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**CALOR** INSTRUMENTS PTY LTD

# Heat Stress Monitor

## Operation Manual

For Version 2.07 Firmware



Manual v1.09

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# ABOUT THIS MANUAL

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## Purpose of this Manual

This manual provides detailed information about the installation of the CALOR Heat Stress Monitor (HSM). It is designed to help users to follow the recommended installation procedure, as well as to help troubleshoot the HSM. This is intended as a reference manual. The manual is intended for firmware 2.07 with only minor differences between versions 2.0. For more information regarding changes see the release notes that are available in the downloads section on the website mentioned below.

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## Who should use this Manual

This manual is for users installing and using the CALOR HSM with firmware 2.0 and above.

The manual provides step-by-step procedures and description for configuring and using the HSM. The manual is organised in a sequential manor for first time users.

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## Help and Additional Information

### Customer Support Information

If you need more information about the CALOR HSM that is not contained in this document, or have problems with the HSM, please contact our Project Coordinator at:

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# How this manual is organised

This manual is organised into seven chapters.

**Chapter 1: Introduction.** An overview of the CALOR INSTRUMENTS - HSM, with a general description of its components.

**Chapter 2: Important Notes.** This chapter will help you to prepare for using the HSM, including what tools are required, how to unpack and to mount HSM.

**Chapter 3: Using The HSM.** Provides step-by-step procedures for using the HSM for the first time.

**Chapter 4: Environmental Analysis.** Describes how to obtain environmental data.

**Chapter 5: Data Logging.** Describes how to run the logger functionality

**Chapter 6: Menu System.** A map of the HSM menu system.

**Chapter 7: Troubleshooting.** This section is for resolving problems that you may encounter when operating the HSM.

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## Conventions used in this manual

There are a few formatting conventions used in this manual to make it easier to read and understand. They are listed below.

**1,2,3** Steps in a procedure are numbered consecutively



This **Note** points out information that helps you perform a step in a procedure



This is a **Warning** message that alerts you for a vital step to be taken, or a condition to be observed, before taking a particular step of a procedure. Failing to do so may result in damage to equipment.

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## CHAPTER 1

# INTRODUCTION

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## What is the Calor Heat Stress Monitor?

The Heat Stress Monitor (**HSM**) is an Environmental Monitoring Instrument designed to provide accurate information relating to the environmental parameters of its location as well as providing health and safety information relating to work load.

The Calor HSM provides two sets of results based on two, internationally recognised algorithms:

**The Heat Stress Model** is based on the wet bulb globe temperature (WGBT) and the “Air Cooling Power (ACP) which is recommended by the industry standard ISO 7243 for assessing the level of heat stress within a given environment. From this algorithm a number of recommendations are output along with a calculated Air Cooling Power.

**The Thermal Work Limit (TWL)** algorithm developed by Dr G Bates is revised and updated from the Heat Stress Model and produces a rating of the environment where the measurements were taken. Within this manual is a series of recommendations associated with each rating.

The HSM allows viewing of environmental data in real-time for monitoring purposes. Data is collected for 2 mins, averaged, and updated once per second. There is also a capability to perform unattended logging of data.

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## Where is it used ?

The small and convenient Heat Stress Monitor (HSM) has applications in military combat and training exercises, mining, foundries, agriculture, offshore oil and gas operations, endurance sports, and many industrial work situations particularly in harsh, hot tropical and arid environments. It is an essential tool for Occupation Health and Safety officers to evaluate work locations to verify that environmental conditions including temperature, humidity and air flow, and that work clothing and personal hydration practices are appropriate and effective for the prevention of Heat Stress.

The HSM is used by engineers and architects to measure airflow and other environmental parameters in industrial and commercial buildings where thermal stress balance is the priority. In addition Health inspectors can assess food outlets for compliance with local health regulations.

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## The Risk of Working in a HOT Environment

Heat stress causes discomfort, reduces productivity and can lead to more serious health effects such as accidents, illness and even death. Prolonged exposure to high temperatures alone can lead to excessive fluid loss, shock, or heat stroke. High humidity compounds the effects of temperature by reducing the cooling effects of sweating. Extended and strenuous exercise, or labour that increases the heat produced by muscles, also contributes to the risk of illness in the form of cramps, exhaustion, or heat stroke. Internal body temperatures, normally 37°C, are considered hazardous between 39-41°C. Death is likely to occur at 42°C and above.

Beating the heat requires monitoring the full range of stress-inducing parameters. Not just the obvious ones, such as ambient temperature, radiant heat and humidity, but also such contributing factors as air flow, clothing, physical exertion, and in some instances barometric pressure.

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## What Does the HSM Measure?

The environmental parameters typically measured to identify heat stress are the dry bulb, wet bulb, and black globe radiant temperatures. From these three readings the wet bulb globe temperature (**WBGT**) index is calculated.

In addition to these parameters the HSM also measures wind speed, which significantly affects evaporative cooling, and barometric pressure. This data is combined with user inputs of clothing type and work level. The degree of acclimatisation status in a specific group under surveillance can also be factored. All data is then combined using algorithms derived from original field and laboratory studies. The output of the model provides specific guidance on selected features such as optimal work/rest cycles, the maximum safe duration of a work shift, and hourly water requirements to replace sweat loss.

In a mining environment one of the few variables that can be adjusted to reduce thermal strain to workers is air velocity. There is an existing strain index that incorporates wind speed in its computation, however, in the past it has not been extensively used, as no single instrument has been able to simultaneously measure all the needed parameters.

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## The HSM Features

- Foldaway Sensor system – Sensors can be rotated and stowed away in the protection of a rear compartment. This allows the module to be deployed without danger of contamination and reduces the risk of breakage.
- Removable environmental data sensor system (module) that can be easily disconnected for replacement or repair.
- All calibration data and signal conditioning electronics are contained in the sensor module.
- Liquid crystal display (LCD) with low power consumption and good contrast in sunlight as well as indoor lighting.
- Backlight for use in very low light conditions.
- The HSM is equipped with thermistor-based sensors to measure air temperature, wind speed, and solar radiation.
- Capacitive polymer-based sensor to measure humidity.
- Piezo-resistive absolute pressure sensor for measuring barometric pressure and estimating altitude.
- Fast response black globe system. Using single piece of copper of 0.15mm wall thickness. Simulated 6 inch Globe with fast response time.
- Environmental data may be displayed in real time.
- Unattended data logging with time stamping.
- Interfaces to a Personal Computer to allow downloading of data logs for analysis.
- Data logging results can be viewed on screen.
- Tripod mount option for data logging mode.

## CHAPTER 2

# IMPORTANT NOTES

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## Precautions

The HSM is a sophisticated electronic instrument and whilst it is small and compact it still needs to be treated with care to ensure the reliability of the data it provides you.

We recommend that the HSM be kept in the hard case provided with the instrument when not in use. At other times it should be kept in a dry and clean environment.

Avoid knocking or dropping the instrument and it should be kept away from water or other liquids.

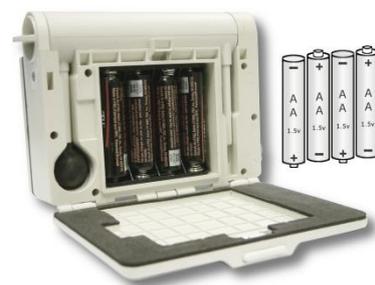
The unique design of the HSM sensors with their ability to be folded away within the device helps protect the sensors from knocks and general wear and tear. For protection, sensors should be folded back in the HSM when not in use.

The HSM requires batteries for operation and these are contained within the rear cover of the device. A small rubber cover protects the batteries and should be refitted whenever batteries are exchanged.

The recommended batteries are 4 off 'AA' type Alkaline or better batteries.



**Take care to ensure the correct orientation of the batteries so as not to short them out.**



Batteries can be affected by heat and this will reduce the life of the battery. It is therefore recommended that the device be kept out of direct sunlight and that the unit is turned off when not required. An automatic turn off function can be initiated through the SYSTEM SETUP menu within the HSM.

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## Maintenance

The Heat Stress Meter takes real time readings from the environment and therefore the sensors must be clean and undamaged.

To clean the sensors, gently wipe the thermistors (the chrome tops of the masts) with dilute ethanol or methylated spirits (a lens cleaning wipe is sufficient). The globe and case can be cleaned with a 30% solution of alcohol.



When not in use always keep the sensors in the non-deployed position; that is in the main enclosure. The Black Globe Radiant Sensor is made of very thin copper and can be dented by dropping the instrument. The sensors are protected when they are in their casings. If the sensors are allowed to get dirty, it may effect the performance of the sensors and hence the readings.

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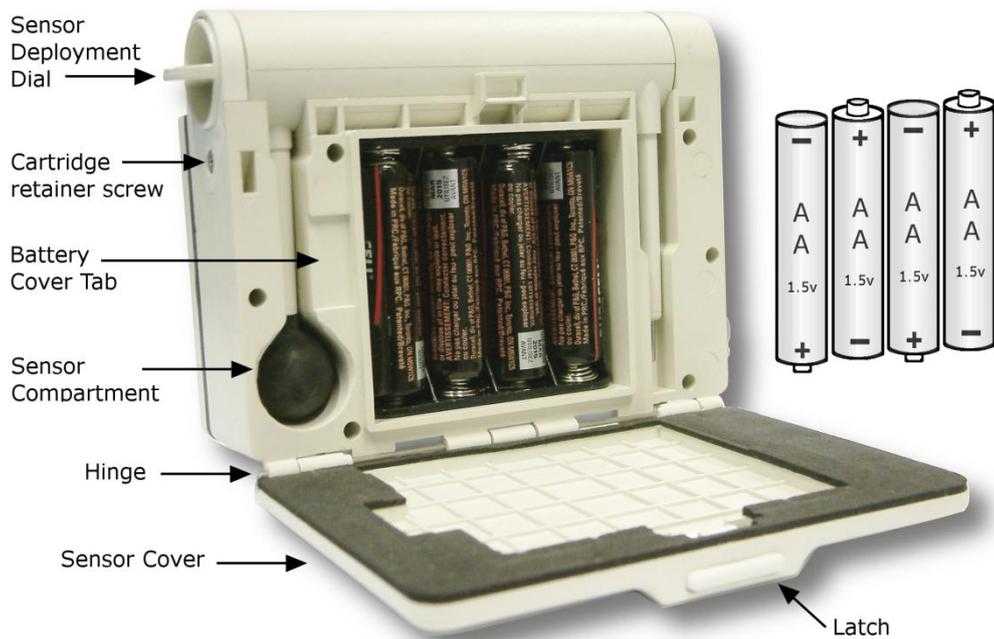
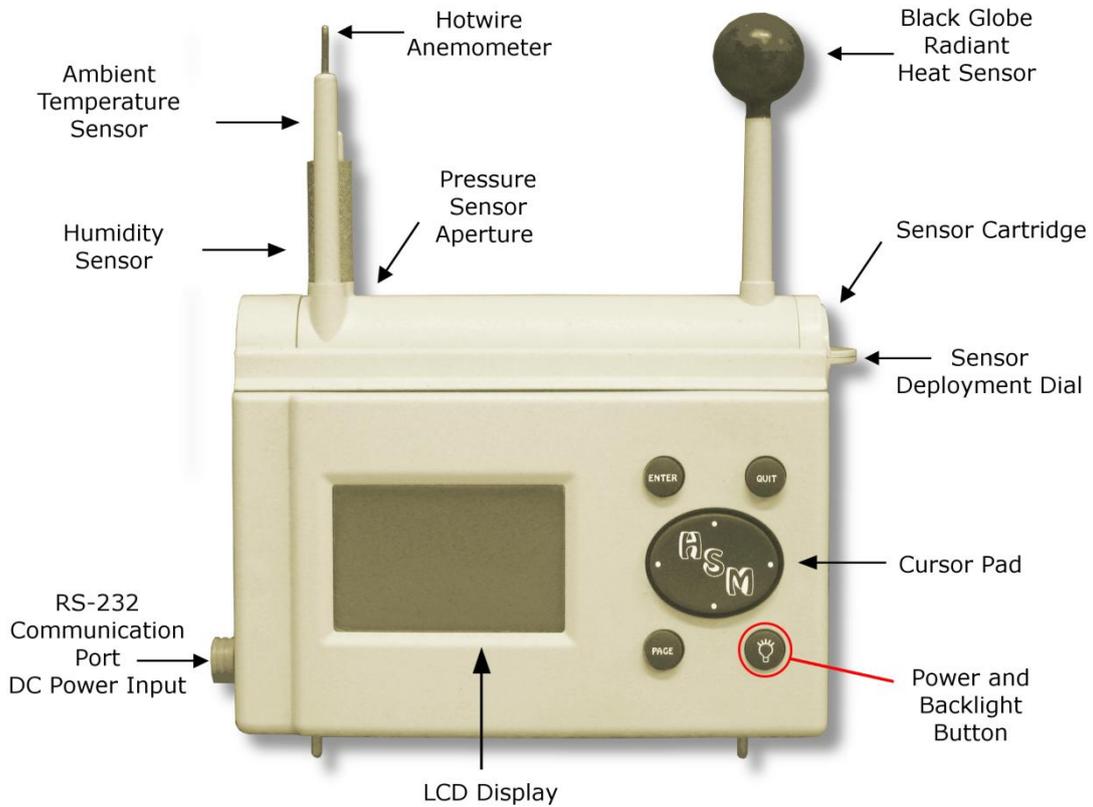
## Calibration

The sensors of the HSM require regular annual calibration where the HSM is returned to Calor Instruments Pty Ltd the address shown on Page iii of this manual.

CHAPTER 3

# USING THE HSM

Using the HSM is very simple and once set up should not require changes in general use. It has an internal setup menu system and configuration menu that is used through the front buttons.



## Front Panel Buttons

The buttons on the front of the HSM are used as follows:



ON/OFF

### ON/OFF

This button is used to turn the HSM, **ON** and **OFF**. Press the button and hold for about 2 seconds until the display indicates that it is turning on and then display the start-up screen of the HSM.

&

To turn **OFF** the HSM press the button and hold. The screen will indicate that it is turning off in 2 seconds. Continue to hold the button until the screen closes down.



Backlight

### BACKLIGHT

The ON/OFF button is also used to turn on and off the backlight for the LCD display so that it can be seen clearly in low light conditions. The screen will brighten and a small globe symbol  will show in the top left of the screen.

The backlight can be toggled ON and OFF by pressing the button momentarily when the display is on. It is recommended that this only be turned on when required so as to extend the battery life.



Cursor Pad

### CURSOR PAD

The HSM uses a 4 way cursor pad to navigate through menu specific selections or control functions such as the LCD contrast level.

The cursor pad has Up, Down, Left and Right operations indicated by the four white dots on the cursor pad. Press the chosen direction once for each step you wish to make.



### PAGE

Is used to step the current displayed screen from one menu screen to another. Each press of the button will step one screen.



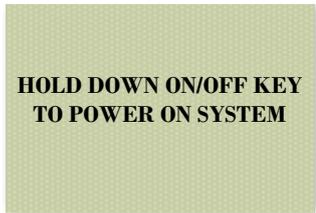
### ENTER

Will allow you access into the current menu screen shown. This will then display a menu of other options that can be accessed by the cursor pad.



### QUIT

Is used to step back out of menus and return to earlier menu options or cancel input operations.



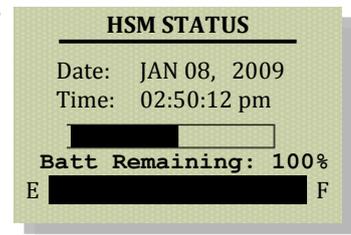
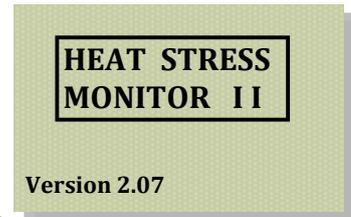
## Starting the Heat Stress Monitor

To turn the HSM on you press and hold down the  (ON/OFF) button on the front panel for about 2 seconds until the splash “HEAT STRESS MONITOR II” screen appears. You can then release the button. If the button is not held on long enough it will automatically turn off when you release the button.

After the splash screen with the version has been displayed for a few seconds the HSM will then display the **HSM STATUS** page shown on the right. This page shows the current Date, Time, LCD Contrast (centre bar graph) and percentage of Battery Charge Level (bottom bar graph).

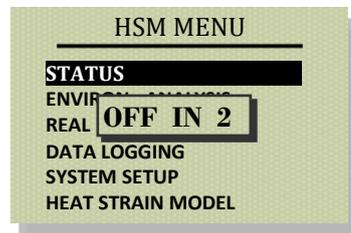
From this page you can also adjust the contrast of the LCD display with the **CURSOR PAD** left and right arrows.

Press  to move to the Main **HSM MENU** as described in the **Using the Menu** section.



## Stopping the Heat Stress Monitor

To turn off the HSM you press and hold down the  (ON/OFF) for about 1 second the HSM will display a small popup counter counting down from 2 seconds, continue to hold the  until the unit turns off. This can be done from within any menu.



## Deploying the Sensors

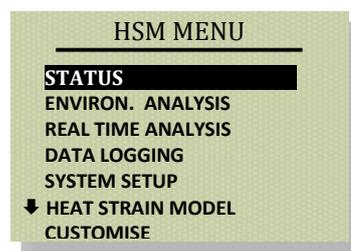
To allow the HSM to take any environmental readings for you must firstly deploy sensors from the rear panel by opening the rear panel and turning the dial on the side of the HSM (left side if observed from the rear).



## Using the Menus

The HSM offers an extensive range of functions, which are grouped into menus. The main menu is shown to the right. To move the **highlight bar** to select an item on the menu use the **Up** and **Down** buttons of the **CURSOR PAD**. To access a selected item press .

The HSM will then present you with a new menu or display results. To return to the previous menu press .

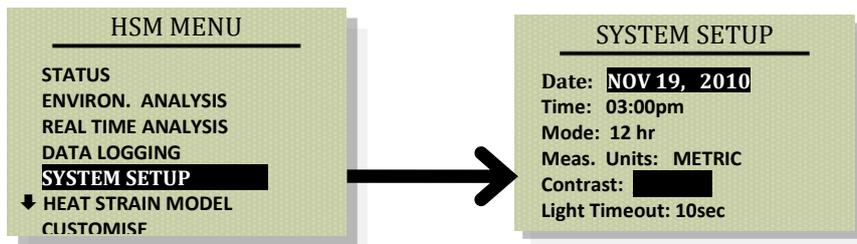


## Entering Data

When entering data via the menu system the **ENTER** will save the data and the **QUIT** will allow you to back out and return to the item selection.

## System Setup

The first time you run your HSM you will most likely need to correctly configure it for your locality and policies. The **SYSTEM SETUP** menu allows you to set the Time and Date, 24 or 12 hour time, Metric or Imperial (English) units and adjust the Backlight Timeout.



### Date

To set the **DATE** move the cursor bar over the **Date:** and press the **ENTER**. The cursor bar will reduce to a small **█** cursor, you can then increment or decrement the *days* with the cursor pad. When you have set the date then press the **ENTER** to save or **QUIT** to return to the main menu.



If you press and hold the cursor pad the days will auto increment/decrement. If you keep holding down the cursor button for a further few seconds the auto rate will increase and start to change months.

### Time

Setting the **TIME** is a similar to setting the date. You move the cursor bar down to the **Time:** and press the **ENTER**. The cursor will change to **█** and the Up and Down cursor buttons will increment or decrement the *minutes*. To adjust the hours press and hold the cursor pad.

### Mode (Hour format)

The HSM supports 12 hour or 24 hour time format. To change this setting, select the **Mode:** press **ENTER**. Pressing the cursor pad will cause the format to toggle back and forth between 12 and 24. Press the **ENTER** to save this or press **QUIT** to return to the main menu.

### Units (Measurement Units)

The HSM supports two types of units the standard **METRIC** format and the **IMPERIAL** system. The HSM will let you toggle between the two.

### Contrast

The contrast of the LCD can be adjusted to best suit the lighting conditions. The cursor pad will increase or decrease the contrast which will be indicated by the bar graph.

## Light Timeout (Backlight Timeout)

To increase battery life you can adjust the time that the backlight is held on for after you press the  whilst the unit is already on. The HSM backlight time out can be set to the following number of seconds: **10, 15, 30, 60, 120, 240 or None**.

To change the Timeout value, select the **Light Timeout:** and move through a list of timeout values with the cursor pad. Then press  to save the selection or  to exit back to the main menu.

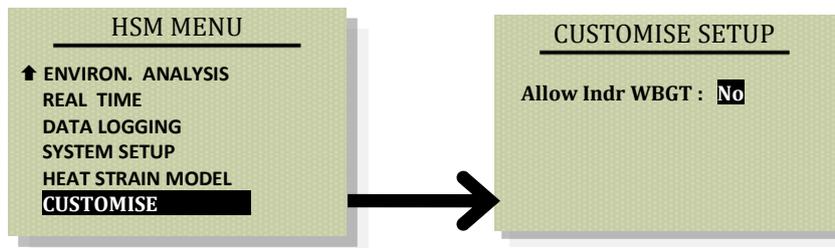
## CUSTOMISE

The customise menu allows you to preset additional configurations or to hide options that are not required for your country or procedures.

The “Allow Indr WBGT” option allows you to preset the WBGT algorithm within the HSM to accommodate for company policies or procedures that require the WBGT to be calculated without input from radiated heat sources.

o When disabled = No (default) the HSM always applies the outdoor WBGT equation (which still gives correct results indoors). We recommend leaving this option disabled.

O When this option is enabled = Yes the operator will be prompted whether a measurement is being performed indoors or outdoors and the appropriate equation is then used to calculate WBGT.

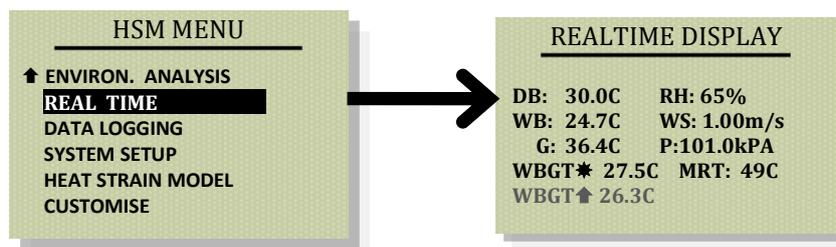


## Real-Time (Display)

The **REALTIME DISPLAY** menu function provides a snapshot of some of the environmental values that the HSM can obtain. The screen is continually updated with the current and ongoing real time readings.



**Make sure the sensors are deployed to allow the HSM to obtain valid readings.**





There are two columns of data values in the Real-time Display.

Value	Definition	Units		Comment
		Metric	Imperial	
<b>DB</b>	Dry Bulb	Degrees Celsius	Degrees Fahrenheit	Ambient temperature value
<b>WB</b>	Wet Bulb	Degrees Celsius	Degrees Fahrenheit	The Wet bulb temperature is a measurement that reflects the physical properties of a system with a mix of gas and vapour.
<b>G</b>	Globe	Degrees Celsius	Degrees Fahrenheit	Black Globe Temperature. Radiated / solar temperature.
<b>WBGT</b>	Wet Bulb Globe Temperature	Degrees Celsius	Degrees Fahrenheit	Is a composite temperature used to estimate the effect of temperature, humidity, wind speed and solar radiation on humans. The WBGT is a part of the <b>ISO 7243 standard</b> . (See definitions for more information)
Second Column				
<b>RH</b>	Relative Humidity	%	%	Percentage of water vapour within the air compared to saturated amount.
<b>WS</b>	Wind Speed	Metres per second	Miles per hour	The airspeed of the wind travelling across the HSM
<b>P</b>	Pressure	Kilo-pascals	Inches of mercury	The atmospheric / barometric air pressure.
<b>MRT</b>	Mean Radiant Temperature	Degrees Celsius	Degrees Fahrenheit	MRT is the most important parameter governing human energy balance. (See definitions section for more information)

WBGT indicators. There three indicators used as suffixes with the WBGT display. : \* ↑  
: This is the default indicator and is used when the customise option Allow Indr WBGT : **No**

These indicators and values appear when the customise option is set to YES Allow Indr WBGT : **Yes**

\* This symbol indicates that this value is the Outdoor WBGT. Eg. WBGT\* **27.5C**

↑ This symbol indicates that this value is the Indoor WBGT. Eg. WBGT ↑ **26.3C**

## CHAPTER 4

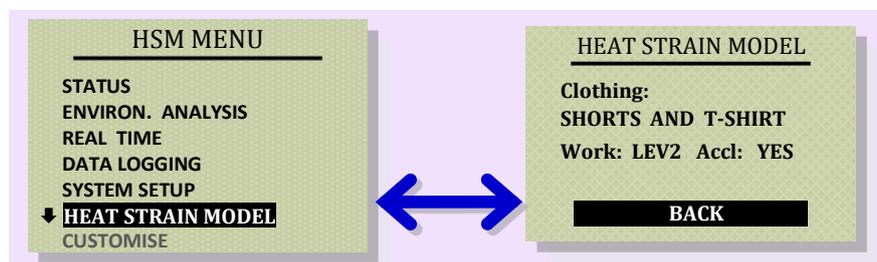
# ENVIRONMENTAL ANALYSIS

## Overview

The HSM contains two similar algorithms for processing the environmental data. One algorithm is called the “**Thermal Work Limit (TWL)**” which classifies the area as a zone with a work limit. This algorithm was developed by Dr G Bates.

The other algorithm is “**Heat Strain Model**” which allows some configuration of clothing and provides recommendations for work rest cycles and fluid intake. This resultant information is discussed later in the section titled “Understanding the Results”. The “Heat Strain Model” is based on Wet Bulb Globe Temperature (WBGT) developed by the United States Army Research Institute of Environmental Medicine (USARIEM).

You can preset the “Heat Strain Model” clothing and work level before doing an analysis. This is accessible via the **Heat Strain Model** menu accessible from the main menu.



## Begin Analysis

This is the main function of the HSM. Firstly you **must** deploy the sensors from the rear panel by opening the rear panel and turning the dial on the right hand side of the HSM.

At this point you must consider how you are going to take your measurement. For best results you should try to place the HSM on a tripod in the centre of the work area.



When taking measurements with the HSM you must consider the following factors:

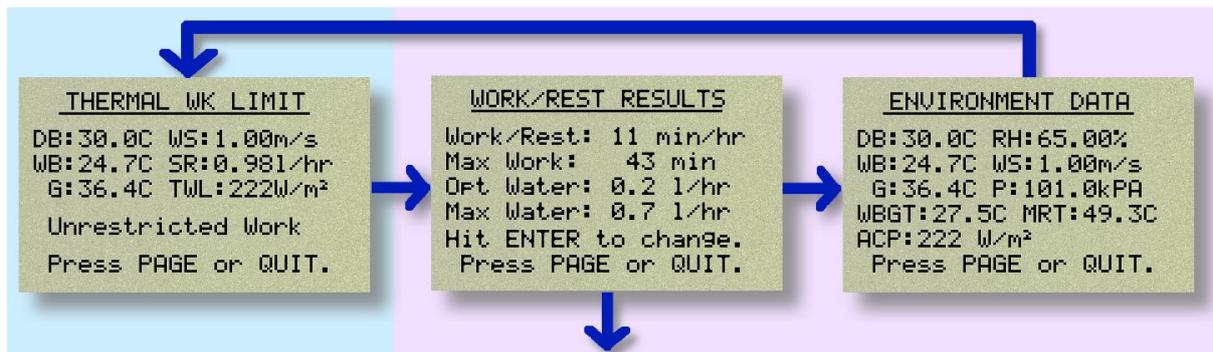
- **Area flow:** Avoid placing the HSM near the outlet of an air-conditioner or in the path a fan unless you are intending to make a comparison of the environment. Also corridors, chimneys and stairways produce airflow.
- **Movement:** Walking with the HSM whilst taking measurements will produce an air-flow which the HSM will calculate as wind. The movement will also alter the radiated heat measurement as you pass objects that are radiating such as the roof, walls, vehicles, heaters etc.
- **Radiated heat:** Avoid placing near heaters, on vehicles, on the ground, computers, machines or fridges. Even groups of people may affect the results.



To begin analysis select ENVIRON. ANALYSIS and press **ENTER** then select either a 2 minute or 30 minute collection cycle then press **ENTER** to start and the DATA COLLECTION IN PROGRESS display will be shown and will display the minutes and seconds remaining for the environmental sample.



The remaining minutes and seconds will count down on this screen. After a while the screen may go blank to save batteries. You can press enter to wake up the screen at any time. On completion the following set of pages/displays can be presented. You can cycle through each of the result pages shown below using the **PAGE** button.



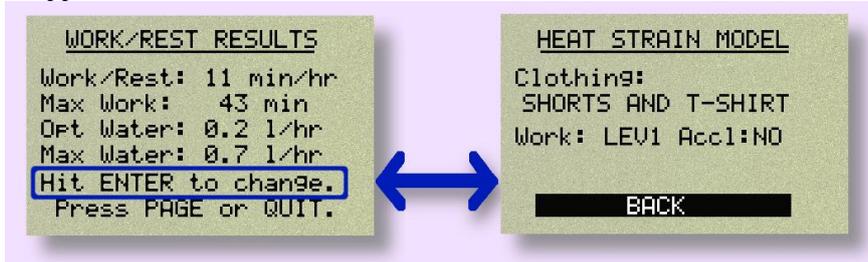
The WORK/REST RESULTS also provides the option to modify some parameters of such as clothing and work level.



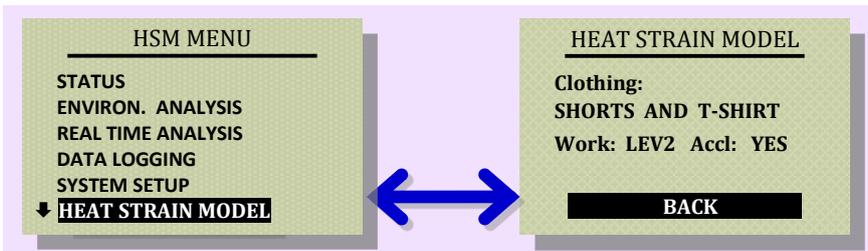
When the HSM has completed the “Data Collection” it will stay in this mode and retain the data for up to 2 hours if you do not QUIT. If you leave the unit unattended it will go into sleep mode after 10 minutes. Pressing any key from this mode will wake up the HSM and return to the results menus above. If you leave the HSM idle after it has gone into sleep you must wake it up before 2 hours if you wish to review or display the information. If you want to retain the data for longer periods then use the “Data Logging” Mode.

# Heat Strain Model

The **HEAT STRAIN MODEL** menu is a configuration menu that provides information to the calculations. This menu allows a customised model to be applied to the workplace environmental factors to assess the Heat Strain factors applicable to this defined scenario.



The configuration menu can be accessed via either the results menu or also via the Main Menu. When accessed via the Main Menu you can preset the clothing type and work level.



The Heat Strain Model, calculates work/rest minutes and water requirements for avoiding heat stress. It was originally developed by the U.S. Army.

Within the **HEAT STRAIN MODEL** menu the following parameters can be altered by moving the cursor to the item, pressing **ENTER** then moving the cursor pad to step or toggle through the possible options. When you have completed you configuration move the cursor and select the **BACK** which will save and return to the previous menu.

## Clothing

**Clothing worn.** There are two pre-set types of clothing to choose from, either **SHORTS AND T-SHIRT** or Trousers with Long Sleeve Shirt - **TROUSERS+L.S. SHIRT**.

## Work

**Work Rate.** This is a Level of work rate with Level 1 being sedentary and Level 5 being the maximum rate. Normal work rate for an 8-12 hour shift would be a Level 2 or intermittently Level 3.

Level 4 or 5 would only be used for flat out short bursts of activity. Values: **Lev1 to Lev5**

WORK RATE TABLE			
Level	Rate	Watts of Allowable work	General Examples
Lev1	Resting / sedentary	< 105 watts	Resting
Lev2	Very Light work rate	105- 150 watts	Sitting driving a car or standing in observation. Light Hand and arm work.
Lev3	Light work rate	150-250 watts	Standing to controlling machines. Arm and trunk. Casual walking.
Lev4	Moderate work rate	250-425 watts	Walking at around 4.5 Km/h, light digging. Moving light wheelbarrow. Sustained hand, arm and trunk work i.e. hammering.

<b>Lev5</b>	Heavy work rate (Flat out short bursts of activity)	425-600 watts	Sawing hard wood, Carry heavy materials. Moving heavily loaded wheelbarrows, carrying loads upstairs or digging. Intense arm and trunk work.
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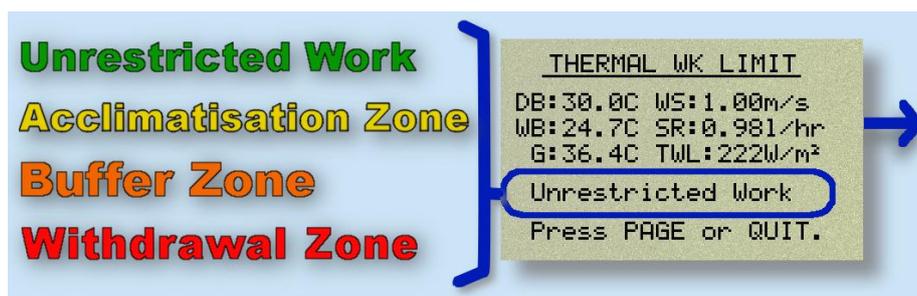
### Accl

**Acclimatisation.** This is the acclimatised status of the person (i.e.: are they used to working in the Heat) this only has a value of YES or NO.

## Understanding the Results

### Thermal Work Limit

The Thermal Work Limit (TWL) is measured in W/m<sup>2</sup> or Watts of allowable work in the environment being assessed.



TWL			
GOOD			BAD
> 220	220 - 140	140 - 115	< 115

The screen will rate the environment of workplace zones rating with one of the following four ratings:

Zone	TWL (W/m <sup>2</sup> )	Recommendations
<b>Unrestricted Work</b>	> 220	<b>No limits</b> on self-paced work for educated, hydrated, acclimatised workers.
<b>Acclimatisation Zone</b>	220 - 140	Affects new workers or those who have been off work for more than 14 days due to illness or leave (outside the tropics), should follow the Buffer Zone recommendations.
<b>Buffer Zone</b>	140 - 115	Any practicable intervention to reduce heat stress should be implemented e.g. provide shade, improve ventilation etc. <ul style="list-style-type: none"> <li>Working alone should be avoided if possible.</li> <li>Un-acclimatised workers not to work in this zone.</li> <li>Fluid intake of ≥ 1 litre per hour required.</li> <li>Work-rest cycling or rotation required.</li> </ul>
<b>Withdrawal Zone</b>	< 115	Work limited to essential maintenance or rescue operations. <ul style="list-style-type: none"> <li>No person to work alone.</li> <li>No un-acclimatised person to work.</li> <li>Documentation required authorising work in hostile thermal conditions for specific purpose.</li> <li>Specific induction required emphasising hydration and identifying signs of heat strain.</li> <li>Apply 20 minutes work - 40 minutes rest schedule.</li> <li>Dehydration testing recommended at end of shift.</li> <li>Personal water bottle (2 litres) must be available at all times.</li> </ul>

## Thermal Work Limit (Values)

**THERMAL WK LIMIT**  
 DB:30.0C WS:1.00m/s  
 WB:24.7C SR:098 l/hr  
 G:36.4C TWL:222W/m<sup>2</sup>  
 Unrestricted Work  
 Press PAGE or QUIT.

Value	Definition	Units		Comment
		Metric	Imperial	
<b>DB</b>	Dry Bulb	Degrees Celsius	Degrees Fahrenheit	Ambient temperature value.
<b>WB</b>	Wet Bulb	Degrees Celsius	Degrees Fahrenheit	The Wet Bulb temperature is a measurement that reflects the physical properties of a system with a mix of gas and vapour.
<b>G</b>	Globe	Degrees Celsius	Degrees Fahrenheit	Black Globe Temperature. Radiated / solar temperature.
Second Column				
<b>WS</b>	Wind Speed	Metres per second	Miles per hour	The airspeed of the wind travelling across the HSM  The HSM should be stationary.
<b>SR</b>	Sweat Rate	Litres per hour	Quarts per hour	Amount of water being expired from the body.
<b>TWL</b>	Thermal Work Limit	Watts/m <sup>2</sup>	Watts/m <sup>2</sup>	A rating or index of thermal stress (See definitions for more information).

## Work/Rest Results (Heat Strain Model)

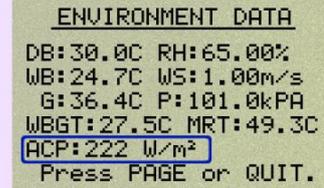
The Heat Strain Model is derived from the WBGT and gives a maximal exposure limit in a measured environment, a work rest cycling regime and recommended water intake.

**WORK/REST RESULTS**  
 Work/Rest: 11 min/hr  
 Max Work: 43 min  
 Opt Water: 0.2 l/hr  
 Max Water: 0.7 l/hr  
 Hit ENTER to change.  
 Press PAGE or QUIT.

Work / Rest Results		
<b>Work/Rest</b>	No Limit	No limit required for this environment when optimum water is supplied.
	Ext Cool	External cooling is required with optimum water.
	xx min/hr	Continuous work and rest cycle of xx minutes per hour, with optimum water. For example 11 minutes work with the 49 remaining minutes rest.
<b>Max Work</b>	xx min	The maximum number of minutes you can work continuously without a rest.
<b>Opt Water</b>	Optimum intake of water in Litres or Quarts per hour	
<b>Max Water</b>	Maximum intake of water in Litres or Quarts per hour	

## Environment Data

The Environmental Data display contains identical information to the Real-Time Display, data covered in Chapter 3 with the addition of **ACP** which is a value specifically for the “Heat Strain Model”. The **ACP** is can be referenced against the following table below as a guide and must always be greater than the work rate.



```

ENVIRONMENT DATA
DB:30.0C RH:65.00%
WB:24.7C WS:1.00m/s
G:36.4C P:101.0kPA
WBGT:27.5C MRT:49.3C
ACP:222 W/m²
Press PAGE or QUIT.
  
```

Value	Definition	Units		Comment
		Metric	Imperial	
<b>DB</b>	Dry Bulb	Degrees Celsius	Degrees Fahrenheit	Ambient Temperature value
<b>WB</b>	Wet Bulb	Degrees Celsius	Degrees Fahrenheit	The Wet bulb temperature is a measurement that reflects the physical properties of a system with a mix of gas and vapour.
<b>G</b>	Globe	Degrees Celsius	Degrees Fahrenheit	Black Globe Temperature. Radiated / solar temperature
<b>WBGT</b>	Wet Bulb Globe Temperature	Degrees Celsius	Degrees Fahrenheit	Is a composite temperature used to estimate the effect of temperature, humidity, wind speed and solar radiation on humans. The WBGT is a part of the <b>ISO 7243 standard</b> . (See definitions for more information)
<b>ACP</b>	Air Cooling Power	watts / m <sup>2</sup> Watts over Metres squared		Equivalent to Watts of allowable work. This value must always be greater than the work rate to avoid heat stress (in conjunction with other guidelines such as work/rest cycles and water intake) (See definitions for more information)
Second Column				
<b>RH</b>	Relative Humidity	%	%	Percentage of water vapor within the air compared to saturated amount.
<b>WS</b>	Wind Speed	Metres per second	Miles per hour	The airspeed of the wind travelling across the HSM.  The HSM should be stationary.
<b>P</b>	Pressure	Kilo-Pascal's	Inches of mercury	The atmospheric / barometric air pressure.
<b>MRT</b>	Mean Radiant Temperature	Degrees Celsius	Degrees Fahrenheit	MRT is the most important parameter governing human energy balance. See the definitions section.

WBGT indicators. There three indicators used as suffixes with the WBGT display. : \* ↑

: This is the default indicator and is used when the customise option Allow Indr WBGT : **No**

These indicators and values appear when the customise option is set to YES Allow Indr WBGT : **Yes**

\* This symbol indicates that this value is the Outdoor WBGT. Eg. WBGT\* **27.5C**

↑ This symbol indicates that this value is the Indoor WBGT. Eg. WBGT ↑ **26.3C**

## Error Results

When the HSM range of measurement has been exceeded or the environment conditions where too unstable the following results may be displayed instead of actual values.

The values **TWL**, **ACP** or **SR** may be displayed as INVALID or OUT OF RANGE depending on space on the screen.

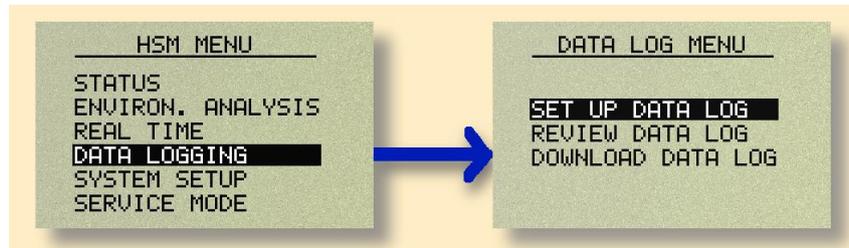
The wind speed **WS** value may be displayed as TOO HIGH if above <10 m/s or will be displayed as UNKNOWN if the wind was too unstable during the Environmental Analysis period.

## CHAPTER 5

# DATA LOGGING

## Datalog Menu

To access the **DATA LOG MENU** select DATA LOGGING from the main menu and press **ENTER**.



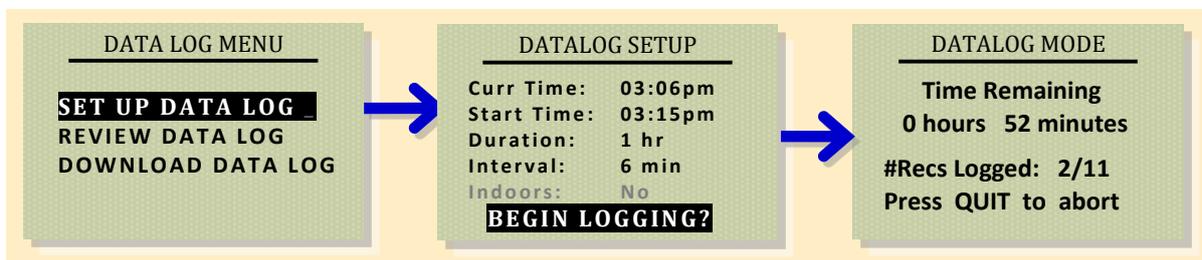
## Datalog Setup

From the **DATA LOG MENU** select SET UP DATA LOG. The **DATALOG SETUP** menu then displays the configurable values for the data logging operation.

These include the **Start Time** for commencement of logging, the **Duration** to log for and the time **Interval** between logs.

To change the **Start Time**, **Duration** and **Interval** to your requirements, use the **ENTER** to initiate the ability to change the values for each. Use the cursor to step up and down to the required item and then press the **ENTER**. This will allow you to change the value using the cursor pad. When finished changing the particular item press the **ENTER** again and it will allow you to step to another selection.

The Curr Time (Current Time) cannot be altered in this menu and if required to do so should be set in the System Setup menu.



**Start Time** is when logging starts and can be set in **15** minute increments up to 23 hours in advance.

**Duration** is the number of hours for a log session and can be set to **1, 2, 4, 8, 12, 16, 24** hours.

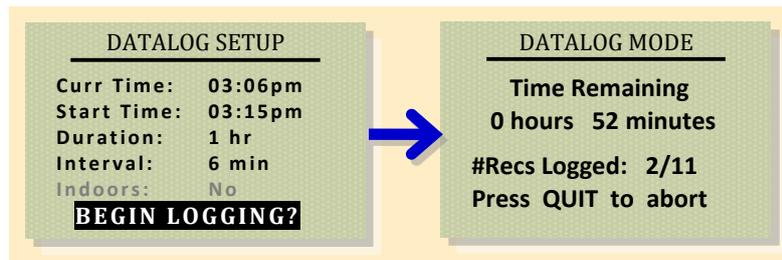
**Interval** is how often the HSM takes a sample and can be set to **6, 12, 15, 30, 60** minutes.

## Datalog Start

To start logging press the **ENTER**. The HSM **DATALOG MODE** screen will then indicate the current state of the logging.



Starting the Datalog will erase any previous logs.



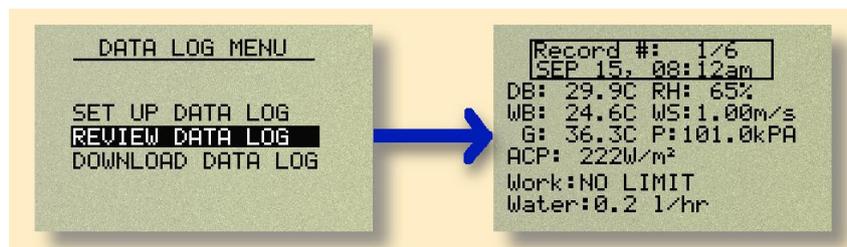
This mode has a 30 second screen shutdown mode to save battery power. The screen display will be blank but can be re-activated by briefly pressing any button on the HSM.

**#Recs Logged** is the Number of records logged of the number of records to be logged within then duration selected.

When logging has reached the duration that you have set and finished, the screen will display the total number of logged records and a message indicating LOGGING COMPLETE.

## Datalog Review

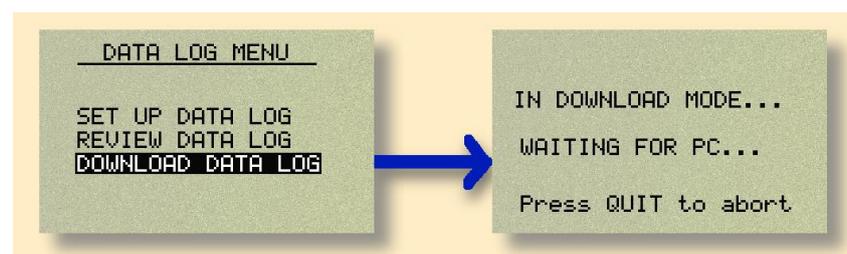
The REVIEW DATA LOG allows each individual log to be viewed. The number of records logged, and the current record being viewed are displayed at the top of the screen. When you select REVIEW DATA LOG it will start from the first record in the log.



To view other records use the Cursor pad RIGHT arrow to move forward through the record numbers and LEFT to step backwards. The UP and DOWN arrows will also step you forwards and backwards to the required records. Press **QUIT** to return to the DATA LOG MENU.

## Datalog Download

The HSM can be connected to a computer to download logged information captured by the HSM. The data is presented in a format that can be imported into Microsoft Excel™. When connecting to the PC the screen shown below will be displayed.



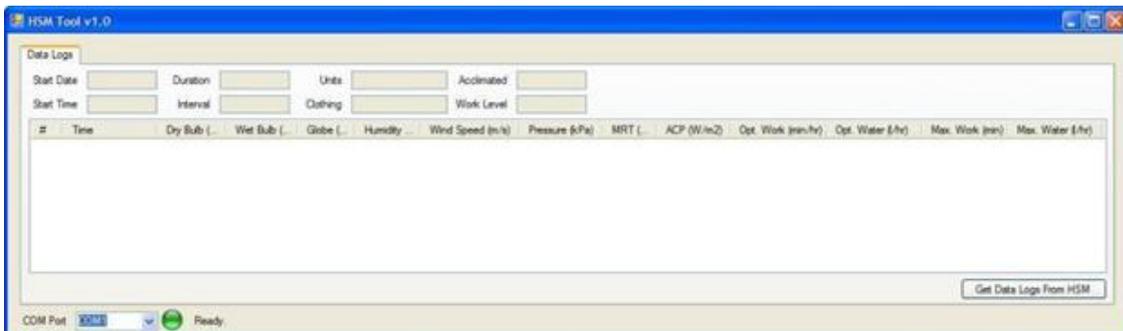
# PC Interface

A software download package called the **HSM Tool v1.0** is available on CD when purchased with the optional **Download Cable**. See the “Accessories” section at the end of this manual. This will allow connection between the HSM and the computer for downloading the logged data.

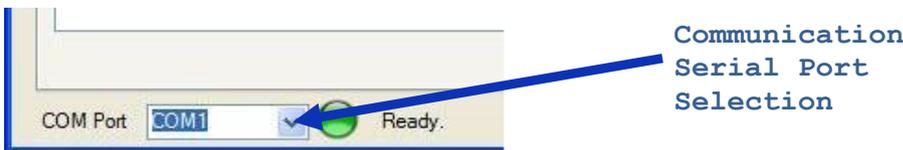


Install the HSM Tool from your CD onto your PC by running the **setup.exe** then do the following steps.

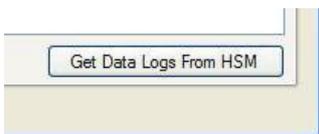
1. Plug the HSM Download Cable into the side of the HSM and make sure it is connected to a serial port on your PC (USB Serial Cables also work).
2. Start the HSM Tool Program. The HSM Tool will display the following screen.



3. Select the Serial / COM (communication) port on the Computer you are using from the pull down list. Then then click on the Get Data Logs From HSM button.



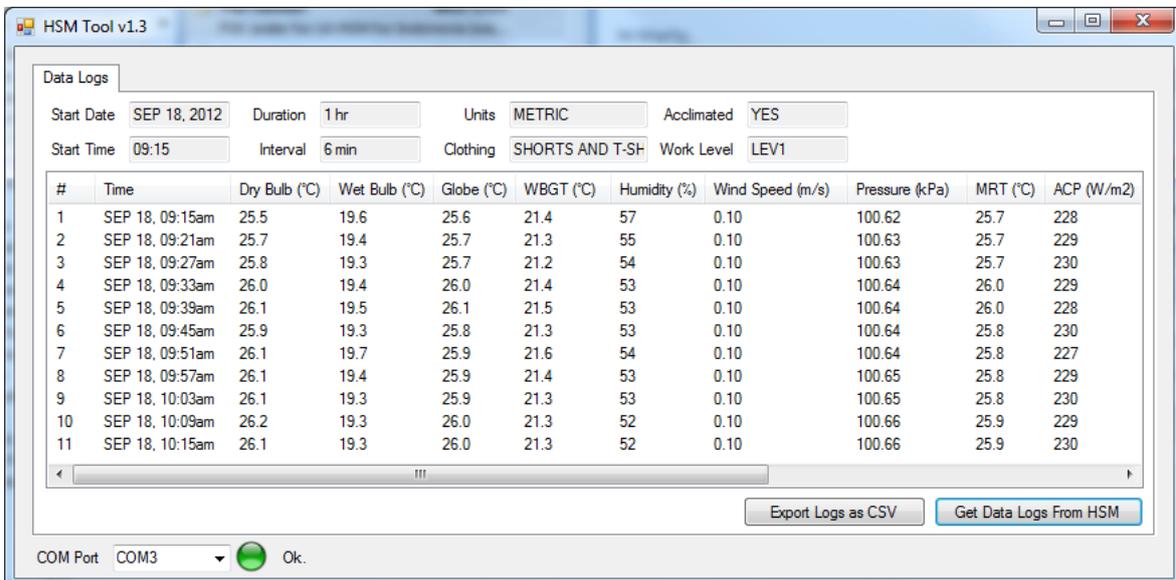
4. Then then click on the **Get Data Logs From HSM** button.



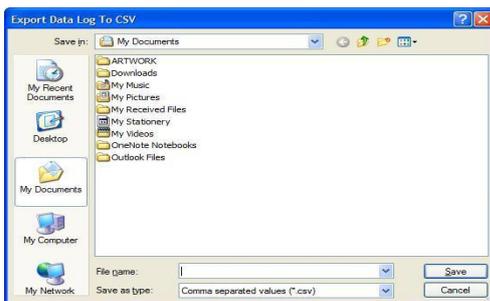
5. If the HSM is NOT plugged in or the Serial COM Port is incorrect then then a Dialog will then prompt you to **Check serial port and make sure HSM is in DOWNLOAD DATA LOG page**. To place the HSM into download mode see previous section in this manual titled “Datalog Download”.



6. After the utility has transferred the data logs from the HSM it will be display as below.



7. To save the data as a file. Press the Export Logs as CSV button and the following screen will appear.



8. Give the file a name preferably containing the current date and then press the Open Button to save. This will then create a CSV file suitable for use with Microsoft Excel™.

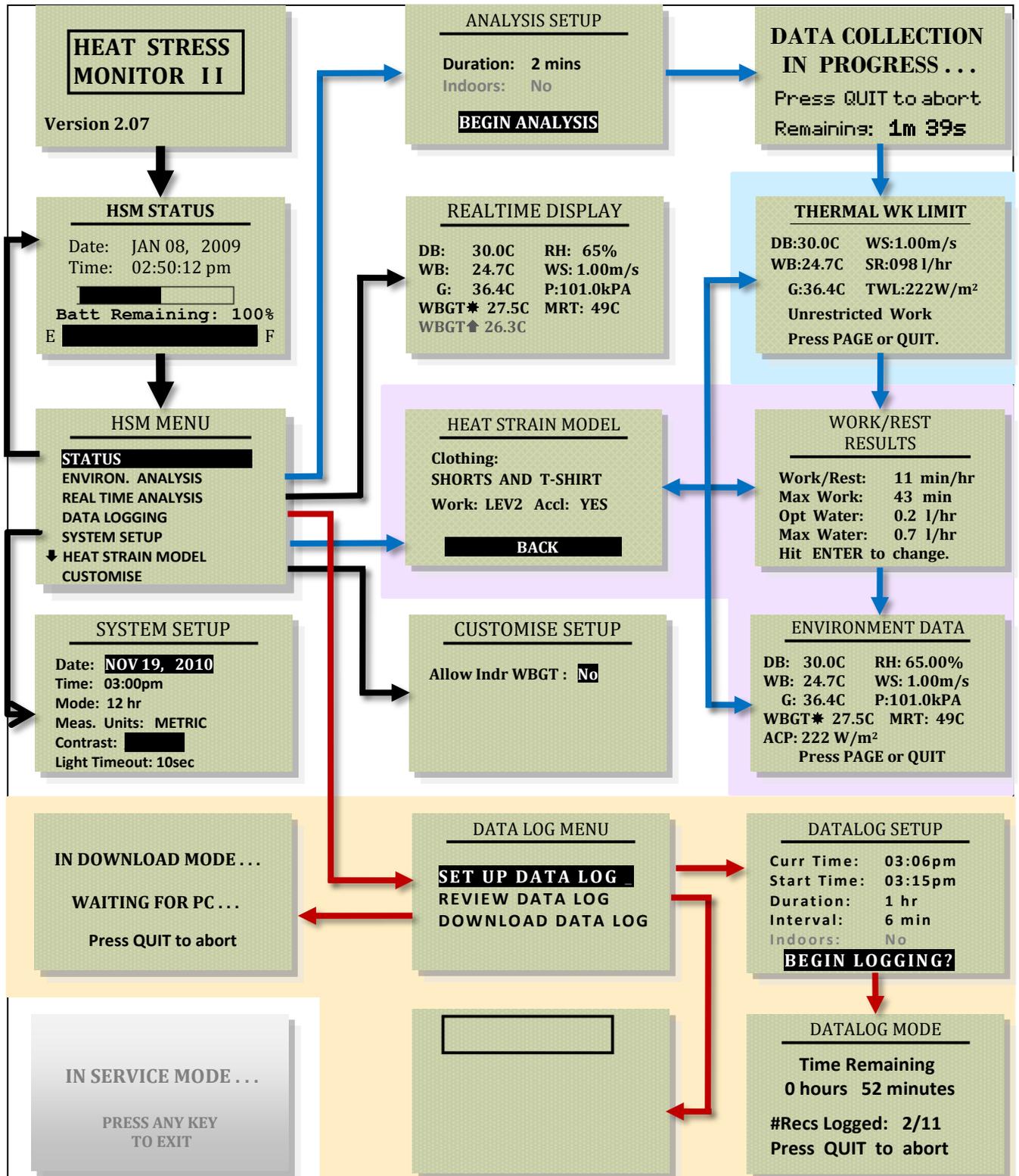
You can now open the saved logs with Microsoft Excel or any program that can read CSV formatted files.



CHAPTER 6

# MENU SYSTEM

The diagram below shows the general structure of the menu system with emphasis placed on the two main functional groups such as Environmental Analysis and Data Logging.



 The SERVICE MODE is for factory calibration only. Pressing any button will exit this mode.

## CHAPTER 7

# TROUBLESHOOTING

The HSM is a sophisticated electronic instrument and whilst it is small and compact it still needs to be treated as delicate equipment. This means keeping it protected when not in use and with the external sensors folded back into the HSM case.

Fault finding is confined to a few simple procedures that can be performed by the user.

## NO DISPLAY

The HSM will indicate when batteries are getting low. But if they are completely drained then the HSM cannot display anything. See BATTERY PROBLEMS below.

## SENSORS NOT WORKING OR DISPLAYING CORRECTLY

Check that the sensors have not been broken or damaged in any way. It is unlikely that the electronics would be faulty and more likely to be sensor damage or failure.

The HSM may display a SENSOR ERROR message which will require the HSM to be returned to Calor Instruments Pty Ltd at the address shown on Page iii of this manual or to your local distributor.

## LCD DISCOLOURING

In extreme direct heat the LCD, even though it is a high temperature device may discolour and go dark. This is normal but if this should happen it is better to provide some form of shade to allow the LCD unit to cool down. Once cooled down the display will return to normal operation.

## DATA LOGGING DOWNLOAD CABLE

The data logging download cable, if purchased, is wired to fit between a HSM and the Serial communications port (RS-232) of your computer. If you have trouble with the cable not working please check with your computer manual as it may be wired in a different manner than the HSM standard cable.

## BATTERY PROBLEMS

A single flat battery can prevent good batteries from working so either check each battery with a multimeter or a battery tester if available. If in doubt then replace ALL the batteries with known good ones.



Check that the battery terminal clips on the HSM wires have not been broken or corroded. These are located in the sealed black rubber cover in the sensor storage void.

Do not leave the batteries in the unit for extended periods – such as longer than 1 year as poor quality batteries may leak chemicals into the HSM corrode the contacts and even destroy the circuitry.

Use only Alkaline or better batteries as these have longer shelf lives, but even these batteries can leak if they become fully discharged.

---

## Error Results

When the HSM range of measurement has been exceeded or the environment conditions were too unstable, then several values / results will display errors such as, INVALID, OUT OF RANGE, TOO HIGH or UNKNOWN. For more information see the paragraph titled Error Results on page 15 within the section called Understanding the Results.

---

## Calibration

The sensors of the HSM require regular annual calibration. This should be scheduled in a maintenance program to ensure correct information is provided to the user. The calibration requires specialised equipment to do this and as such the unit should be returned to your distributor or to **Calor Instruments Pty Ltd** at the address shown on Page iii of this manual.

---

# GLOSSARY

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## Terms and Abbreviations

ACP	Air Cooling Power
BGT	Black Globe Temperature. Measurement of Radiated / solar temperature.
Celsius	The Metric unit of temperature also known as Centigrade. $^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 5/9$
CD	CD-ROM. Compact Disk – Read Only Memory.
COM	Communication. Usually Communications port such as serial.
CSV	Comma Separated Values
DB	Dry Bulb (Ambient Temperature value)
Fahrenheit	The Imperial / English unit of temperature. $^{\circ}\text{F} = ^{\circ}\text{C} \times 9/5 + 32$
G	Globe. See BGT
grams	Metric (SI) unit of mass
HSM	Heat Stress Monitor
Kilopascal	1000 Metric Pascal units of air pressure
LCD	Liquid Crystal Display
m	Metres
Metric	Metric System of Measurement. (See SI)
Miles	Imperial unit of distance
MRT	Mean Radiant Temperature
NIOSH	National Institute for Occupational Safety and Health
P	Pressure. (The atmospheric / barometric air pressure)
Pascal	Metric unit of Air pressure
PC	Personal Computer
RH	Relative Humidity. See Definitions for more information.
Relative Humidity	Percentage of humidity. The amount of water vapor within the air.

RS-232	Recommended Standard 232. A standard of serial communications for computers.
SI	International System of Units
SR	Sweat Rate
TWL	Thermal Work Limit
USARIEM	United States Army Research Institute of Environmental Medicine
W	Watt. Derived unit of power. One watt is equivalent to 1 joule of energy per second.
WB	Wet Bulb
WBGT	Wet Bulb Globe Temperature
WS	Wind Speed

## DEFINITIONS

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### Acclimatisation

It has been well documented that when people work in a hot environment for the first time, their work performance is reduced, their heart rate and core temperature increases, and they are more prone to heat disorders, such as heat syncope and heat exhaustion and the far more serious condition of heat stroke.

Acclimatisation advantages a person by:

- Increasing the plasma volume by up to 25%.
- Reducing the sodium lost in sweat by up to 50%
- Increasing the sweat rate
- Initiating sweat onset earlier
- Redistributing blood to the periphery more efficiently.
- Production of heat shock proteins which reduces thermal injury to cells.

The duration of time it takes to bring about these adaptive changes varies depending on whether the person is active in the heat and the duration of heat exposure. It is generally thought that 4-5 days is sufficient to acquire a good percentage of the advantageous adaptation however, to fully acclimatise takes at least 14 days exposure.

A new worker may require work hardening and/or acclimatisation prior to commencing a physically demanding job in a hostile climate; recognition of this must be incorporated into heat management protocols.

Reference: [www.pointhealth.com.au/pdf/heat%20illness](http://www.pointhealth.com.au/pdf/heat%20illness)

---

### Air Cooling Power

Is the cooling power of the air on a sweating person, measured in watts per square meter of body surface area. Clothing has a major impact on the ability of the body to cool itself via sweating as the following Air Cooling Power calculations shows:

Environmental conditions: 28° C wet bulb air temperature, air speed 1 m/s:

ACP for unclothed body	313 W/m <sup>2</sup>
ACP for lightly clothed body	168 W/m <sup>2</sup>
ACP for heavily clothed body.	127 W/m <sup>2</sup>

Key issues for clothing include: fabric vapour permeability and conductivity, clothing design (ventilation, e.g. “bagginess”), amount of clothing and type of personal protective equipment. For example. Wearing leather boots is better than impermeable rubber boots.

---

## Dew Point

The dew point is the temperature to which a given parcel of humid air must be cooled, at constant barometric pressure, for water vapour to condense into water. The condensed water is called dew. The dew point is a saturation temperature.

The dew point is associated with relative humidity. A high relative humidity indicates that the dew point is closer to the current air temperature. Relative humidity of 100% indicates the dew point is equal to the current temperature and the air is maximally saturated with water. When the dew point remains constant and temperature increases, relative humidity will decrease.

---

## Dry-Bulb Temperature

The dry-bulb temperature is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture. Dry bulb temperature is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature.

---

## Mean Radiant Temperature (MRT)

Is defined as the uniform temperature of a surrounding surface giving off blackbody radiation (emissivity  $e = 1$ ) which results in the same radiation energy gain on a human body as the prevailing radiation fluxes which are usually very varied under open space conditions.

MRT is the most important parameter governing human energy balance, especially on hot sunny days.

MRT also has the strongest influence on thermo physiological comfort indexes such as PET (Physiological Equivalent Temperature) or PMV (Predicted Mean Vote) which are derived from heat exchange models. Another definition of MRT is the MRT of non-uniform environment (e.g., walls, overhead, deck and objects of different emissivity at different temperatures) is defined as the temperature of a uniform black enclosure in which a solid body or an occupant would exchange the same amount of radiant heat as in the given non-uniform environment. It is estimated from dry-bulb and globe temperatures and air movement and is useful in determining radiative heat transfer (net gain or loss) relative to humans.

---

## Relative Humidity

The relative humidity of an air-water mixture is defined as the ratio of the partial pressure of water vapour in the mixture to the saturated vapour pressure of water at a prescribed temperature. Relative humidity is expressed as a percentage and is defined in the following manner.

$$RH = \frac{P(H_2O)}{P^*(H_2O)} \times 100\%$$

Where:

$RH$  is the relative humidity of the mixture being considered;

$P(H_2O)$  is the partial pressure of water vapour in the mixture; and

$P^*(H_2O)$  is the saturated vapour pressure of water at the temperature of the mixture.

---

## Thermal Work Limit

Thermal Work Limit is a heat stress index designed primarily for self-paced workers. It represents the limiting sustainable metabolic rate that a well hydrated, acclimatised worker can maintain in a specific thermal environment within safe limits of core body temperature and sweat rate.

---

## Wet Bulb Temperature (WB)

The wet-bulb temperature is a type of temperature measurement that reflects the physical properties of a system with a mixture of a gas and a vapour, usually air and water vapour.

For air that is less than saturated (100 percent relative humidity), the wet-bulb temperature is lower than the dry-bulb temperature; and the dew point temperature is less than the wet-bulb temperature.

Cooling of the human body through perspiration is inhibited as the wet-bulb temperature (and relative humidity) of the surrounding air increases.

---

## Wet Bulb Globe Temperature (WBGT)

The wet bulb globe temperature (WBGT) is a calculated temperature that was developed in the late 1950's for the US Marine Corps Recruit Depot on Parris Island South Carolina, to minimize heat stress during training. The index is calculated by measuring the natural wet bulb, globe temperature and dry bulb temperature. The calculated WBGT values are compared to reference values corresponding to different metabolic workloads to establish if the environment is excessive given the task being performed. Should the environment be excessive a work/rest cycling can be implemented for work to continue. The value is a time weighted average (TWA) based on the different tasks a particular person may perform over the shift. Some of the benefits of the WBGT are; it is relatively easy to measure, the instrumentation is simple and not excessively expensive. WBGT values are now used in the ISO 7243 standard and by NIOSH to set work limits.

# SPECIFICATIONS

## Physical

- Max Dimensions: 120mm x 94mm x 45mm (Due to the shape its volume is less)
- Weight: 370grams (with batteries)
- LCD: 119 x 73 pixel graphics

## Electrical

- Uses four standard AA-sized, 1.5V, alkaline batteries.
- Serial RS-232 Interface

The HSM uses the battery at different rates depending on the mode of operation as follows:

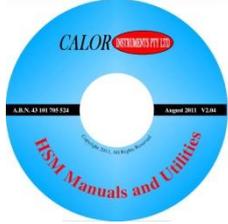
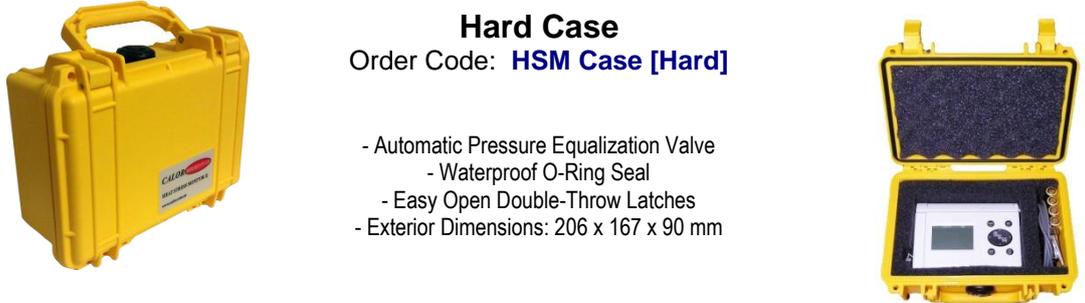
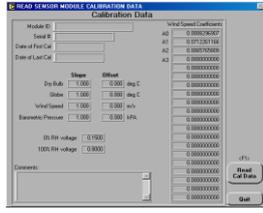
Mode	Average Current Drain	NOTES
Off	0 milliamps	
Logging	< 1 milliamp per hour (averaged over 1 hour)	Most battery efficient mode. The HSM only wakes up for a few milliseconds on each periodic to take a sample.
Menus	10 milliamps	Used when navigating through menus or reviewing, logs and results.
Backlight	20 milliamps	Backlight adds 20 milliamps to all display modes.
Real-Time Display	90 milliamps	This mode should be used sparingly

This table is a guide to the best way to operate the unit to maximise battery life.

## Sensor

- Dry bulb =  $\pm 0.2$  °C from 5-55 °C
- Globe =  $\pm 0.2$  °C from 5-70 °C
- Relative Humidity =  $\pm 2\%$  from 0-95% non condensing
- Pressure =  $\pm 1.5$  KPA from 40-115 KPA
- Wind speed =  $\pm 0.2$  m/sec or 10%, whichever is the greater, from 0.1-8.0 m/sec

# ACCESSORIES

<p><b>HSM Manuals and Utilities CD (Software)</b> Order Code: <b>HSM CD</b></p> 	<p><b>Replacement Sensor Module</b> Order Code: <b>HSM Sensor</b></p> 
<p><b>DC Plug Pack &amp; Download Cable – 2mtrs</b> Order Code: <b>HSM Serial [Cable – Plugpack]</b></p> <p>- Australian Format Plugpack AS3112 90V - 265V AC (Adaptor required for Countries other than Australia)</p> 	<p><b>Download Cable (Serial) – 2mtrs</b> Order Code: <b>HSM Serial [Cable]</b></p> <p><b>USB to RS232 Converter</b> Order Code: <b>PID 8523</b></p> 
<p><b>Hard Case</b> Order Code: <b>HSM Case [Hard]</b></p> <ul style="list-style-type: none"> <li>- Automatic Pressure Equalization Valve</li> <li>- Waterproof O-Ring Seal</li> <li>- Easy Open Double-Throw Latches</li> <li>- Exterior Dimensions: 206 x 167 x 90 mm</li> </ul> 	
<p><b>Tripod (Large)</b> Order Code: <b>HSM Tripod[Lg]</b></p> <ul style="list-style-type: none"> <li>- 3 way head with QR plate</li> <li>- Flip leg locking system</li> <li>- Max Height: 1305mm</li> <li>- Min Height: 420mm</li> <li>- Closed Length: 445mm</li> <li>- Weight: 0.86kg</li> <li>- Load Capacity: 3.0kg</li> </ul> 	<p><b>Tripod (Small)</b> Order Code: <b>HSM Tripod [Sm]</b></p> <ul style="list-style-type: none"> <li>- Max Height: 210mm</li> <li>- Min Height: 125mm</li> <li>- Closed Length: 130mm</li> <li>- Weight: 0.1kg</li> <li>- Load Capacity: 1.0kg</li> </ul> 
<p><b>Recalibration Service</b> Order Code: <b>HSM Recal</b></p> 	<p><b>Tripod mounting plate</b> Order Code: <b>HSM Tripod[MP]</b></p>  <p>Fits any tripod with a 1/4BSW thread</p>

