |
| Data Storage Points | | | **2300** | **1889** |

** All Kestrel Meters with temperature measurement allow you to measure air, water, and snow temperature.*

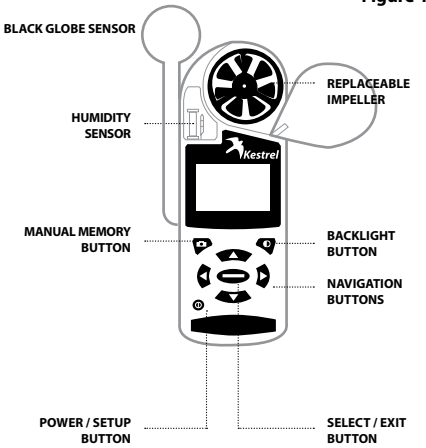
o = *Optional Feature*



## GETTING TO KNOW YOUR KESTREL

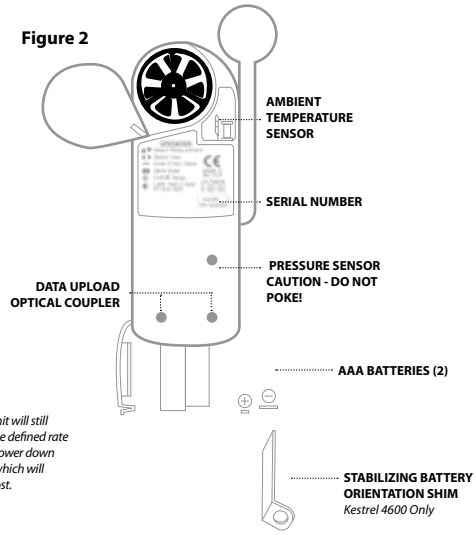
**FRONT**

**Figure 1**




**BACK**

**Figure 2**




*Even when the Kestrel display is off, the unit will still automatically collect and store data at the defined rate (see "Memory Options" ). To completely power down the unit, you must remove the batteries, which will cause time, date and user settings to be lost.*

## Battery Installation

- Insert batteries into bottom of Kestrel unit as shown on battery door.
- Snap door closed.

**KESTREL 4600:**

AAA batteries have a magnetic signature strong enough to affect the Kestrel compass readings. Please follow this extra step to ensure the batteries stay in proper orientation.

Before closing the door, push the plastic shim (provided with unit) between batteries and place clear ring on end over positive battery "bump."

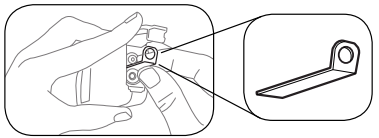


**Figure 1**

*When replacing batteries in the Kestrel 4600, always keep the shim and re-insert with new batteries as described.*

## Turning ON and OFF

- Press ⓘ to turn on the meter.
- Hold ⓘ for 3 seconds to turn off the meter.

*You can also select "Off" on the Main Setup Menu options.*

## Main Setup Menu

- When unit is on, press ⓘ to access the Main Setup Menu which is used to customize preferences.
- Press ▲ and ▼ to scroll through the options.
- Press ⬭ to select the highlighted option.

## Date and Time Setup

- After battery installation, the meter will automatically enter the Date and Time Setting mode.
- Press ▲ and ▼ to scroll to each option.
- Press ◀ and ▶ to adjust each option.
- Press the ⓘ button to exit to the Main Setup Menu.

## System

Contrast, auto shutdown, and calibrations can be reconfigured as needed in the System screen.

- Use ▲ or ▼ to highlight one of the following options:

**Contrast**

- Press ◀ or ▶ to increase or decrease the display contrast from 0 (lightest) to 20 (darkest).

**Auto Shutdown**

- Press ◀ or ▶ to set the time at which the display will automatically shut off after non-use (choose 15 min, 60 min, or Off to de-activate auto shutdown).

*Battery life will be shortened if the Auto Shutdown is turned to "Off."*

**Baro Cal**

*Recalibration of this sensor is not recommended without speaking to an NK technician. See "Barometric Pressure & Altitude Setup" section on page 10 for calibration instructions.*

**Humidity Cal**

*Recalibration of this sensor is not recommended without speaking to an NK technician. Full humidity calibration instructions are provided with the Kestrel RH Calibration Kits. The unit may also be returned to NK for calibration.*

*Visit www.nkhome.com for more information.*

**Date & Time**

- Press ⓘ to enter the Main Setup Menu.
- Use ▲ or ▼ to highlight Date & Time.
- Press ⬭ to enter the Date & Time Screen.
- Press ◀ or ▶ to change each value.

**Language**

Display text can be set to 1 of 5 languages: English, French, German, Italian, and Spanish.

- Press ▲ or ▼ to scroll the desired language.
- Press ⬭ to select the highlighted language.

**Restore**

This menu contains options for global settings of all units to metric or imperial, and returning the reference values for the Alt and Baro screens to default (0 ft, 29.92 inHg).

To change units:

- Press ▲ or ▼ to scroll to the desired setting and press ◀ or ▶.

To return the reference values for the Baro and Alt screens to default:

- Scroll to Defaults and press ◀ or ▶.

## Memory Options

- Press ▲ or ▼ to scroll to one of these options:

| | | |
|---|---|---|
| Clear Log | Go | Press ◀ or ▶ to clear stored data (will also clear Min/Max/Avg log). |
| Reset MMA | Go | Press ◀ or ▶ to clear Min/Max/Avg data (Chart data will remain intact). |
| Auto Store | On | Press ◀ or ▶ to turn "On" (data will automatically store at Store Rate) or "Off" (data will only store when manually captured with the button). |
| Store Rate* | 1hr | Press ◀ or ▶ to increase or decrease frequency at which data is stored (from 2 sec - 12 hr). |
| Overwrite | On | Press ◀ or ▶ to turn "On" (will discard oldest data point to capture new data when log is full) or "Off" (will not capture new data when log is full). |
| Man Store | On | Press ◀ or ▶ to turn "On" or "Off" (Off will disable 📷 button). |

** When unit is off, data will continue to be stored unless the 2 sec or 5 sec Store Rates have been selected.*

**Data Storage**

To manually store data, press the 📷 button. The screen will confirm data storage status.

- **Data Stored:** verifies that data was captured and will appear on chart.
- **Full:** indicates overwrite is off and data log is full.
- **Off:** indicates that the Manual Store button has been disabled.

*See Main Setup Menu for more information on memory.*

## Measurements

Use this setup to "hide" unwanted Measurement screens from the normal Measurement navigation.

- Use ▲ or ▼ to scroll to the desired Measurement screen.
- Press ◄ or ► to turn screen "On" and "Off".

*The Kestrel Meter will continue to log data for hidden measurements. To view logged data of the hidden measurement, go to Measurement setup, select the Measurement screen you want to view, and turn it back "On."*

When the Kestrel is in Chart mode, the upper and lower limits of the graph scale may need to be adjusted to fully view all data points. You can customize these value limits using the Graph Scale setup.

- Press ▲ or ▼ to scroll to the Measurement you want to adjust, then press ⬭.
- In the new screen, use ▲ or ▼ to highlight "Set High" or "Set Low".
- Press ◄ or ► to adjust the value limit of your chosen option.

## Units

This setup option lets you select units of measure to best suit your application.

- Use ▲ or ▼ to scroll to each measurement.
- Press ◄ or ► to change the unit of measurement.

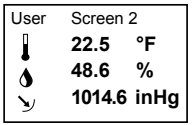
## User Screens

The Kestrel allows you to set up to 3 customized User Screens that will display 3 **current** Measurement values on the same screen. These screens are helpful for quick reference if you need to monitor multiple measurements at once. The User Screen option allows you to customize your user screens.

- Press ▲ or ▼ to highlight . User Screen 1, 2 or 3, then press ⬭.
- Use ◄ or ► to set your preferred measurement option.
- Press ▲ or ▼ to highlight the remaining lines, and use ◄ or ► to set those Measurement options.

Repeat these steps to set up the other User Screens.
When accessed through the Measurement navigation, each User Screen will display current data for the chosen measurements as programmed.

**Figure 1**




*Sample User Screen*

## SCREEN NAVIGATION

### Measurement Screens

- Press ▲ or ▼ to scroll through the Measurement screens.

### Measurement Modes

- From your chosen Measurement screen, use ◄ or ► to scroll through the Mode options:

*Current: Displays instantaneous reading.*

*Min/Max/Avg: Displays the Minimum, Maximum, and Average readings from stored data (Displays --.- if no data has been stored).*

*Chart: Displays graph of stored data points for each measurement.*

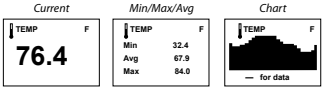



**Figure 1**

**To View Chart Data:**

- Press ⬭ while viewing a chart. A cursor will appear on the most recent data point.
- Press ◄ or ► to scroll through saved data:

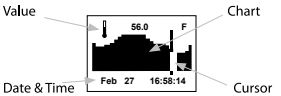



**Figure 2**

The data value will be displayed at the top of the screen. The date and time when each data point was stored will be displayed at the bottom of the screen.

- Press ▲ or ▼ to review the chart data for other measurements.

### MAX/AVG FUNCTIONS - Wind Speed & Wind Chill

These values are measured independently from stored and charted data to allow the user to start and stop the averaging period in the manner most appropriate for their application. Averaging on all wind-related values will be started and stopped together.

**To measure these values:**

- Press ▲ or ▼ to scroll to a wind measurement screen, then use ◄ or ► to select Min/Max/Avg screen.
- Press ⬭ to begin collecting data.
- Press ⬭ again to stop data collection and display the Maximum and Average values.

*This routine will work simultaneously for both measurements, regardless of which one is displayed when run. No other Min/Max/Avg or stored data will be affected.*

- To clear data, press ⬭ when the screen says "— clear".

*Other measurements will display min / max / avg data based on the data stored in the log (using either auto-stored or manually captured data). This data can be cleared by using "Reset MMA" under memory options.*

### Backlight

- Press 🔦 to activate backlight for one minute.
- Press 🔦 again to deactivate the light manually.

## MEASURING HEAT STRESS

The Kestrel Heat Stress Trackers will only yield accurate measurements using the following guidelines. It is important that the meter be fully acclimated to the measurement environment for accurate readings.

**Proper Placement**
The Kestrel Heat Stress Trackers should always be used at least 3 feet from the ground. If the unit is laid on the ground, it will compromise the measurements of user's conditions. To ensure proper placement, use the Kestrel Vane Mount (included) and Compact Collapsible Tripod.

**Optimal Acclimating Time**
If taken from a cool environment, where the Kestrel Heat Stress Tracker was stored, to an outside heat stress climate, the unit will need to adjust accordingly. Give the unit a minimum of 7 minutes to adjust to the outside climate if taken from storage (examples: air conditioned building, car glove box, truck gearbox, etc). 10 minutes of acclimation time is recommended. If worn on the person without the Black Globe exposed, the meter will need at least 2 minutes to display accurate measurements (examples: jeans pocket, shirt pocket, etc).

**Repeat Measurements**
When transporting the unit with the intention of taking repeat measurements, such as on a hike or march, try to keep the unit exposed as much as possible. A Kestrel Belt-Clip Carry Pouch or MOLLE-Compatible Tactical Carry Pouch is ideal for this purpose as the Black Globe sensor remains exposed to the air.

*Note: Please read the cautions and warnings on page 2 of the manual carefully. Consider all relevant factors, such as amount of work being completed, distance traveled with respect to people or animals, or clothing worn when making judgments on heat stress.*

## WET BULB GLOBE TEMPERATURE

### Measuring

The unit will calculate and display Wet Bulb Globe Temperature based on Globe Temperature, Relative Humidity, Ambient Temperature, Barometric Pressure, and Wind Speed.

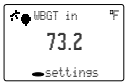



**Figure 1**

### To Change WBGT settings:

- Press ⬭ while on the Wet Bulb Globe Temperature screen.
- Use ◀ or ▶ to change the "Type" setting between outdoor and indoor, (see glossary for more info).
- Use ▼ to scroll to "App", then use ◀ or ▶ to change the Application.
- Press ⓘ to exit the WBGT settings screen.

*Note: Warning zones for WBGT are listed in figure 1 (page 12). If red or black warnings are displayed, the number will flash to alert the user with the screen name contrast inverting. Unless the screen says "None", the flag color will flash. See below screenshots for examples of inverting screen contrast. For information on work/rest ratios and water consumption, refer to Figure 1.*

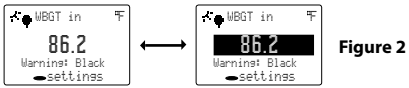



**Figure 2**



## SIX USER-SETTABLE WARNING ZONES

The Kestrel Heat Stress Trackers allow you to customize the settings of your heat-related warning zones based on your specific needs.


Your Kestrel Heat Stress Tracker allows you to activate and set up to six customized heat stress warning zone thresholds to trigger warnings identified by color names on screen. The warnings are in increasing order of severity of risk of heat injury as shown.

**Figure 3**

## SET OUTDOOR/INDOOR MODE AND TURN ON THE WARNING ZONES

- Navigate to the WBGT Screen.
- Press ⬭ to enter the Settings Screen.
- Use ◀ or ▶ to change the "Type" setting between outdoor and indoor.
- Use ▼ to highlight "Warnings," then use ◀ or ▶ to turn on or off.

## TO SET WBGT WARNING ZONES

- Press ⬭ while on the WBGT Screen.
- Use ▼ to highlight "Warning setup" and press ⬭.
- Use ▲ or ▼ to scroll to different warnings zones identified by color names.
- Press ⬭ to enter the selected warning zone.
- On the selected warning zone screen, press ▶ to turn the "Warning" on or off.
- Press ▼ to highlight "Temp." Use ◀ or ▶ to adjust the temperature value. Refer to the "WBGT Reference Guidelines" on the reverse side of this insert for suggested settings.

When a warning zone is turned "On," the WBGT screen will display the appropriate warning color (i.e. Warning: White) related to the specified temperature.

*Note: The Red Warning Zone is further identified by a reverse flash of the warning. The Black Warning Zone will reverse flash the WBGT value to alert the user. See below screenshots for examples of the screen reverse flash.*

### WARNING

The following WBGT Reference Guidance Charts are summarized from well-regarded published papers, policies and position statements relating to preventing heat injury. These guidelines are provided for reference only and do not constitute medical advice.

These guidelines, and your Kestrel Heat Stress Tracker, must be employed with care and good judgment. Please remember that certain individuals are more susceptible to exertional heat stress and the Kestrel Heat Stress Trackers are environmental meters, not medical devices. For more information on heat stress injury prevention, visit HeatStress.com.

When in doubt, set your Zone Thresholds lower, reduce work time and increase rest and hydration.

**Figure 4**

## Work/Rest and Water Consumption Table

***Applies to average sized, heat-acclimated soldier wearing BDU, hot weather. (See TB MED 507 for further guidance.)***

| Easy Work | Moderate Work | Hard Work |
|---|---|---|
| • Weapon Maintenance<br>• Walking Hard Surface at 2.5 mph, < 30 lb Load<br>• Marksmanship Training<br>• Drill and Ceremony<br>• Manual of Arms | • Walking Loose Sand at 2.5 mph, No Load<br>• Walking Hard Surface at 3.5 mph, < 40 lb Load<br>• Calisthenics<br>• Patrolling<br>• Individual Movement Techniques, i.e., Low Crawl or High Crawl<br>• Defensive Position Construction | • Walking Hard Surface at 3.5 mph, ≥ 40 lb Load<br>• Walking Loose Sand at 2.5 mph with Load<br>• Field Assaults |

| Heat Category | WBGT Index, F° | Easy Work | | Moderate Work | | Hard Work | |
|---|---|---|---|---|---|---|---|
| | | *Work/Rest (min)* | *Water Intake (qt/hr)* | *Work/Rest (min)* | *Water Intake (qt/hr)* | *Work/Rest (min)* | *Water Intake (qt/hr)* |
| 1 | 78° - 81.9° | NL | ½ | NL | ¾ | 40/20 min | ¾ |
| 2 (GREEN) | 82° - 84.9° | NL | ½ | 50/10 min | ¾ | 30/30 min | 1 |
| 3 (YELLOW) | 85° - 87.9° | NL | ¾ | 40/20 min | ¾ | 30/30 min | 1 |
| 4 (RED) | 88° - 89.9° | NL | ¾ | 30/30 min | ¾ | 20/40 min | 1 |
| 5 (BLACK) | > 90° | 50/10 min | 1 | 20/40 min | 1 | 10/50 min | 1 |

- The work/rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hrs of work in the specified heat category. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr).
- **NL** = no limit to work time per hr.
- **Rest** = minimal physical activity (sitting or standing) accomplished in shade if possible.
- ***CAUTION: Hourly fluid intake should not exceed 1½ qts.***

  ***Daily fluid intake should not exceed 12 qts.***
- If wearing body armor, add **5°F** to WBGT index in humid climates.
- If doing Easy Work and wearing NBC (MOPP 4) clothing, add **10°F** to WBGT index.
- If doing Moderate or Hard Work and wearing NBC (MOPP 4) clothing, add **20°F** to WBGT index.

*For additional copies, contact: U.S. Army Center for Health Promotion and Preventive Medicine Health Information Operations Division at (800) 222-9698 or CHPPM - Health Information Operations@apg.amedd.army. mil.*
*For electronic versions, see http://chppm-www.apgea.army.mil/heat. Local reproduction is authorized.*
*June 2004*

CP-033-0404

*Figure 4: Work/Rest ratios and Water Consumption Guidelines. (Source: U.S. Army Center for Health Promotion and Preventive Medicine Health Information Operations Division. URL: http://safety.ucanr.org/files/2091.pdf)*

*For additional copies, contact: U.S. Army Center for Health Promotion and Preventive Medicine Health Information Operations Division at (800) 222-9698 or CHPPM - Health Information Operations@apg.amedd.army. mil. For electronic versions, see http://chppm-www.apgea.army.mil/heat. Local reproduction is authorized. June 2004*

**Figure 5**

| GUIDANCE FOR HIGH SCHOOL ATHLETICS | |
|---|---|
| **WBGT READING** | **ACTIVITY GUIDELINES & REST BREAK GUIDELINES** |
| UNDER 82.0 | Normal activities - Provide at least three separate rest breaks each hour of minimum duration of 3 minutes each during workout. |
| 82.0 - 86.9 | Use discretion for intense or prolonged exercise; watch at-risk players carefully; Provide at least three separate rest breaks each hour of a minimum of four minutes duration each. |
| 87.0 - 89.9 | Maximum practice time is two hours! For football: players restricted to helmet, shoulder pads and shorts during practice. All protective equipment must be removed for conditioning activities. For all sports: Provide at least four separate rest breaks each hour of a minimum of four minutes each. |
| 90.0 - 92.0 | Maximum length of practice is one hour, no protective equipment may be worn during practice and there may be no conditioning activities. There must be 20 minutes of rest breaks provided during the hour of practice. |
| OVER 92 | NO OUTDOOR WORKOUTS! Cancel exercise; delay practice until a cooler WBGT reading occurs. |

GHSA Heat Index Record Sheet. Georgia High School Athletic Association Heat Index Measurement and Record. 2012:1.

**Figure 6**

| GUIDANCE FOR ATHLETIC TRAINERS | | | |
|---|---|---|---|
| **WBGT** | **FLAG COLOR** | **LEVEL OF RISK** | **COMMENTS** |
| <18°C (<65°F) | Green | Low | Risk low but still exists on the basis of risk factors. |
| 18-23°C (65-73°F) | Yellow | Moderate | Risk level increases as event progresses through the day. |
| 23-28°C (73-82°F) | Red | High | Everyone should be aware of injury potential; individuals at risk should not compete. |
| >28°C (82°F) | Black | Extreme or Hazardous | Consider rescheduling or delaying the event until safer conditions prevail; if the event must take place, be on high alert. |

Roberts WO. Medical management and administration manual for long distance road racing. In: Brown CH, Gudjonsson B, eds. *IAAF Medical Manual for Athletics and Road Racing Competitions: A Practical Guide*. Monaco: International Amateur Athletic Federation Publications; 1998:39–75.

**Figure 7**

| GUIDANCE FOR CHILDREN'S SPORTS PRACTICE | | |
|---|---|---|
| **MODIFYING PRACTICE SESSIONS FOR EXERCISING CHILDREN** | | |
| **WBGT** | | **RESTRAINTS ON ACTIVITIES** |
| °F | °C | |
| <75.0 | <24.0 | All activities allowed, but be alert for the prodromes of heat-related illness in prolonged events. |
| 75.0-78.6 | 24.0-25.9 | Longer rest periods in the shade; enforce drinking every 15 min. |
| 79.0-84.0 | 26.0-29.0 | Stop activity of unacclimatized persons and high-risk persons; limit activities of all others (disallow long-distance races, cut the duration of other activities. |
| >85.0 | >29.0 | Cancel all athletic activities. |

Notes:
1. Source: reference (7).
2. These guidelines do not account for clothing. Although the effects of the uniform clothing and protective equipment (i.e., American football) on sweating and body temperature in younger athletes are unknown, uniforms should be considered when determining playing/practice limitations based on the WBGT.
3. Eight to 10 practices are recommended for heat acclimatization (30–45 min each; one per day or one every other day).
4. Differences of local climate and individual heat acclimatization status may allow activity at higher levels than outlined in the table, but athletes and coaches should consult with sports medicine staff and should be cautious when exceeding these limits.

American Academy of Pediatrics. Climatic heat stress and the exercising child and adolescent. *Pediatrics* 106(1):158–159, 2000.

In addition to utilizing the guidance that is applicable to your environment and/or event, please refer to YOUR SPECIFIC STATE'S REQUIREMENTS for measuring WBGT and heat acclimatization guidelines.

**Figure 8**

| ISO 7243 THRESHOLD LIMIT VALUES FOR WORK ENVIROMENTS | | | | | | |
|---|---|---|---|---|---|---|
| **WORK-REST REGIMEN** | **WORK LOAD** | | | | | |
| | **LIGHT** | | **MODERATE** | | **HEAVY** | |
| | °C | °F | °C | °F | °C | °F |
| Continuous work | 30.0 | 86.0 | 26.7 | 80.1 | 25.0 | 77.0 |
| 75% work + 25% rest; each hour | 30.6 | 87.1 | 28.0 | 82.4 | 25.9 | 78.6 |
| 50% work + 50% rest; each hour | 31.4 | 88.5 | 29.4 | 84.9 | 27.9 | 82.2 |
| 25% work + 75% rest; each hour | 32.2 | 90.0 | 31.1 | 88.0 | 30.0 | 86.0 |

Parsons, Ken. Heat Stress Standard ISO 7243 and its Global Application. *Industrial Health* 2006(44):368-379.

## Measuring

The unit will also display a measure of human heat stress known as "Thermal Work Limit," or "TWL." TWL is based upon Globe Temperature, Relative Humidity, Ambient Temperature, Barometric Pressure, Wind Speed, and parameters specific to the population using the Thermal Work Limit measurement. These parameters are the Intrinsic Clothing Insulation Factor (IClo), Vapor Permeation Factor (VPF), Position of the body (Pos), and surface area of the person (Area). See Clothing Ensemble Level Setting Screen below. TWL is measured in terms of the heat energy a person can dissipate from their surface area in Watts per square meter (w/m2). TWL incorporates recommended acclimitization, buffer and withdrawal zones as depicted in the following chart (page 16).

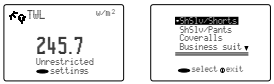



**Figure 1**

## To Change TWL settings:

- Press ⬭ while on the Thermal Work Limit screen.
- Use ▲ or ▼ to scroll to different ensembles.
- Press ⬭ to select the desired ensemble.
- A bullet indicates the selected ensemble.
- Press ⓘ to exit the WBGT settings screen.
- If Custom is selected, each factor specific to the user can be altered (shown above).
- To view the specifics of an ensemble, press ⬭ after selecting it.
- If viewing the Custom ensemble specs, use ◀ or ▶ to adjust each value, and ▲ or ▼ to scroll to different parameters.
- Press ⓘ to exit the ensemble specs, and once more to exit TWL settings screen.

*Note: "Acclim" will blink on the TWL screen when the meter detects that Acclimatization is the current zone. In the Buffer or Withdrawal zones, the number will flash as shown in the screenshots below. For information on TWL interventions, refer to Figure 2. For typical numeric values for each factor, refer to Figure 3.*

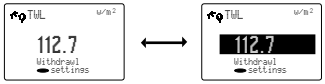



**Figure 2**

| TWL (w/m²) | > 220 | 140-220 | 115-140 | < 115 |
|---|---|---|---|---|
| **Working Zone** | **Unrestricted** | **Acclimatization** | **Buffer** | **Withdrawal** |
| **Interventions** | **No limits on self-paced work** for trained, hydrated workers. | **No restriction for acclimatized workers Workers with uncertain acclimatization status should not work alone in this zone**<br>• Be aware of increased risk of heat illness<br>• Dehydration test for first two shifts back from leave | **Buffer zone exists to identify situations in which environmental conditions may be limiting to work**<br>• Any practicable intervention to reduce heat stress should be implemented e.g. provide shade, improve ventilation etc<br>• Working alone to be avoided if possible<br>• Unacclimatized* workers not to work in this zone<br>• Use the technical information sheets **'Work-rest cycling – sample schedules' and 'Fluid requirements for working in heat'** to prescribe maximum exposure time, work/rest cycling and fluid intakes appropriate for type of work and conditions | **Work limited to essential maintenance or rescue operations**<br>• No person to work alone<br>• No unacclimatized* person to work<br>• Documentation required authorising work in hostile thermal conditions for specific purpose<br>• Specific induction required emphasizing hydration and identifying signs of heat strain<br>• Apply 20 minutes of work – 40 minutes rest schedule<br>• Required fluid intake exceeds 600 ML per 30 minutes<br>• Personal water bottle (2 liter capacity) must be on the job at all times<br>• Mandatory dehydration testing at end of shift |

**Unacclimatized workers are defined as new workers who have been off work for more than 14 days due to illness or leave (outside the tropics).*

*Figure 3: TWL values, working zones, and interventions.Source: Health Authority, Abu Dhabi. URL: http://haad-safe.ae/index.php?option=com_content&view=article&id=27&Itemid=50*

| ENSEMBLE | IClo | VPF |
|---|---|---|
| Men's business suit: Long sleeve shirt/ tweed suit jacket & long, loose trousers | **1.13** | **0.37** |
| Short sleeve shirt/denim shorts | **0.41** | **0.43** |
| Work Clothes: Short sleeve shirt/long trousers (denim) | **0.50** | **0.40** |
| Work Clothes & Coveralls | **0.96** | **0.39** |

| POSITION | VALUE |
|---|---|
| Lying down | **0.00** |
| Standing up | **1.00** |

*Figure 4: (left/above) Typical values for IClo, VPF, and POS. Typical value for Area of a man is 1.7. Sources: "Heat and Moisture Transfer Through Clothing" (http://www.ibpsa.org/proceedings/BS2009/BS09_1360_1366.pdf), and "A Comprehensive Database for Estimating Clothing Insulation," Institute for Environmental Research, Kansas State University; Elizabeth McCullough and Byron James.*

## BLUETOOTH SETUP (BLUETOOTH ENABLED METERS ONLY)

To transfer your Kestrel's real-time and logged data wirelessly and automatically to a laptop or PDA, follow these set up steps.

### Enable the Kestrel's BLUETOOTH Capability

- Press ⓜ to enter the Main Menu.
- Use ▲ or ▼ to highlight "Bluetooth," then press ⬭.
- Use ◀ or ▶ to change from "Off/Disabled" to "On/Ready".

### Set BLUETOOTH Range

In Bluetooth screen:

- Use ▲ or ▼ to highlight "Range".
- Use ◀ and ▶ adjust the range to "Low" (3ft), "Medium" (10ft), or "High" (30ft).

### Obtain your Kestrel BLUETOOTH PIN and ID

For added security, each Kestrel comes with a unique PIN and ID number to ensure proper pairing.

In the Bluetooth screen:

- Use ▲ to highlight "Info," then press ⬭ to view your unique ID and PIN.

### Pair Your Kestrel with Your Computer

First, make sure your Kestrel unit's Bluetooth is set to ON. Open the Bluetooth management software on your computer and follow the prompts to enter the PIN. A COM Port will be assigned and displayed in the software once connection to the Kestrel is established.*

☐ *This is a general guideline for pairing your Kestrel with your computer. Individual Bluetooth software programs and navigation may vary, and some computers do not come equipped with Bluetooth capability and will need additional products to communicate via Bluetooth.*

** A "Bluetooth Error" screen will appear on the Kestrel if pairing is unsuccessful.*

### Set Up Kestrel Communicator Software

- Go to: http://www.nkhome.com/kestrel/software.
- Download and install the Kestrel Communicator Software from this link.
- Once installed, the "Kestrel Communicator" icon will appear on your desktop. Click on the icon and use the "Help" tab to find full instructions for use.





## Setting Barometric Pressure & Altitude

The Kestrel meter measures "station pressure", which changes in response to both changes in altitude and changes in atmosphere. Barometric pressure is a measurement of the air pressure adjusted to sea level. To obtain accurate barometric pressure and altitude readings, you must first know EITHER your location's current barometric pressure OR your current altitude.

☐ *Station pressure is displayed if the reference altitude is set to zero.*

☐ *Be sure to adjust your reference measurements for altitude and/or barometric pressure when you change your location or when there have been dramatic changes in weather conditions.*

### OPTION 1

### Start with Known Altitude for your Location

- Use ▲ or ▼ to scroll to highlight the "BARO" screen
- Press ⬭ to enter the "REF BARO" screen

| | |
|---|---|
| Baro | Displays current Barometric Pressure |
| Ref Alt | Use ◀ or ▶ to set the known Altitude |
| Sync Alt | Use ◀ or ▶ to switch "On" and sync the Baro reading to the "Altitude" screen |

When "Sync Alt" is turned "On," the current Barometric Pressure data is automatically used as a reference for Altitude, and both screens will show accurate readings.

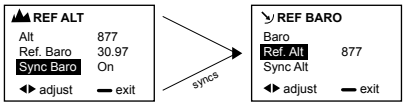



**Figure 1**

### OPTION 2

### Start with Known Barometric Pressure for your Location

- Use ▲ or ▼ to highlight the "Altitude" screen
- Press ⬭ to enter the "REF ALT" screen

When "Sync Baro" is turned "On," the current Altitude data is automatically used as a reference for Barometric Pressure, and both screens will show accurate readings.

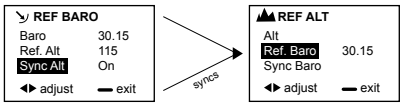



**Figure 2**

☐ *"Density Altitude" screen data is calculated from the absolute values of station pressure, relative humidity and temp., and is not affected by the reference values entered in the "Baro" and "Altitude" screens.*

## IMPELLER REPLACEMENT

### Replacing the Kestrel impeller

☐ *Press only the sides of the impeller when removing and inserting to avoid damaging the precision hub bearing.* (*Figure 1*).

- Press FIRMLY on the impeller module to remove it.
- Insert the new impeller so the side that has the small triangle (close to the perimeter) faces the front of the Kestrel when installed. Orient one "arm" of the module straight up. (*Figure 2*). The impeller can be pushed in from either side.

**Figure 1**

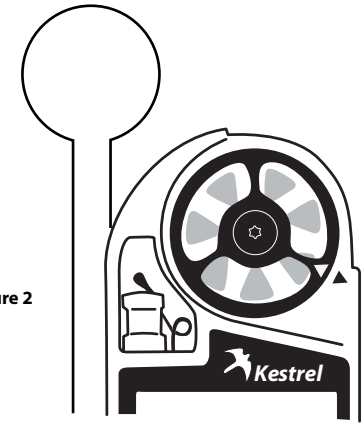



**Figure 2**



## COMPASS CALIBRATION (4600 ONLY)

In addition to Wind Speed and Wind Chill, the **Kestrel 4600** also measures Direction, Headwind/Tailwind and Crosswind.

### Digital Compass Calibration

☐ *The digital compass must be calibrated to correct for the AAA batteries' magnetic field. It must be re-calibrated every time the battery door is opened, and it will not display or log any direction values until calibration is complete.*

***Impeller should be removed during calibration for best results.*

- Remove the impeller by pressing the edges to pop it out (reinsert after calibration is complete).
- Place the Kestrel meter in the foam stand provided so it remains balanced and vertical [ *Figure 1*]. You may also hold the Kestrel meter vertically in your hand and turn your body.

**To Calibrate:**

- In Main Setup Menu, use ▲ or ▼ to highlight "System", then press ⬭.
- Press ▼ to highlight "Compass Cal", then press ⬭.

**Follow the prompts on screen:**

- Press ⬭ to start.
- Slowly spin the upright meter around three (3) full times.
- Each rotation should take approximately 10 seconds.
- When calibration is finished, the screen will read "Cal Complete".
- Press ⓘ to exit to Main Menu.

To verify the digital compass' accuracy, test it against a compass; the Kestrel meter readings should be within ±5° of the reference compass or better. If readings appear incorrect, simply run the calibration routine again.

**Calibration Error Messages**

There are three error messages that the meter may display during calibration. Press ⓘ to exit the error screen and run the calibration again.

- *Magnetic Batteries:* The magnetic field of the Kestrel's batteries is interfering with calibration. Simply open the battery door, rotate one or both batteries, and run the calibration again.
- *Too Slow:* The unit was spun too slowly during calibration.
- *Too Fast:* The unit was spun too quickly during calibration.

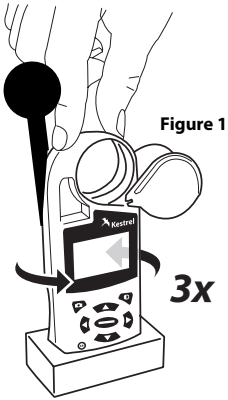



**Figure 1**

## Measuring Direction

*The Kestrel 4600's digital compass must be vertical to achieve accurate readings. Keep the unit positioned as close to vertical as possible when using any compass-related feature. After opening the battery door, you must re-run the calibration routine or readings will not register. For maximum accuracy, the impeller should be spinning while measuring to eliminate its magnetic pull.*

### True North vs. Magnetic North Readings

The Kestrel 4600 default Direction display mode is Magnetic North. To view Direction in True North mode:

- In the Direction screen, press ⬭.
- Use ◀ or ▶ to choose your mode.
- If you choose True North, use ▼ to highlight "Variation", then use ◀ or ▶ to input the Variation for your location.

### To measure Direction:

- Hold the unit vertically and point the BACK of the unit toward the direction you want to measure.
- The unit will display the cardinal direction and degrees.

*The Direction measurement does not record Max and Average and will display N/A on that mode screen.*

## Measuring Headwind/Tailwind & Crosswind

The Kestrel 4600 automatically calculates Headwind and Crosswind with respect to a runway or target direction. You must first set the "Heading" to view these measurements:

- Press ⬭ while on the Headwind or Crosswind screen.
- Use ▲ or ▼ to choose "Auto Set" or "Manual Set", then press ⬭.

  **In Auto Set:** *Point the unit down the runway or target, then press ⬭ to automatically set the heading.*

  **In Manual Set:** *Use ◀ or ▶ to enter the known runway or target heading, and press ⬭ to save.*

  *Both screens will always display the Magnetic North heading at the top (even if the Direction screen is set to True North mode).*
- After setting the heading, scroll to the desired parameter and orient the Kestrel so the wind blows directly through the impeller.



# VANE MOUNT ASSEMBLY

## Assembling the Vane Mount

The Kestrel Vane Mount allows you to mount your Kestrel on any 1/4-20 equipped tripod for long-term condition monitoring. The Vane Mount will keep your Kestrel correctly oriented into the wind to fully capture relevent conditions.

The Vane Mount is designed for extreme light weight and portability, and assembles in seconds. The Portable Vane Mount contains four components: a zippered carry pouch, a cup bracket with incorporated level, a boom and a flight.

### Step 1

**Assemble the boom.** Unfold the two pieces and stretch the bungee gently, then slide the two pieces together (like a tent pole).

### Step 2

**Attach the flight to the flat end of the boom.** Grasp the silver bungee end AND the transparent bungee washer, then pull the bungee out about 1/2 an inch. Drop the bungee into the slot in the center of the flight while slipping the boom end into the opening in the center of the flight.

### Step 3

**The assembled flight and boom looks like this.**

### Step 4

**Attach the boom to the cup bracket.** Locate the arrow on the inside of the cup bracket base. Insert the boom end in the direction of the arrow, all the way through the base of the vane mount. Grasp the silver bungee end AND the small bungee washer, then pull the boom back, stretching the bungee. Drop the bungee into the slot and slip the boom end into the opening near the compass. Gently rotate the boom until the angled end "seats" into the base of the opening.

### Step 5

**Attach the Vane Mount to your tripod and level your tripod.** Spin the Vane Mount knob onto the 1/4-20 mount on your tripod. Slip your Kestrel into the Vane Mount with the display facing the bubble level and the back side of the Kestrel facing the flight and boom. Adjust the flight so it is vertical. Observing the level on the Vane Mount, fairly adjust your tripod so the Vane Mount is level and rotates freely and evenly.

## DATA LOGGING AND MIN/MAX/AVERAGE

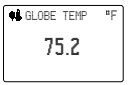
*When Autostore is on and the unit is off, the heat stress measurements will not be stored because they use calculations that cannot be performed without power. When reviewing data in the graphical display, the symbol "–" will appear at the top of the display for any points not logged due to the above condition.*

In wind-related measurements, a timer will appear at the bottom of the screen after starting the MMA feature – this timer displays the elapsed time. Additionally, for each minute this feature is running a data set will be stored in memory reflecting the instantaneous conditions at that time. This will happen regardless of memory settings.

For additional information on memory options and logging data, please refer to the main Kestrel 4000 series manual.

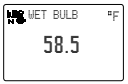
## GLOSSARY

### Globe Temperature




The Black Globe on the Kestrel Heat Stress Trackers is representative of the amount of heat-absorption via the color black. Typically, Globe Temperature is taken using a 6" diameter copper globe painted black with an internal thermometer. However, the Kestrel 4400 and 4600 use a 1" copper globe painted black for calculations.
Globe Temperature is representative of the temperature of the Black Globe itself without accounting for air temperature.

### Naturally Aspirated Wet Bulb Temperature




The Kestrel Heat Stress Trackers' Naturally Aspirated Wet Bulb Temperature function accounts for the effects of humidity on the human body. By combining relative humidity and wind speed, the temperature displayed is indicative of the evaporative cooling happening to the Kestrel 4400 or 4600.

### Wet Bulb Globe Temperature (WBGT)

The WBGT is a composite measurement of Naturally Aspirated Wet Bulb, Globe Temperature & Dry Bulb Temperature. This environment data combines temperature, humidity, wind speed and thermal radiation to access heat stress.

### Outdoor WBGT

$$= 0.7\ T_{NWB} + 0.2\ T_G + 0.1\ T_D$$

### Indoor WBGT

**Where =** $T_{NWB}$ **= Naturally Aspirated Wet Bulb Temperature**

$T_G$ **= Globe Temperature**

$T_D$ **= Dry Bulb Temperature**

### Thermal Work Limit (TWL)

Like WBGT, TWL uses environmental measurements, including thermal radiation, to predict work limits for people exposed to heat stress. Different attributes of clothing (such as its ability to insulate and allow water vapor to pass through it) are also used to calculate TWL.

### Acclimatization (Acclimatize)

Defined as the process of gradually adjusting to a change in environment (such as a change in temperature, humidity, etc). During TWL mode "Acclim" will flash when the value being displayed falls within the acclimitization zone. For example, people who have not worked in such conditions should not be left alone until they have acclimatized, a process requiring several days of gradually increased exposure to heat stress conditions.

### Black Globe

Typically a 6" copper sphere colored matte black with a thermometer in the center. This thermometer reads the surface temperature of the Black Globe, which indicates the radiant heat exposure of one in sunlight. The Kestrel 4400 and 4600 Heat Stress Trackers use a 1" Black Globe that is calibrated to achieve the same measurements as a 6" globe.

## MAINTENANCE & SERVICE

### Maintenance & Storage

To avoid scratching the window, store the Kestrel Heat Stress Tracker in the soft pouch and/or use the Kestrel lens cleaning kit.

### Software

To download the Kestrel Communicator software, visit: www.nkhome.com/kestrel-software.

### Calibrations, Certifications & Service

Every NK product is tested and calibrated before it leaves our factory. We warrant that it will perform within specifications when you receive it. The unit may be returned to NK for factory calibration, or you can contact NK for field calibration instructions (RH Calibration Kits are available on our website).

Each Kestrel Meter comes with a Certificate of Conformity, stating the specifications for that product.

If you are concerned your Kestrel is not performing within specifications upon receipt, please contact us and we will review your concerns. If necessary, we will test or recalibrate any unit within 30 days of purchase.

Beyond 30 days, we offer reasonably-priced tests, calibration services, NIST-traceable calibrations, and full Kestrel Meter tune-ups.

We offer full factory service on every product we manufacture for as long as we make the product (and as long after as component availability permits). If we cannot repair a product, we will offer you a replacement under our Loyalty Discount (even for accidental damage and misuse).

Please contact NK if you feel your product is not working properly. We can often solve product issues by phone or e-mail, saving you the time and expense of returning the unit. If we require the product to be returned, you can obtain a Return Authorization to expedite the handling of your return.

**Made in the USA**

Your Kestrel Weather & Environmental Meter was designed, developed and built in the USA by Nielsen-Kellerman Co. of US and imported components. We are a lean manufacturing enterprise committed to continuous improvement of our products, processes, people and partners. We strive to conduct our business in a sustainable manner and minimize harm to the environment by actively implementing company-wide plans to conserve energy, reduce waste, and recycle.



## BATTERY MAINTENANCE

### Batteries

Kestrel Weather & Environmental Meters require 2 AAA batteries. Average battery life is 300 hours based on typical use. Based on specific usage, *Bluetooth*®-enabled meters will average less battery life.

☐ *When using the Kestrel meter in extremely cold weather, it is recommended to use lithium batteries for optimal performance.*

### Kestrel Battery Recommendations- Avoiding Corrosion and Damage

Your Kestrel meter will safely operate on high-quality alkaline batteries, lithium batteries or rechargeable NiMH batteries. **Please follow these recommendations to select the right battery for your use and avoid damage to your Kestrel meter.**

· **Lithium AAA batteries** (such as Energizer® Advanced or Ultimate brands) are virtually leak proof and provide up to 50% additional capacity in *Bluetooth*® equipped models as well as improved cold weather performance. They are also 30% lighter than alkaline batteries and provided extended cold temperature performance for data logging. We recommend using lithium batteries for most Kestrel applications.

· **Rechargeable NiMH batteries** are an excellent option for high-drain applications, such as extended use of the *Bluetooth*® data transmission features. Low self-discharge NiMH batteries are a particularly good choice as they will hold their charge for months and still be ready to go when you want to put your Kestrel to use. You can also bring a supply of pre-charged batteries to the field, and still have the option of recharging them many times. Recommended options include Sanyo® eneloop® and Rayovac® Platinum pre-charged rechargeable batteries.

· **Alkaline batteries** are a cost-effective option when you will be regularly changing or inspecting the batteries, and can control storage conditions and duration. All alkaline batteries are prone to leaking potassium hydroxide, particularly as they near full discharge. As batteries discharge, they release a small amount of hydrogen gas, which exerts pressure inside the battery and may eventually rupture its seals. Once a leak has occurred, the potassium hydroxide and carbon dioxide from the air form potassium carbonate crystals that grow and follow along the metal electrodes to the circuit board, causing oxidation of the circuit and components. *Damage caused by leaking alkaline batteries is usually irreversible, and is NOT covered under the Kestrel warranty.* When choosing to install alkaline batteries, follow these recommendations carefully to avoid corrosion damage:

- Use US-made, name-brand batteries wherever possible. Do not mix brands of batteries. Do not mix alkaline batteries with other types (lithium or rechargeable).
- Do not mix batteries of different ages or usage – replace both batteries at the same time with new batteries that have not reached their expiration date.
- Remove batteries for long-term storage (more than one month of non-use). Even when powered down, the Kestrel continues to log data and slowly discharge the batteries.
- Change your batteries when below 20% capacity.
- Inspect your batteries regularly (at least once a month) and remove immediately if you notice ANY moisture or white crystal line material at either end.
- Always store your Kestrel meter with batteries installed within the specified temperature limits: -22.0 °F to 140.0 °F | -30.0 °C to 60.0 °C. Be particularly careful not to leave a Kestrel meter with batteries installed inside a hot car in the summer.
- **CAUTION:** If you notice you have a leaking alkaline battery, be careful not to touch it with your bare skin or allow it to come in contact with your eyes as the leaking material is very caustic. Remove and dispose of both batteries. If possible, loosen and vacuum out any white powder. DO NOT BLOW INTO THE COMPARTMENT TO REMOVE THE POWDER – it can cause eye or skin damage and will be driven further inside the unit. You may attempt to use a cotton swab moistened with white vinegar to clean the contacts and gently swab out the battery compartment. Do not exert any force against the contacts inside the battery compartment or you may bend or break them. Allow the battery compartment to dry completely and try installing fresh batteries. If your unit still does not power up, you may contract Kestrel Support to inquire about our Customer Loyalty Trade-In Program, which provides a significant discount toward a replacement Kestrel meter.

# 5-YEAR LIMITED WARRANTY

Your Kestrel Heat Stress Tracker is warrantied to be free of defects in materials and workmanship for a period of FIVE YEARS from the date of its first consumer purchase. NK will repair or replace any defective meter or part when notified within the warranty period, and will return the meter via domestic ground shipping or NK's choice of method of international shipping at no charge. The following are excluded from warranty coverage: damage due to improper use or neglect (including corrosion); damage caused by severe or excessive impact, crushing or mechanical harm; modifications or attempted repairs by someone other than an authorized NK repair agent; impeller failure not caused by a manufacturing defect; normal usage wear; and/or damage caused by failed or leaking batteries; and accuracy issues resolvable by recalibration. If no warranty registration or proof of purchase is provided, the warranty period will be measured from the meter's date of manufacture.

**Except for the warranties set forth herein, NK disclaims all other warranties, expressed, implied or statutory, including, but not limited to, the implied warranties of merchantability or fitness for a particular purpose. Any implied warranties that may be imposed by applicable law are limited to the term of this warranty. In no event shall NK be liable for any incidental, special or consequential damages, including, but not limited to, loss of business, loss of profits, loss of data or use, whether in an action in contract or tort or based on a warranty, arising out of or in connection with the use or performance of an NK product, even if NK has been advised of the possibility of such damages. You agree that repair, and (upon availability) replacement, as applicable, is your sole and exclusive remedy with respect to any breach of the NK Limited Warranty set forth herein.**

All **product liability** and **warranty options** are governed exclusively by the laws of the **Commonwealth of Pennsylvania.**



NOTES:

by NK

NIELSEN-KELLERMAN
21 Creek Circle, Boothwyn, PA 19061
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Web: NKhome.com
Email: info@NKhome.com

**Kestrel® Weather & Environmental Meters are designed and manufactured in the USA**

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

RoHS COMPLIANT

NK#xxxx_1_13.3.19