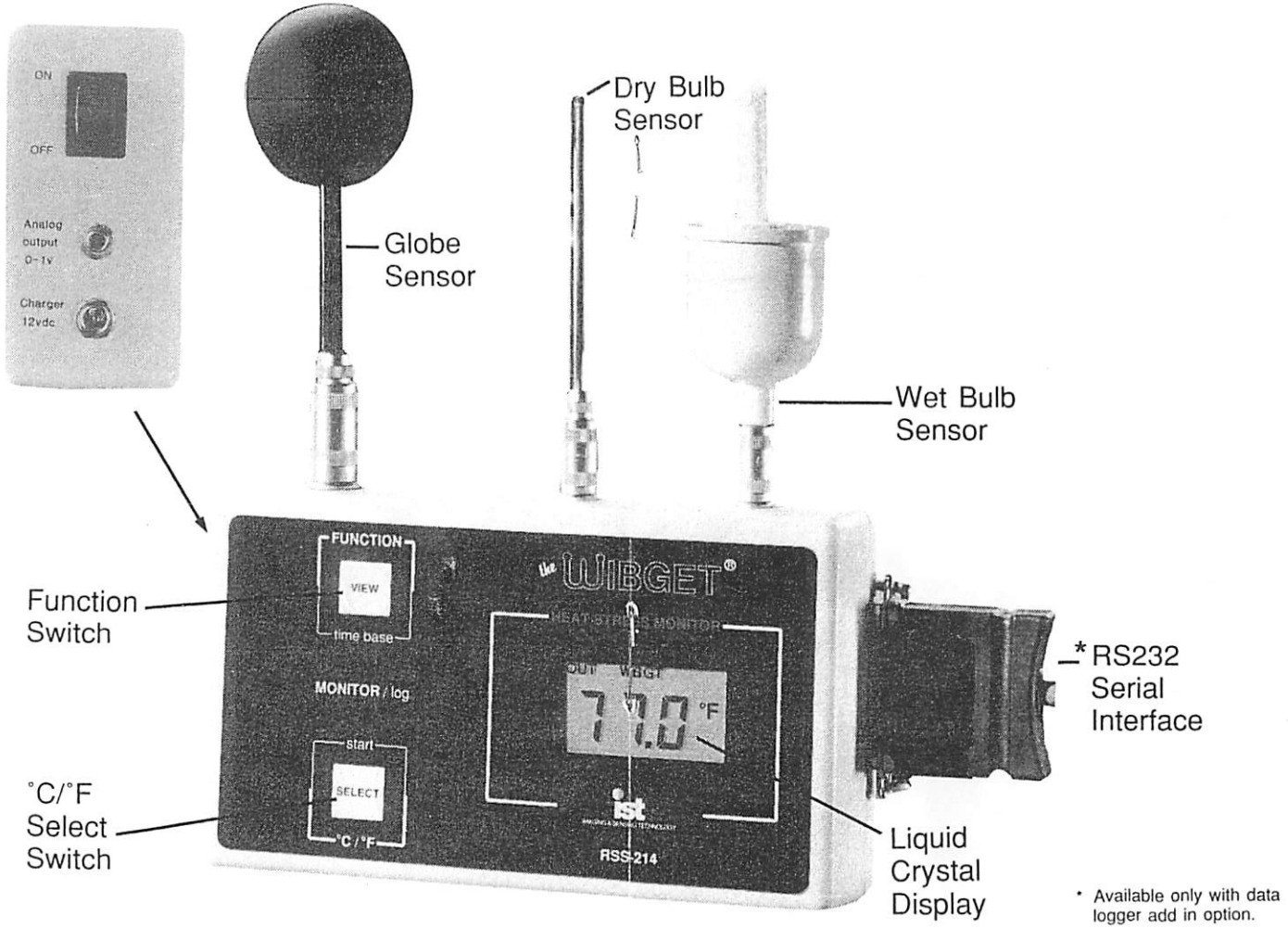
The RSS214 WiBGeT® with optional Data Logger/RS232 Communications Port



* Available only with data logger add in option.

WiBGeT® SPECIFICATIONS

Accuracy @ Air Speed = 180 fpm minimum

Within ranges below ± 0.3°C (± 0.5°F)

Ranges	°C	°F
Display	0 to 100+	32 to 199.9
Monitor	0 to 65	32 to 150
Sensors	0 to 100	32 to 210
Storage	-25 to 65	-10 to 150

Response

Electronic	<3 seconds
Sensors (90%)	<2.2 minutes
Sensors (95%)	<4.5 minutes

Battery

Operating Time	17 hr. nom.
Recharge Time	14 hr. nom.

Additional features

Analog/Recorder Output	10mV/°C ± 1mV

Data Logger/RS232C Port Option

Memory type	Nonvolatile
Communications standard	RS232C
Max. # of data sets	511
Auto. Log interval	0.5-30 minutes
Auto. log period	255 to 15,300 min.
- approximately	4.2 hr. to 10.6 days

EXIA LR84375

INTRINSICALLY SAFE WHEN USED WITH THE FOLLOWING SENSORS:

Dry Bulb	P/N	323-1402
Wet Bulb	P/N	323-1203
Globe Sensor	P/N	323-1003
Function Check Plug	P/N	323-2400
Personal Sensor Set	P/N	323-2220
Remote Sensor (10')	P/N	323-2200
Remote Sensor (20')	P/N	323-2201
Remote Sensor (50')	P/N	323-2202
Remote Sensor (100')	P/N	323-2203

NOTE: The supplied A.C. Adaptor is not intrinsically safe. The RS232 serial data output port is not to be used in a hazardous location.

Refer to Canadian Standards Association Standard C22.2 No. 157.

CONTENTS

INTRODUCTION

DESCRIPTION AND FEATURES:

The RSS-214 WiBGeT® is a hand held micro- processor based Wet Bulb Globe Thermometer which accurately measures environmental factors that contribute to heat stress.

Key WiBGeT® features are listed below:

Direct Measurement and Display of
- Wet Bulb Temperature (WB)
- Dry Bulb Temperature (DB)
- Vernon Globe Equivalent Temp. (GT)
- Indoor Wet Bulb Globe Temp. (IN WBGT)
  IN WBGT = 0.7WB + 0.3GT
- Outdoor Wet Bulb Globe Temp. (OUT WBGT)
  OUT WBGT = 0.7WB + 0.2GT + 0.1DB

Liquid Crystal Display - accurate and easy to read.

Celsius or Fahrenheit Operation - a push of the SELECT button switches scales.

Portability - its compact, light weight design makes the WiBGeT® a true hand held unit useable in almost any area.

Data Logging - with the optional add-in Data Logger/RS232C Port accessory, the WiBGeT® can log and store up to 511 complete measurement records (data sets), at preselected intervals, for later transmission to a printer or computer.

WHAT IS WBGT?:

The Wet Bulb Globe Temperature (WBGT) method and index are tools for the safe management of human Heat Stress exposure. WBGT is a weighted sum of DRY BULB, WET BULB and VERNON GLOBE temperatures.

Dry Bulb Temperature (DB) provides a measure of simple "ambient Temperature".

Wet Bulb Temperature (WB) provides a measure of evaporative cooling including affects of air speed and humidity. WB is always lower than DB.

VERNON (6" black) GLOBE temperature (GT) provides a measure of radiant heat load including air speed effects. The WiBGeT®'s 'PATENTED, FAST RESPONDING, MINI GLOBE' provides Tg where Tg = 2/3 GT + 1/3 DB. Fast, accurate response and compactness are hallmarks of the WiBGeT®.

The above temperatures (GT,WB,DB) are summed to generate WBGT as follows:

INDOOR WBGT = 0.7 WB + 0.3 TG
= 0.7 WB + 0.45 Tg - 0.15 DB

OUTDOOR WBGT = 0.7 WB + 0.2 TG + 0.1 DB
= 0.7 WB + 0.3 Tg

NOTE: Refer to the American Conference of Governmental Industrial Hygienists TLV's.

SETUP (see Figure 2 on page 16)

SENSOR INSTALLATION:
Remove the WiBGeT® monitor and its Dry Bulb, Wet Bulb and Globe sensors from the carry case. Holding each sensor in turn by its connector plug, align it vertically and rotationally with its receptacle (as indicated by symbols on top of the unit), then push it firmly into place. An audible 'click' indicates full engagement.

NOTE: DO NOT TWIST SENSORS ONCE ENGAGED!

WET BULB PREPARATION:
The Wet Bulb sensor requires careful attention to assure accuracy. Its wick (or sock) must be replaced at the first sign of discoloration, stiffness or poor wetting (see MAINTENANCE). Fill the reservoir and wet the wick using distilled (or demineralized) water. A bottle and demineralizer are provided. The Wet Bulb reservoir may be refilled, without impacting instrument readings, by adding room temperature water to the sponge (not to

the wick). Refilling is normally required daily. Conditions of low humidity, high temperature or high air speed may require more frequent refilling.

NOTE: The Wet Bulb wick must remain wet during operation to assure accuracy.

LOCATION AND ENVIRONMENT:
For optimum accuracy the sensors should be positioned in an open space within the work area, 3 to 6 feet (1 to 2m) above the floor/ground. For all practical purposes, accurate readings may be taken 3 to 5 min. after initial exposure to a new or changed environment. When radiant loading is high {GT = DB + 20°C (36°F)}, careful consideration must be given to shielding of the Dry Bulb sensor. For additional setup information see the American Conference of Governmental Industrial Hygienists - TLV's.

DO NOT expose the WiBGeT® meter to DB temperatures above 65°C (150°F). To monitor hotter environments, use a Remote Sensor Set accessory and relocate the meter to a cooler area.

KEEP ALL CONNECTORS CLEAN AND DRY. If a connector becomes wet, it must be thoroughly dried prior to instrument usage. Condition of the sensor receptacles may be tested by removing all sensors, turning the WiBGeT® on and checking that all functions read 0.0± 0.3°C or 32.0± 0.5°F.

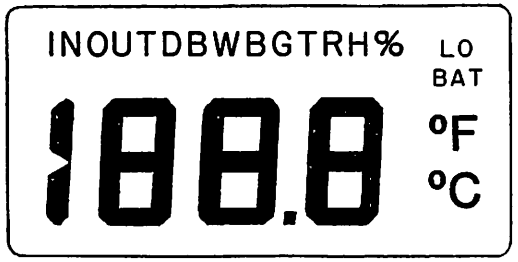


Figure 1
Fully Driven Display

OPERATION

POWER ON/SELF DIAGNOSTICS:

Rock the ON/OFF switch (located on unit's upper left side) to its ON position. Built in self diagnostics will immediately activate all display segments (see Figure 1 above). After five seconds the display will indicate "OUT WBGT" in °C. If the display remains blank (or fades) or if any segment fails to activate or if an "E #" code appears (even momentarily) or if the "LO BAT" indicator reappears anytime during operation, refer to MAINTENANCE.

MONITOR MODE:

Press SELECT to toggle between temperature scales (°C/°F).

Press VIEW to display the next parameter in the display loop; WB, DB, GT, IN WBGT, OUT WBGT, WB, DB,... Repeat as required.

ANALOG/RECORDER OUTPUT (monitor mode only)
An analog signal proportional to the display value [0 mV at 0.°C (32.0°F) to 1000 mV at 100.0°C (212.0°F)] is provided via a mini phone jack located on the monitor's lower left side. The recording device must have a minimum input impedance of 1000 ohms. Error is less than 0.1 C° relative to the display value.

OPTIONAL LOG MODE:

The Data Logger/RS232C Port accessory is a powerful WiBGeT® add-in option providing nonvolatile digital data storage and communications capabilities. Up to 511 data sets (record #, time and date and the five monitor functions) may be logged and stored for later transmission to most popular computers or serial printers. Logged data is fully secured against corruption or loss.

Logged data WILL NOT be lost if: - the unit is turned off - the sensors are removed - a battery failure occurs - the memory becomes full.

ENTER LOG MODE - depress and hold VIEW, press SELECT then release both. The display will read "AP." (APPEND). To append (add) data to that already in memory, press SELECT again. If not, press VIEW. In either case, the display now indicates the time interval used during your previous logging session. If you wish to activate log mode using this interval, simply press SELECT again, otherwise, proceed to INTERVAL SELECTION.

NOTE: Memory is cleared ONLY when "AP." is NOT chosen while entering LOG MODE.

INTERVAL SELECTION - available intervals are .0, 0.5, 1.0, 2.0, 5.0, 6.0, 10.0, 20.0, and 30.0 minutes. Press VIEW to display the next interval choice - repeat until the desired interval is displayed. Press SELECT to activate log mode using this interval (selecting .0 allows DEMAND LOGGING only). The display now functions as an auto-incrementing record counter.

DEMAND LOGGING - pressing SELECT while log mode is active (regardless of which interval was chosen previously) causes immediate logging of an additional data set. This allows manual control during periods of special interest, without otherwise affecting the logging process.

VIEW WHILE LOGGING - press and hold VIEW to see a current FUNCTION. To see the next FUNCTION, release VIEW and repeat.

EXIT LOG MODE - depress and hold VIEW, press SELECT then release both. The display will read one of the monitor functions indicating a return to the MONITOR MODE.

NOTE: 1) The WiBGeT® resets itself to MONITOR MODE when memory becomes full.

NOTE: 2) The WiBGeT® may be switched OFF at any time without ill effect.

COMMUNICATIONS MODE:

Logged data may be dumped to a printer or computer via the WiBGeT®'s RS232C serial communications port and interface cable. Switch selectable options are provided to accommodate various receiving devices.

Table 1

SWITCH		CHOICE	NOTES
1	* ON	1200 Baud	Transmission Rate
	OFF	300 Baud	
2	* ON	N/A	Not Used
	OFF	N/A	
3	ON	Headings	Printer Format
	* OFF	No Headings	Computer Format
4	* ON	Pin 2	Data Out Pin
	OFF	Pin 3	

Asterisks (*) indicate factory settings.

To change switch settings, access to the inside of the instrument is required. With the power OFF, remove the 4 screws at the rear of the instrument and carefully separate the rear case from the unit enough to gain access to the switch bank located just below the Globe Sensor jack. Using a ball point pen or other small implement, move each switch to its required position. Once complete, reinstall the rear case and screws. Regardless of which operating mode the WiBGeT® is in, it will respond to a data transmission request from any properly setup receiving device equipped with an RS232C serial port. Data may be transmitted while the WiBGeT® is logging without disruption of either activity. First, connect the WiBGeT® to your device via the serial interface cable provided then proceed.

DOWN LOADING TO A PRINTER - (see Table 2 on page 10) Ensure that both units are powered ON then switch the printer 'ON LINE' to force the RS232C DTR and RTS lines high. The WiBGeT® will immediately begin down loading headings followed by data. The display will indicate the current data set being transmitted. Once down loading is complete, switch the printer 'OFF LINE'

and the WiBGeT® will resume its prior to down loading operation.

UP LOADING TO A COMPUTER - (see Table 2). The user may require some technical knowledge of the computer/system and of serial data transfer conventions. The WiBGeT® will begin sending data as soon as DTR and RTS are activated by the computer. A menu driven program contained on the included software diskette provides controlled data handling with formatted screen and printer outputs. It also offers spread sheet (ASCII) data file creation and diskette storage tools. An IBM PC or compatible operating under PC DOS[1] or equivalent is required. Follow instructions on the diskette label and stored in the READ.ME file.
Once your data has been up loaded/stored, you may retrieve and manipulate it as needed using the power of the computer. Formerly tedious calculational tasks such as determining time-weighted-average WBGT become automatic and error free.

[1] registered trade mark of Micro-Soft Inc.

If other software is preferred or the software provided is not compatible with your computer system, contact IST for application assistance.

MAINTENANCE

WET BULB:
Operation with a fouled wick can lead to errant (high) readings.

WICK REPLACEMENT: To replace a fouled wick, pull it and its sponge straight upwards over the sensor. Slide a new, clean, proper fitting, cotton wick over the sensor such that it reaches the bottom of the reservoir and fits snugly over the tip. To prevent water spillage, a snugfitting annular sponge should be placed over the wick encased sensor and positioned in the mouth of the reservoir.

NOTE: Dampening the sponge and wick facilitates removal and replacement.

RSS-214 WiBGeT DATA

Upload Data: 1991/05/01 Time : 9:03 File: DEMO.WBG Desc: DEMO

RECORD NUMBER	TIME (hh:mm)	WET BULB	DRY BULB	GLOBE	WBGT IN	WBGT OUT	WBGT TWH	METABOLIC RATE	METABOLIC TWH
TEST: 91/04/26 LOCATION:					CLO VALUE:	0.0			
1	9:23	22.2	22.0	23.5	22.6	22.5			
2	9:25	15.9	21.2	23.2	18.1	17.9			
3	9:27	12.6	16.1	24.9	16.3	15.4			
4	9:29	18.8	35.0	36.5	24.1	24.0			
5	9:31	20.9	37.4	43.1	27.5	26.9			
6	9:33	20.7	36.1	36.3	25.4	25.3			
7	9:35	19.7	33.2	30.1	22.8	23.1			
8	9:37	18.9	31.5	28.4	21.7	22.1			
9	9:39	18.4	30.2	27.6	21.1	21.4			
10	9:41	18.0	29.6	25.7	20.3	20.7			
11	9:43	17.6	28.5	25.5	19.9	20.2			
TEST: 91/04/27 LOCATION: SITE "A"					CLO VALUE:	1.0			
12	10:16	14.4	19.0	21.5	16.5	16.3		0.3	
13	10:26	13.6	18.8	20.3	15.6	15.5		0.3	
14	10:36	14.1	18.3	20.9	16.1	15.9		0.3	
15	10:46	13.6	18.0	19.6	15.4	15.2	15.4	0.3	0.3
16	10:56	13.5	17.6	19.0	15.2	15.0	15.2	0.3	0.3
17	11:06	13.2	17.0	18.4	14.8	14.6	15.3	0.3	0.3
18	11:16	13.1	16.8	18.1	14.6	14.5	15.2	0.3	0.3
19	11:26	13.3	18.0	18.8	14.9	14.8	15.2	0.4	0.4
20	11:36	14.2	18.7	21.0	16.2	16.0	15.2	0.6	0.4
21	11:46	14.0	17.8	19.8	15.7	15.5	15.2	0.5	0.4
22	11:56	13.5	17.4	19.0	15.2	15.0	15.5	0.4	0.4
23	12:06	13.4	17.1	18.7	15.0	14.8	15.6	0.3	0.4
24	12:16	13.4	18.2	19.2	15.1	15.0	15.5	0.3	0.3
25	12:26	14.4	19.1	21.4	16.5	16.3		0.3	
26	12:36	14.1	18.2	20.1	15.9	15.7		0.4	
27	12:46	13.7	17.6	19.3	15.4	15.2		0.4	
TEST: 91/04/28 LOCATION:					CLO VALUE:	0.0			
28	22:54	17.3	22.8	22.1	18.8	18.8			
29	23:00	17.3	27.3	26.9	20.2	20.2			
30	23:06	17.4	27.5	26.7	20.2	20.3			
31	23:12	17.4	27.6	27.0	20.3	20.4			
32	23:18	17.5	27.5	27.1	20.3	20.4			
33	23:24	17.4	27.2	27.1	20.3	20.3	20.2		
34	23:30	17.6	27.7	27.4	20.5	20.5	20.4		
35	23:36	17.3	27.3	27.2	20.3	20.3	20.4		
36	23:42	17.5	27.8	27.3	20.4	20.5	20.5		
37	23:48	17.7	28.5	27.5	20.6	20.7			
38	23:54	17.7	28.4	27.8	20.7	20.8			
39	0:00	17.7	28.4	27.6	20.7	20.8			
40	0:06	17.9	28.8	27.9	20.9	21.0			
41	0:12	17.9	28.0	27.9	20.9	20.9			

Table 2
Typical Printer/Screen Output

WATER TREATMENT: For maximum accuracy and extended wick life, distilled water should be used (available from most pharmacies). Alternately, demineralized tap water may be used - be sure to follow instructions supplied with the demineralizer carefully.

BATTERY: The WiBGeT® is powered by a rechargeable 9v (8.4v) Nickel Cadmium battery and comes with an external charger.

CHARGING: When the battery becomes near fully discharged, "LO BAT" appears in the upper right-hand corner of the display. For continued/continuous operation or to simply recharge the battery, connect the charger via its receptacle (12vdc) located on the lower left side of the monitor. Recharging requires a minimum of 12 hours. Although Nickel Cadmium batteries may be recharged many times, they eventually degrade, requiring replacement.

REPLACEMENT: With the power 'OFF', remove all four corner screws from the rear case and open the instrument. Noting the battery's location, replace it. Reinstall the rear case using the reverse process.

GENERAL CARE- CLEANING: To clean external surfaces, use a soft wipe/tissue dampened with a mild detergent in warm water solution.

STORAGE: Remove each sensor by pulling straight up (DO NOT TWIST) on its connector collar. Empty the Wet Bulb reservoir and squeeze excess water from its sponge. Return all items to their proper location in the carry case.

CALIBRATION:

Routine checking of functional accuracy may be performed using the optional Function Check Plug. With all three sensors removed, simply insert this Check Plug into the Globe Sensor socket and set the ON/OFF switch to ON. Readings of 25.0 ± 0.3°C (77.0 ± 0.5°F) for all functions indicate that the WiBGeT®'s electronics (excluding sensors) are operating within acceptable limits. CERTIFICATION OF CALIBRATION (including sensors) traceable to national temperature standards is available direct from the manufacturer. If traceable certification is required, IST Canada should be contacted directly. Under normal conditions, it is recommended that the WiBGeT® be recertified yearly.

TROUBLESHOOTING:

SYMPTOM	CAUSE	SOLUTION
Unit doesn't respond when switched on.	Battery/ charger failing.	Replace battery and charger.
Battery period too short.	Battery/ charger failing.	Replace battery and charger.
Very high reading(s).	Connector wet.	Rinse - alcohol, check per pg 6.
WiBGeT® sends data but PC does not receive.	Internal switch #4 setting incorrect.	Reset switch #4 then cold boot PC to reset comm port.
Computer or printer produces nonsense.	Internal switch #1 setting incorrect.	Set to alternate position (switch baud rates - 300 or 1200).
Computer locks up or printer produces single column.	Internal switch #3 setting incorrect.	Set to alternate position (switch format - printer or computer).

If an 'E' Code appears on the display (even momentarily) during POWER ON/SELF DIAGNOSTICS, refer to the following:

CODE	PROBABLE CAUSE	SOLUTION
E1, E2, E3	Component failure	Return for repair
E4, E5	Analog O/P out of calibration	Adjust Trim R to 250mv at 25.0°C
E6GT E6WB E6DB	Sensor specific malfunction	Plug in/replace affected sensor(s)
E7 E8	Memory failure or Low battery	Return for repair Recharge/replace

FACTORY RETURN INSTRUCTIONS: If your WiBGeT® should require factory service you will need a Returned Material Report authorization number (RMR#). This may be obtained by contacting the factory at 1-800-432-1478. If you are returning the unit from outside the U.S., your WiBGeT® will be subjected to a government program called 'customs clearance'. The delays caused by the customs proceedings can be minimized if you do the following:

1) Enclose a note on letterhead stating - "This package contains one instrument Model _____, serial # _____. It is the property of the undersigned and is being sent to U.S. for repair and will be returned. The value of this instrument, for customs purposes, is $ _____.

2) Place the note in an envelope marked 'CUSTOMS PAPERS', and affix the envelope to the outside of the shipping carton.

3) In addition, once you have obtained an RMR# from the factroy, please note on the outside of the package "RMR# _____ HEAT STRESS MONITOR ENCLOSED".

You will be contacted as soon as an estimate of the repair has been established. Standard repair time is 10 working days after receipt of the unit.

PART AND ACCESSORY ORDERS

To order, contact your local distributor. If in doubt; phone, fax or write the factory (see outside back cover).

REPLACEMENT PARTS and their part numbers:

- Wet Bulb Service Kit 323-5020
  demineralizer, 6 wicks, 2 sponges
- Wet Bulb Sensor 323-1203
- Dry Bulb Sensor 323-1402
- Globe Sensor 323-1003
- Charger and Battery 323-5025
- Instruction Manual 326-0205
- Carry Case 323-2608

ACCESSORIES:

- Function Check Plug 323-2400
  provides reference inputs in place of sensors - adds confidence.
- Remote Sensor Set/Extension 323-220x
  in lengths of: 3m, 6m, 15m, 30m, 60m allows remote measurements of hostile environments up to 100°C (210°F).
- Personal Sensor Set 323-2220
  hard hat mounted for hands free surveying and mobile monitoring.
- Data Logger/RS232C Port 323-5030
  c/w interface cable and software selectable interval, digital, data logging and digital communications.

An Excerpt of

1996

TLVs® and BEIs®

Threshold Limit Values for Chemical Substances and Physical Agents Biological Exposure Indices

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ACGIH WORLDWIDE

HEAT STRESS

The heat stress TLVs specified in Table 1 and Figure 1 refer to heat stress conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. These TLVs are based on the assumption that nearly all acclimatized, fully clothed (e.g., lightweight pants and shirt) workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (100.4°F).

Where there is a requirement for protection against other harmful substances in the work environment and additional personal protective clothing and equipment must be worn, a correction to the Wet Bulb Globe Temperature (WBGT) TLV values, as presented in Table 2, must be applied.

Since measurement of deep body temperature is impractical for monitoring the workers' heat load, the measurement of environmental factors is required which most nearly correlate with deep body temperature and other physiological responses to heat. At the present time, the WBGT Index is the simplest and most suitable technique to measure the environmental factors. WBGT values are calculated by the following equations:

1. Outdoors with solar load:
   $WBGT = 0.7\ NWB + 0.2\ GT + 0.1\ DB$
2. Indoors or Outdoors with no solar load:
   $WBGT = 0.7\ NWB + 0.3\ GT$

where: WBGT = Wet Bulb Globe Temperature Index
NWB = Natural Wet-Bulb Temperature
DB = Dry-Bulb Temperature
GT = Globe Temperature

The determination of WBGT requires the use of a black globe thermometer, a natural (static) wet-bulb thermometer, and a dry-bulb thermometer.

Higher heat exposures than those shown in Table 1 and Figure 1 are permissible if the workers have been undergoing medical surveillance and it has been established that they are more tolerant to work in heat than the average worker. Workers should not be permitted to continue their work when their deep body temperature exceeds 38°C (100.4°F).

Evaluation and Control

I. *Measurement of the Environment*

The instruments required are a dry-bulb, a natural wet-bulb, a globe thermometer, and a stand. The measurement of the environmental factors should be performed as follows:

TABLE 1. Examples of Permissible Heat Exposure Threshold Limit Values [Values are given in °C and (°F) WBGT]*

Work–Rest Regimen	Work Load		
	Light	Moderate	Heavy
Continuous work	30.0 (86)	26.7 (80)	25.0 (77)
75% Work — 25% Rest, each hour	30.6 (87)	28.0 (82)	25.9 (78)
50% Work — 50% Rest, each hour	31.4 (89)	29.4 (85)	27.9 (82)
25% Work — 75% Rest, each hour	32.2 (90)	31.1 (88)	30.0 (86)

*As workload increases, the heat stress impact on an unacclimatized worker is exacerbated (see Figure 1). For unacclimatized workers performing a moderate level of work, the permissible heat exposure TLV should be reduced by approximately 2.5°C.

A. The range of the dry and the natural wet-bulb thermometer should be –5°C to +50°C (23°F to 122°F) with an accuracy of ± 0.5°C. The dry bulb thermometer must be shielded from the sun and the other radiant surfaces of the environment without restricting the airflow around the bulb. The wick of the natural wet-bulb thermometer should be kept wet with distilled water for at least 1/2 hour before the temperature reading is made. It is not enough to immerse the other end of the wick into a reservoir of distilled water and wait until the whole wick becomes wet by capillarity. The wick should be wetted by direct application of water from a syringe 1/2 hour before each reading. The wick should extend over the bulb of the thermometer, covering the stem about one additional bulb length. The wick should always be clean and new wicks should be washed before using.

B. A globe thermometer, consisting of a 15-cm (6-inch) diameter hollow copper sphere painted on the outside with a matte black finish or equivalent, should be used. The bulb or sensor of a thermometer (range –5°C to +100°C [23°F to 212°F] with an accuracy of ± 0.5°C) must be fixed in the center of the sphere. The globe thermometer should be exposed at least 25 minutes before it is read.

TABLE 2. TLV WBGT Correction Factors in °C for Clothing

Clothing Type	Clo Value*	WBGT Correction
Summer work uniform	0.6	0
Cotton coveralls	1.0	–2
Winter work uniform	1.4	–4
Water barrier, permeable	1.2	–6

Clo: Insulation value of clothing. One clo unit = 5.55 kcal/m²/hr of heat exchange by radiation and convection for each °C of temperature difference between the skin and adjusted dry-bulb temperature.

C. A stand should be used to suspend the three thermometers so that they do not restrict free air flow around the bulbs, and the wet-bulb and globe thermometers are not shaded.

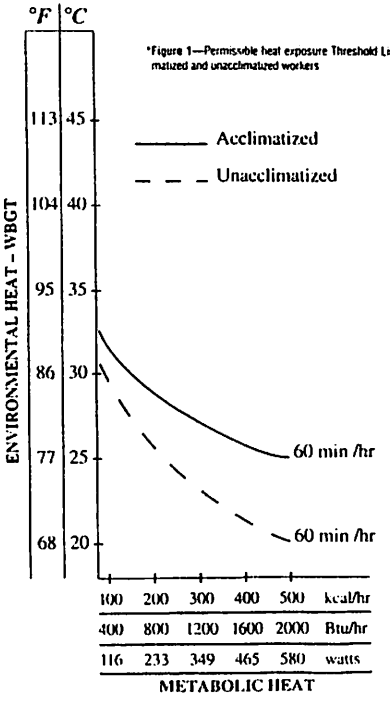

*Figure 1—Permissible heat exposure Threshold Limit Values for heat acclimatized and unacclimatized workers

D. It is permissible to use any other type of temperature sensor that gives a reading identical to that of a mercury thermometer under the same conditions.

E. The thermometers must be placed so that the readings are representative of the conditions under which the employees work or rest, respectively.

II. *Work Load Categories*

Heat produced by the body and the environmental heat together determine the total heat load. Therefore, if work is to be performed under hot environmental conditions, the workload category of each job should be established and the heat exposure limit pertinent to the workload evaluated against the applicable standard in order to protect the worker exposure beyond the permissible limit.

A. The work load category may be established by ranking each job into light, medium, or heavy categories on the basis of type of operation:

(1) light work (up to 200 kcal/hr or 800 Btu/hr): e.g., sitting or standing to control machines, performing light hand or arm work,

(2) moderate work (200–350 kcal/hr or 800–1400 Btu/hr): e.g., walking about with moderate lifting and pushing, or

(3) heavy work (350–500 kcal/hr or 1400– 2000 Btu/hr): e.g., pick and shovel work.

Where the work load is ranked into one of said three categories, the permissible heat exposure TLV for each workload can be estimated from Table 1 or calculated using Tables 3 and 4.

B. The ranking of the job may be performed either by measuring the worker's metabolic rate while performing a job or by estimating the worker's metabolic rate with the use of Tables 3 and 4. Additional tables available in the literature[1–4] may be utilized also. When this method is used, the permissible heat exposure TLV can be determined by Figure 1.

III. *Work–Rest Regimen*

The TLVs specified in Table 1 and Figure 1 are based on the assumption that the WBGT value of the resting place is the same or very close to that of the workplace . Where the WBGT of the work area is different from that of the rest area, a time-weighted average value should be used for both environmental and metabolic heat.

The time-weighted average metabolic rate (M) should be determined by the equation:

$$\text{Av. } M = \frac{M_1 \times t_1 + M_2 \times t_2 + \ldots + M_n \times t_n}{t_1 + t_2 + \ldots + t_n}$$

TABLE 3. Assessment of Work Load

Average values of metabolic rate during different activities.

A. Body position and movement	**kcal/min**
Sitting	0.3
Standing	0.6
Walking	2.0–3.0
Walking up hill	add 0.8 per meter (yard) rise

B. Type of Work		**Average kcal/min**	**Range kcal/min**
Hand work	*light*	0.4	0.2–1.2
	heavy	0.9	
Work with one arm	*light*	1.0	0.7–2.5
	heavy	1.7	
Work with both arms	*light*	1.5	1.0–3.5
	heavy	2.5	
Work with body	*light*	3.5	2.5–15.0
	moderate	5.0	
	heavy	7.0	
	very heavy	9.0	

where M_1, M_2...and M_n are estimated or measured metabolic rates for the various activities and rest periods of the worker during the time periods t_1, t_2...and t_n (in minutes) as determined by a time study.

The time-weighted average WBGT should be determined by the equation:

$$\text{Av. WGBT} = \frac{WBGT_1 \times t_1 + WBGT_2 \times t_2 + \ldots + WBGT_n \times t_n}{t_1 + t_2 + \ldots + t_n}$$

where $WBGT_1$, $WBGT_2$ ... and $WBGT_n$ are calculated values of WBGT for the various work and rest areas occupied during total time periods and t_1, t_2 ... and t_n are the elapsed times in minutes spent in the corresponding areas which are determined by a time study. Where expo-

sure to hot environmental conditions is continuous for several hours or the entire work day, the time-weighted averages should be calculated as an hourly time-weighted average, i.e., $t_1 + t_2 + \ldots t_n = 60$ minutes. Where the exposure is intermittent, the time-weighted averages should be calculated as two-hour time-weighted averages, i.e., $t_1 + t_2 + \ldots + t_n = 120$ minutes.

The TLVs for continuous work are applicable where there is a work–rest regimen of a 5-day work week and an 8-hour work day with a short morning and afternoon break (approximately 15 minutes) and a longer lunch break (approximately 30 minutes). Higher exposure values are permitted if additional resting time is allowed. All breaks, including unscheduled pauses and administrative or operational waiting periods during work, may be counted as rest time when additional rest allowance must be given because of high environmental temperatures.

IV. *Water and Salt Supplementation*

During the hot season or when the worker is exposed to artificially generated heat, drinking water should be made available to the workers in such a way that they are stimulated to frequently drink small amounts, i.e., one cup every 15–20 minutes (about 150 ml or 1/4 pint).

The water should be kept reasonably cool, 10°C to 15°C (50°F to 60°F) and should be placed close to the workplace so that the worker can reach it without abandoning the work area.

The workers should be encouraged to salt their food well during the hot season and particularly during hot spells. If the workers are unacclimatized, salted drinking water should be made available in a concentration of 0.1% (1 g salt to 1.0 liter or 1 level tablespoon of salt to 15 quarts of water). The added salt should be completely dissolved before the water is distributed, and the water should be kept reasonably cool.

TABLE 4. Activity Examples

- Light hand work: writing, hand knitting
- Heavy hand work: typewriting
- Heavy work with one arm: hammering in nails (shoemaker, upholsterer)
- Light work with two arms: filing metal, planing wood, raking of a garden
- Moderate work with the body: cleaning a floor, beating a carpet
- Heavy work with the body: railroad track laying, digging, barking trees

Sample Calculation

Assembly line work using a heavy hand tool.

A. Walking along		2.0 kcal/min
B. Intermediate value between heavy work with two arms and light work with the body		3.0 kcal/min
	Subtotal:	5.0 kcal/min
C. Add for basal metabolism		1.0 kcal/min
	Total:	6.0 kcal/min

V. *Other Considerations*

A. *Clothing:* The permissible heat exposure TLVs are valid for light summer clothing as customarily worn by workers when working under hot environmental conditions. If special clothing is required for performing a particular job and this clothing is heavier or it impedes sweat evaporation or has higher insulation value, the worker's heat tolerance is reduced, and the permissible heat exposure TLVs indicated in Table 1 and Figure 1 are not applicable. For each job category where special clothing is required, the permissible heat exposure TLV should be established by an expert.

Table 2 identifies TLV WBGT correction factors for representative types of clothing.

B. *Acclimatization and Fitness:* Acclimatization to heat involves a series of physiological and psychological adjustments that occur in an individual during the first week of exposure to hot environmental conditions. The recommended heat stress TLVs are valid for acclimated workers who are physically fit. Extra caution must be employed when unacclimated or physically unfit workers must be exposed to heat stress conditions.

C. *Adverse Health Effects:* The most serious of heat-induced illnesses is heat stroke because of its potential to be life threatening or result in irreversible damage. Other heat-induced illnesses include heat exhaustion which in its most serious form leads to prostration and can cause serious injuries as well. Heat cramps, while debilitating, are easily reversible if properly and promptly treated. Heat disorders due to excessive heat exposure include electrolyte imbalance, dehydration, skin rashes, heat edema, and loss of physical and mental work capacity.

If during the first trimester of pregnancy, a female worker's core temperature exceeds 39° C (102.2°F) for extended periods, there is an increased risk of malformation to the unborn fetus. Additionally, core temperatures above 38°C (100.4°F) may be associated with temporary infertility in both females and males.

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DOCUMENTATION FOR HEAT STRESS

Heat stress is defined as the total net heat load on the body with contributions both from exposure to external sources such as environmental, and from internal metabolic heat production. Man's exposure to heat stress conditions produces physiological responses or displacement of functions referred to as heat strain and characterized by an increase in: *a)* "core" or "deep body temperature", *b)* heart rate, *c)* blood flow to the skin, and *d)* water and salt loss due to sweating. Conditions of excessive heat stress may occur either when the physical work is too heavy or the environment is too hot in relation to each other.

If work is to be performed under hot environmental conditions, the work load category (light, medium, heavy) of each job must be established[5,6] and the heat exposure limit maintained at or below the applicable Threshold Limit Value (TLV) in order to protect the worker from the risk of acute heat illnesses.

As a result of a process known as thermal homeostasis, man is normally able to maintain deep body temperature within acceptable narrow limits by means of a sophisticated thermoregulatory system. This is an autonomically controlled physiological response resulting in increased blood flow from sites of heat production in the muscles and deep body tissue to the cooler body surfaces where the heat is dissipated via the physical channels of conduction, convection, radiation and evaporation. If the heat gain exceeds the body's ability of heat dissipation, heat will be stored in the body as measured by its rising temperature.

Occasionally, as a result of the body's inability to cope with excess heat load, three heat illnesses may occur. Heat stroke is a state of thermoregulatory failure and is the most serious of the heat illnesses. Heat stroke is characterized by hot, dry skin, rapidly rising body temperature, collapse, loss of consciousness and convulsions. If deep body temperature approaches 41.1°C (106°F), the danger of heat stroke is imminent. Without prompt treatment, including removal of the victim to a cool area and reduction of the rapidly increasing body temperature, preferably by immersing the body in an ice bath, heat stroke will be fatal. A heat stroke victim needs immediate medical attention.

Heat exhaustion is a less severe heat illness than heat stroke and is characterized by clammy moist skin, weakness or extreme fatigue, nausea, headache, no excessive increase in body temperature and low blood pressure with a weak pulse. Without prompt treatment, collapse is inevitable. Heat exhaustion most often occurs in persons who's total blood volume has been reduced due to dehydration, i.e., depletion of body water as a consequence of deficient water and salt intake. Exposure of such persons to hot environmental conditions causes a major shift in the body's remaining blood supply to the skin vessels in an attempt to dissipate the heat load and ultimately results in an inadequate supply of blood being delivered to the brain.

Heat exhaustion occurs most often among individuals who have a low level of cardiovascular fitness, or are unacclimatized to heat. Lying down in a cool place and drinking slightly salted water (0.1% NaCl) will result in rapid recovery of the victim. A physician should be consulted prior to resumption of work.

The third heat illness, heat cramps, is characterized by painful spasms in one or more skeletal muscles. Heat cramps primarily occur in persons who sweat profusely in heat without replacing salt losses. Resting in a cool place and drinking a cup of saline solution (0.9% NaCl) will alleviate the cramps rapidly.

The TLVs for heat stress are intended to provide guidelines on conditions under which it is believed that nearly all heat acclimatized workers dressed in their usual work uniforms and receiving adequate water and salt intake should be able to function effectively without exceeding a deep body temperature of 38°C (100.4°F).[1,2] By general consensus among work physiologists, this temperature represents the value below which the body temperature must be maintained to minimize the risk of heat illness. Ideally, continuous monitoring of deep body temperature could assure that this limit would not be exceeded. This is not normally done, however, as the measurement of deep body temperature is impractical for routine monitoring of worker heat load. The TLVs for heat stress provide an index which combines measurable environmental factors for the purpose of predicting safe working conditions in a hot environment, i.e., conditions where worker deep body temperature would not exceed 38°C.

When permitting higher exposure limits than those recommended for continuous work, some provision for additional rest time becomes necessary. In general, when the work on a job is self-paced, the workers will accomplish this themselves by spontaneously limiting their hourly work load to 30-50% of their maximum physical performance capacity through the interspersing of unscheduled breaks or the setting of an appropriate work speed. In this manner, the *daily average* of their metabolic rate will seldom exceed 330 kcal/hr; however, within an 8-hour work shift, there may be periods where their hourly average metabolic rate will be higher. Under very hot conditions, any practice of allowing a compression of the work schedule rather than the interspersion of unscheduled breaks should be discouraged.

A comprehensive review of the numerous available heat stress indices by the TLV Committee in 1970, and a more recent review by the National Institute for Occupational Safety and Health[10] concluded that the Wet Bulb Globe Temperature Index (WBGT) is the simplest and most suitable currently available index. The numerical value for the WBGT Index can be calculated by one of two equations previously presented, depending on the presence or absence of solar loading. The methodology involved in the measurement of these parameters is explained by Minard.[3,4]

The TLVs for heat stress will not afford adequate protection to unacclimatized workers, for without proper acclimatization and the resulting series of physiological and psychological adjustments that

occur in an individual during this first week of exposure to a hot environment, tolerance to heat is significantly reduced.[11] Further, adequate protection may not be provided during simultaneous exposure to certain sources of non-ionizing radiation including microwaves, radiofrequency and infrared radiation.

Certain persons, however, who demonstrate a higher than average tolerance to heat are able to withstand heat exposures higher than those permitted by this TLV and still maintain their deep body temperature below 38°C. For these workers, higher heat exposures are acceptable provided they have been appropriately identified through an acceptable medical selective test, such as the one presented by Shvartz,[12] and provided the workers are under medical surveillence.

Evidence presented by Lind[13] shows that man can maintain his deep body temperature at a constant level, even though the environmental heat load increases up to a certain point which he called the Upper Limit of Prescriptive Zone (ULPZ). When the environmental temperature exceeds the ULPZ, then the deep body temperature becomes sensitive to changes in climatic conditions. No worker should be permitted to continue working when his deep body temperature exceeds 38°C.

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