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Heat Wave: A Web-based Heat Stress Management Tool

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Heat Wave:

A Web-based Heat Stress Management Tool

**Presented at the American Industrial Hygiene
Conference and Exposition – Atlanta, GA**



May 12, 2004

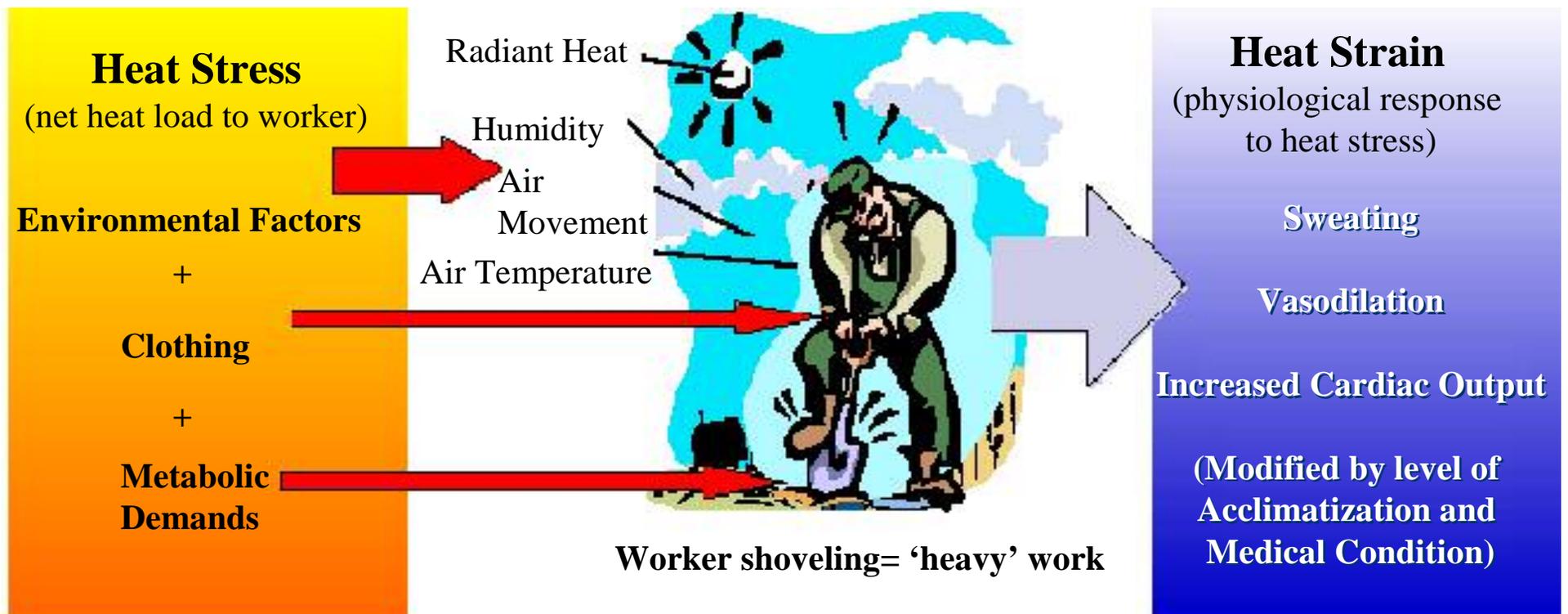
Robert B. Anderson, CIH, CSP, MSPH
D.H. MacQueen, G.W. Laguna
Safety and Environmental Protection

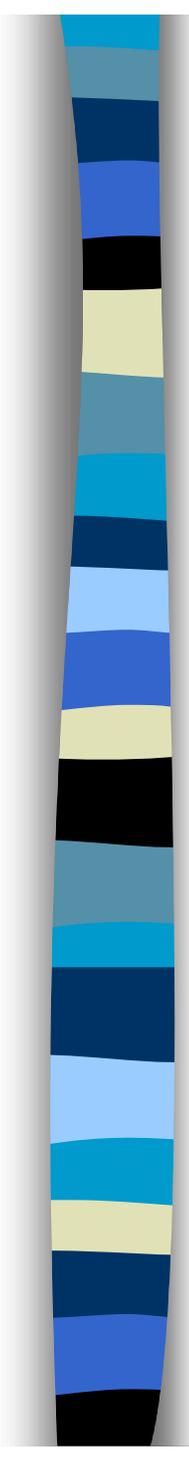
UCRL-CONF-203698. Work performed under the auspices of the U.S. Department of Energy
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Heat stress exposure vs. heat strain response





Supervisor – Heat Stress / Strain

- **Will** – Heat stress be an issue today?
- **When** – To actively manage it?
 - What options do I have?
 - What information/tools are available?



Welcome to HeatWave--a resource for supervisors, technicians, industrial hygienists, and LLNL employees seeking guidance on heat stress issues for workers. The heat stress tools below give information specific to your situation. Educational information is presented to both support informal presentations and provide detailed, in-depth understanding.

Will Heat Stress be an Issue Today? When?	<u>Proceed</u>
WBGT Meter vs. Work Rest Regimen Tables	<u>Proceed</u>
<i>Heat Wave</i> Glossary and Information	<u>Proceed</u>
A "Tail-Gate" PowerPoint presentation on Heat Stress	<u>Download</u>
General Controls	<u>Proceed</u>
Heat Stress tools for the NTS	Future
Useful links to Heat Stress Information	<u>Proceed</u>

Wed Apr 7 14:19:27 2004

For more information about this Web Tool, contact [Robert Anderson](#), HC Team 4



For information regarding heat stress pertaining to operations in your work area, contact your cognizant team Industrial Hygienist.



■ Estimator Intent:

Answer Question for Supervisor...

When to deploy a WBGT meter *today* and begin to actively manage heat stress risks?



■ Estimator User Input:

- Acclimatization
- Clothing Ensemble
- Work Rate

>> Trigger value (WBGT °C)
for initiating work/rest regimen based
on ACGIH, TLV[®] screening criteria

>> Compared to modeled data



■ Estimator Output:

- If work/rest regimen currently needed: displays time and ambient air temperature when this started



■ Estimator Output:

- If trigger point has not been reached, user invited to “Estimate” the time this may occur today using data collected during the previous 5 days
- Today’s forecasted high temperature also displayed



Will Heat Stress be an Issue Today . . . When?

Directions	What does this tool do?
Choose the appropriate values in the tables below, Scroll to bottom of page and press PROCEED	Allows user to ESTIMATE the time TODAY when a Work/Rest Regimen may be needed (more)

Select the Site where work is to be performed	
<input checked="" type="radio"/> LLNL Main Site	<input type="radio"/> LLNL Site 300

Select the Acclimatization Level for affected employees (more)	
<input type="radio"/> Un-acclimatized (more)	<input checked="" type="radio"/> Acclimatized (more)

Select the Work Rate for affected employees (more)	
<input type="radio"/> Light Work	example: Sitting or standing, controlling machines
<input checked="" type="radio"/> Moderate Work	example: Walking about w/ moderate lifting and pushing
<input type="radio"/> Heavy Work	example: Pick and shovel work
<input type="radio"/> Very Heavy Work	example: Shoveling wet sand

Select the Clothing Description for affected employees (more)		
<input type="radio"/>	SMS polypropylene coveralls; limited use coveralls with hood (particle barrier only) made of melt blown polypropylene	-1.0
<input type="radio"/>	Polyester coveralls; light weight polyester (98% Nylon 3oz. with a hood of the same material (ProTech2000)	0

Select the Clothing Description for affected employees (more)

<input type="radio"/>	SMS polypropylene coveralls; limited use coveralls with hood (particle barrier only) made of melt blown polypropylene	-1.0
<input type="radio"/>	Polyester coveralls; light weight polyester (98% Nylon 3oz. with a hood of the same material (ProTech2000)	0
<input type="radio"/>	Std. 4 oz L-Sleeve cotton shirt and 8 oz cotton pants, equals reference ensemble for setting clothing adjustment additions	0
<input type="radio"/>	Flame-retardant shirt and pants, long-sleeve Zirpo " wool shirt and pants made from FR8 " treated cotton fabric	0.5
<input type="radio"/>	DuPont, Kappler Tyvek" 1424 without hood and gloves	1.0
<input type="radio"/>	Flame-retardant shirt and pants, long-sleeve shirt and pants made pants made from FR9 " treated cotton fabric	1.0
<input type="radio"/>	DuPont, Kappler NexGen" without hood and gloves	2.0
<input type="radio"/>	MB polyethylene coveralls, limited use with hood, (particle barrier only) made from a meltblown polypropylene (Tyvek 1422A)	2.0
<input type="radio"/>	Flame-retardant shirt and pants, with single layer jacket long-sleeve shirt and pants and jacket made from FR9 " treated cotton fabric	2.0
<input type="radio"/>	Water Barrier, vapor permeable coveralls; limited use, coveralls with hood made from a tri-laminate fabric of micro-porous film	2.5
<input type="radio"/>	Flame-retardant shirt and pants, with double-layer jacket; long-sleeve shirt and pants and double-layer jacket made from FR9 " treated cotton fabric	3.0
<input type="radio"/>	Polyester coveralls; light weight polyester w/ a hood of same material worn over a surgical scrub suit	3.0
<input type="radio"/>	Cloth coveralls (CC) std. anti-contamination coveralls with hood and hand and foot coverings, cotton or cotton poly blend wts. 8-9 oz	3.5

	treated cotton fabric	
<input type="radio"/>	Polyester coveralls; light weight polyester w/ a hood of same material worn over a surgical scrub suit	3.0
<input type="radio"/>	Cloth coveralls (CC) std. anti-contamination coveralls with hood and hand and foot coverings, cotton or cotton poly blend wts. 8-9 oz	3.5
<input type="radio"/>	Cloth coveralls over scrub suit: or CC plus set of 2oz underalls (surgical scrub suit	4.5
<input checked="" type="radio"/>	Double cloth coveralls or CC with second set of CC only	5.0
<input type="radio"/>	Water Barrier, vapor permeable coveralls; limited use, coveralls with hood made from a tri-laminate fabric of with a tetraflouroethylene micro-porous film	6.0
<input type="radio"/>	Vapor-Barrier coveralls and hood made of light weight fabrics designed for limited use worn over cloth coveralls; typical fabrics may be a polyethylene coated spunbonded polyethylene or a polyvinyl chloride	8.5
<input type="radio"/>	DuPont, Kappler TyChem™ without hood and gloves	10.0
<input type="radio"/>	Encapsulating suit or turn-out gear; total encapsulating suits (e.g. Level A) ; reusable whole body chemical protective suits; firefighter turn-out gear	11
<input type="radio"/>	Custom value - Consult with cognizant Industrial Hygenist to determine custom clothing addition value as needed. Type clothing description in text box below and clothing addition value in the box to the right. Then press PROCEED	<input type="text"/>
	<input type="text"/>	

Proceed

Fri Oct 10 13:36:36 2003

Based on the variables you chose

Today's Date: 5/3/2004 Current Time: 9:59 Current Temp: 73 ° F

Variable (Change Variables)	Selected Value
Site	LLNL Main Site
Acclimatization Level (more)	Acclimatized
Clothing Ensemble (more)	Clothing Addition Value = 5.0 Double cloth coveralls or CC with second set of CC only
Work Rate (more)	Moderate

. . . and the tables below, you can determine if **Heat Stress** will be an issue to manage today . . . and if so . . . When?

Note: All times are in Military format. Example 2:00 = 2 AM, 14:00 = 2 PM

TIME and TEMP shown indicate when Work/Rest Regimen are ESTIMATED to be needed TODAY		TODAY'S Forecast HIGH Temperature
Time (Mil.)	Temp	
User to estimate time from table below		88 ° F (Forecast)
What are the Options		
Get Work/Rest Regimen Table		

Useful data when estimation is necessary			
Previous 5 days	TIME and TEMP when Work/Rest Regimen would have been needed		HIGH Temperature for the Day (Use when estimation is necessary)
	Time (Mil.)	Temp	
5/2/2004	10:30	77 ° F	92 ° F
5/1/2004	14:00	83 ° F	85 ° F
4/30/2004	15:45	79 ° F	80 ° F
4/29/2004	Not needed	Not needed	78 ° F
4/28/2004	Not needed	Not needed	81 ° F



What are my Options . . .

- Change the Variables (Back to variable choices):
 - Consider a Clothing Ensemble with lower Addition value (PPE must adequately protect from other inherent hazards)
 - Consider reduced Work Rate
- Timing:
 - Consider conducting these operations on a different day
 - Consider starting the work as early in the day as practical and avoiding exposures during hottest parts of the day
- If Heat Stress exposure must occur . . . PLAN ahead and manage as you would any other risk



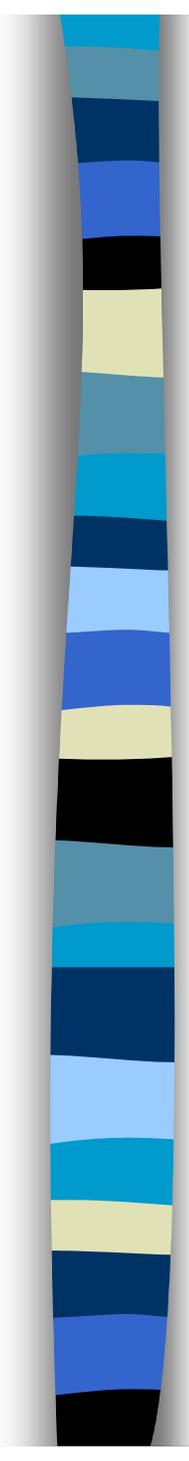
What are my Options . . .

- Under these conditions . . .
 - If Work Rate = Very Heavy > OR >
 - If Clothing Addition = 6 or greater > OR >
 - If this work is new, unique, or exposures extreme > OR >
 - If you need access to a WBGT meter or ES&H Tech > OR >
 - To ask Q's or just keep them apprised of your plan. . . then:
Contact your Team Industrial Hygienist
- If you are comfortable moving forward and have a WBGT meter . . .
 - If you have not yet done so this season, Review the [Heat Stress Tailgate \(Download\)](#) with affected employees. For a quick refresher, see ([General Controls for HS](#)) before conducting the work
 - [Create WBGT Meter vs. Work/Rest Regimen Table\(s\)](#)
 - Set up the WBGT meter in the affected work area



■ Estimator Output:

- If clothing addition value $\Rightarrow >6^{\circ}\text{C}$, or
If work rate is Very Heavy.....
 - Then work/rest regimen always
needed, & detailed analysis or
physiological monitoring



A practical method for physiological monitoring

- Work/rest regimen-***required***
And-- \leq moderate wk rates
with excursions to heavy
- **Rest phase** measurements of
 - *Seated Heart Rate*
 - *Oral Temperature*
- **Extend** rest times if:
 - Data ***trends*** increase **OR**
 - Numeric ***values*** reached

Clothing Ensemble (more)	Clothing Addition Value = 6.0	Water Barrier, vapor permeable coveralls; limited use, coveralls with hood made from a tri-laminate fabric of with a tetrafluoroethylene micro-porous film
Work Rate (more)		Moderate

... and the tables below, you can determine if Heat Stress will be an issue to manage today ... and if so ... When?

Note: All times are in Military format. Example 2:00 = 2 AM, 14:00 = 2 PM

TIME and TEMP shown indicate when Work/Rest Regimen are ESTIMATED to be needed TODAY		TODAY'S Forecast HIGH Temperature	
Time (Mil.)	Temp		
Always	Work Rate = Very Heavy OR Clothing Addition => 6 Additional documentation and/or physiological monitoring may be required, please contact your Team IH	80 ° F (Forecast)	
What are the Options			
Get Work/Rest Regimen Table			
Useful data when estimation is necessary			
Previous 5 days	TIME and TEMP when Work/Rest Regimen would have been needed		HIGH Temperature for the Day (Use when estimation is necessary)
	Time (Mil.)	Temp	
10/9/2003	Always	All Temperatures	72 ° F
		All	



■ Estimator:

When to deploy a meter to actively manage heat stress



WBGT Meter vs. Work/Rest Regimen Tables [\(more\)](#)

Variable (Change Variables)		Selected Value
Acclimatization Level (more)		Acclimatized
Work Rate (more)		Moderate
Clothing Ensemble (more)	Clothing Addition Value = 4.5	Cloth coveralls over scrub suit; or CC plus set of 2oz underalls (surgical scrub suit)
What are the Options		

Directions: For each combination of variables you may encounter PRINT a separate table for field use. Set up a WBGT meter in the work area to emulate work conditions. Check variable selections for applicability. See table below for Work vs. Rest Regimen.

° C WBGT Meter Reading		Work/Rest minutes per hour
Greater Than	Less Than or Equal to	
	22.2	Work 60 minutes/Rest 0 minutes
22.2	23.5	Work 45 minutes/Rest 15 minutes
23.5	24.9	Work 30 minutes/Rest 30 minutes
24.9	26.6	Work 15 minutes/Rest 45 minutes
> 26.6		STOP! Contact your Industrial Hygienist

IMPORTANT: Never ignore symptoms of heat related disorders no matter what measurements indicate. Symptoms may include: feeling over-heated, fatigue, headache, nausea and/or weakness. If symptoms do not resolve within 15 minutes, transport immediately to medical for evaluation.

Unless specifically requested to do so by your cognizant Industrial Hygienist, do not use these data if your situation significantly differs from the variables described above.



WBGT Meter vs. Work/Rest Regimen Tables [\(more\)](#)

Variable (Change Variables)		Selected Value
Acclimatization Level (more)		Acclimatized
Work Rate (more)		Moderate
Clothing Ensemble (more)	Clothing Addition Value = 6.0	Water Barrier, vapor permeable coveralls; limited use, coveralls with hood made from a tri-laminate fabric of with a tetrafluoroethylene micro-porous film
Work Rate = 'Very Heavy' OR Clothing Addition => 6 Additional documentation and/or physiological monitoring may be required, please contact your Team IH		
What are the Options		

Directions: For each combination of variables you may encounter PRINT a separate table for field use. Set up a WBGT meter in the work area to emulate work conditions. Check variable selections for applicability. See table below for Work vs. Rest Regimen.

° C WBGT Meter Reading		Work/Rest minutes per hour
Greater Than	Less Than or Equal to	
	20.7	Work 60 minutes/Rest 0 minutes
20.7	22	Work 45 minutes/Rest 15 minutes
22	23.4	Work 30 minutes/Rest 30 minutes
23.4	25.1	Work 15 minutes/Rest 45 minutes
> 25.1		STOP! Contact your Industrial Hygienist

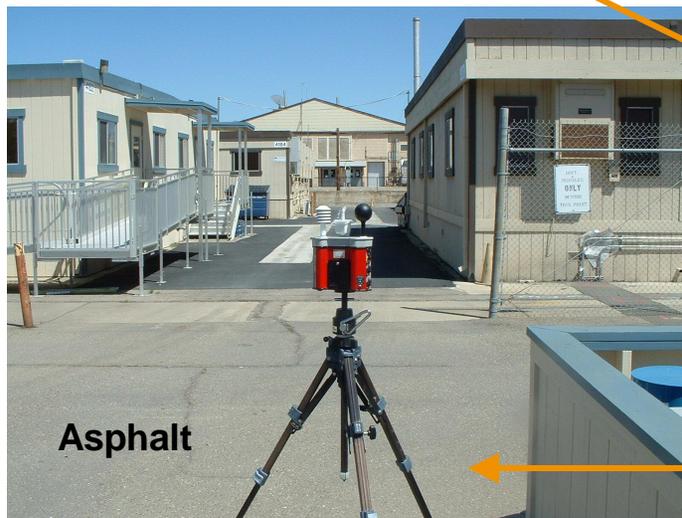
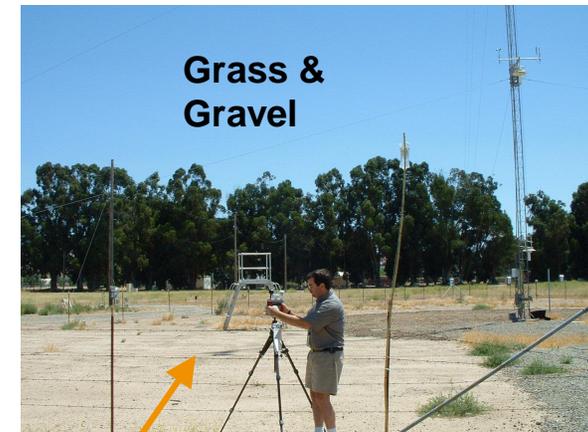
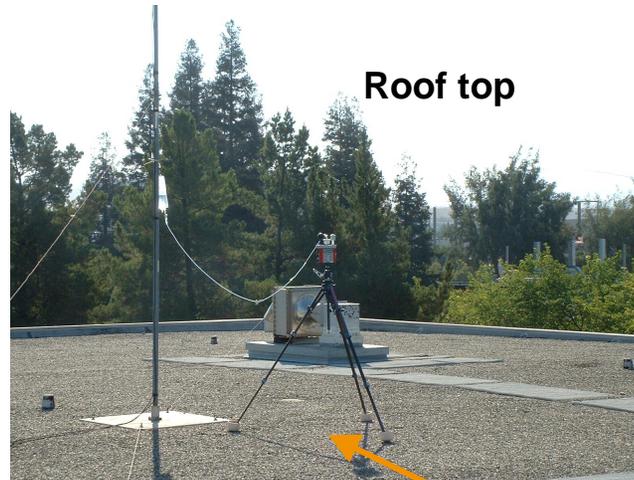
IMPORTANT: Never ignore symptoms of heat related disorders no matter what measurements indicate. Symptoms may include: feeling over-heated, fatigue, headache, nausea and/or weakness. If symptoms do not resolve within 15 minutes, transport immediately to medical for evaluation.

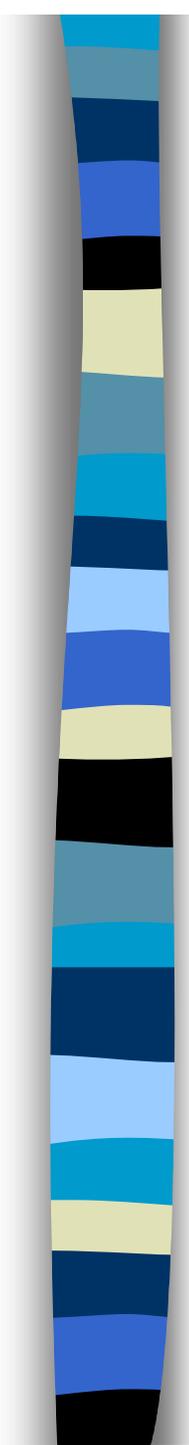


■ WBGT Meter vs. Work / Rest Regimen Tables:

Clear decision points for meter data for any set of variables desired

Limitations using modeled unadjusted WBGT data





Limitations using modeled unadjusted WBGT data

- Do **NOT** use Met. Tower modeled data for **local** decision making regarding a WBGT based work/rest regimen
- Modeled data differ by **+/- 2.0 °C-WBGT** compared to local outdoor WBGT data due to environmental differences
- Deploy a **meter at work location**
 - Run work/rest regimen on local meter data **ONLY**



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For information regarding heat stress pertaining to operations in your work area, contact your cognizant team Industrial Hygienist.



General Controls for Heat Stress

- Start the work as early in the day as practical.
- Wear the most breathable garments available that meet personal protective requirements.
- Share knowledge about heat stress among those affected.
- Drink plenty of water, one cup every 20 minutes is recommended.
- If you feel over-heated, fatigue, headache, nausea and/or weakness take a break and keep an eye on co-workers for these symptoms. Encourage self-regulation. If symptoms do not resolve in 15 minutes, call 911 and have the person transported to medical for evaluation. **Do not delay transport.**
- Work within your own personal limits.
 - These may be influenced by age, obesity, a low-salt diet, medications or medical issues including kidney and heart disease, high blood pressure, diabetes, conditions affecting temperature regulation or alcohol overuse.
 - If you have not worked in high heat conditions for some time, don't over do it. Allow yourself to get acclimatized over several days.



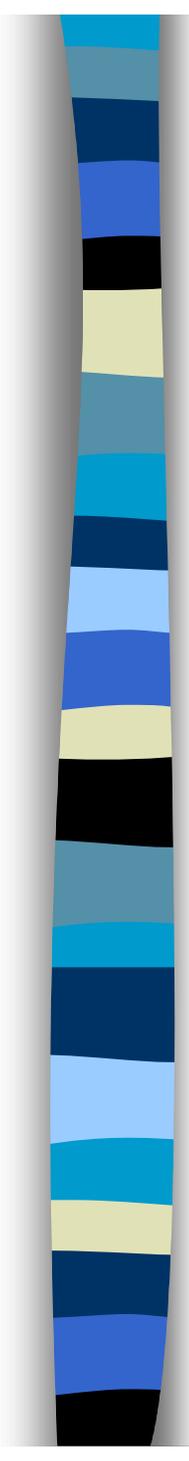
General Controls for Heat Stress

- Healthy lifestyles, ideal weight and electrolyte balance are encouraged including the consumption of some salty foods as part of your diet.
- When resting, do so in the shade with garments removed that inhibit the movement of air. A fan may help.
- Keep your IH informed about what challenges you face and seek their guidance for new, unique or extreme exposures.
- If conducting operations under a Work/Rest Regimen
 - Cycles are based on one hour increments
 - Example 75% of work 25% of rest means: 45 minutes of work and 15 minutes of rest each hour
 - Rest in shade, cool water available, use of fan encouraged
 - Work only at or below indicated rates



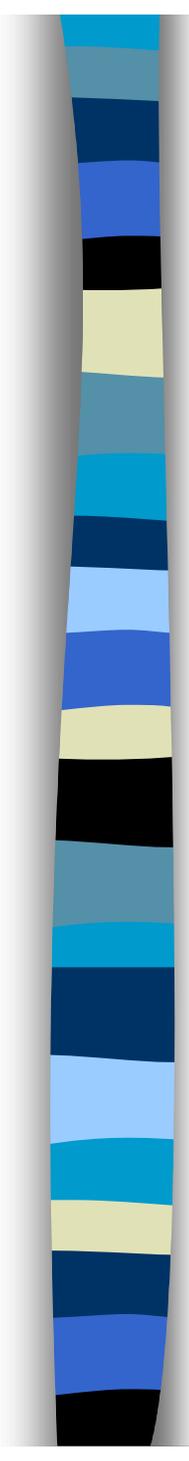
■ Tailgate Meeting & General Controls:

Encourages self-regulation; communicates protective means, risk factors, signs, symptoms and first-aid methods



- Positive feedback - Supervisors like these tools

- **Educate** – Self and workers of risks/controls
- **Inform** – Without dictating policy
- **Clear** – Information and decision points
- **Flexible** – Meets any level of need
- **Easy** – Field friendly even if conditions change

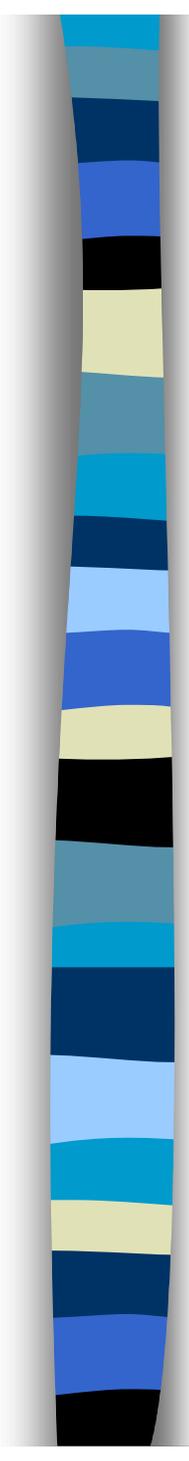


About the model ...

- $^{\circ}\text{C-WBGT}_{\text{out}} = 0.7_{\text{nwb}} + 0.2_{\text{g}} + 0.1_{\text{db}}$

Or.... is a *f* function of:

- Dew point water vapor pressure
 - Wind speed
 - Ambient air temperature
 - Solar load
- Data collected continuously at LLNL meteorological tower



About the model ...

- **> 1700 empirical data points vs. Met Tower**
- **LLNL Model:**
 - **Resulted from best fit of empirical to Met. Tower data**



LLNL WBG Model

$$^{\circ}\text{C WBG T} = 6.25 + (0.51\text{Td}) + (0.28\text{E}) + (-0.51\text{Vw}) + (2.23\text{Rs})$$

Where:

Td = Dry bulb temperature ($^{\circ}\text{C}$)

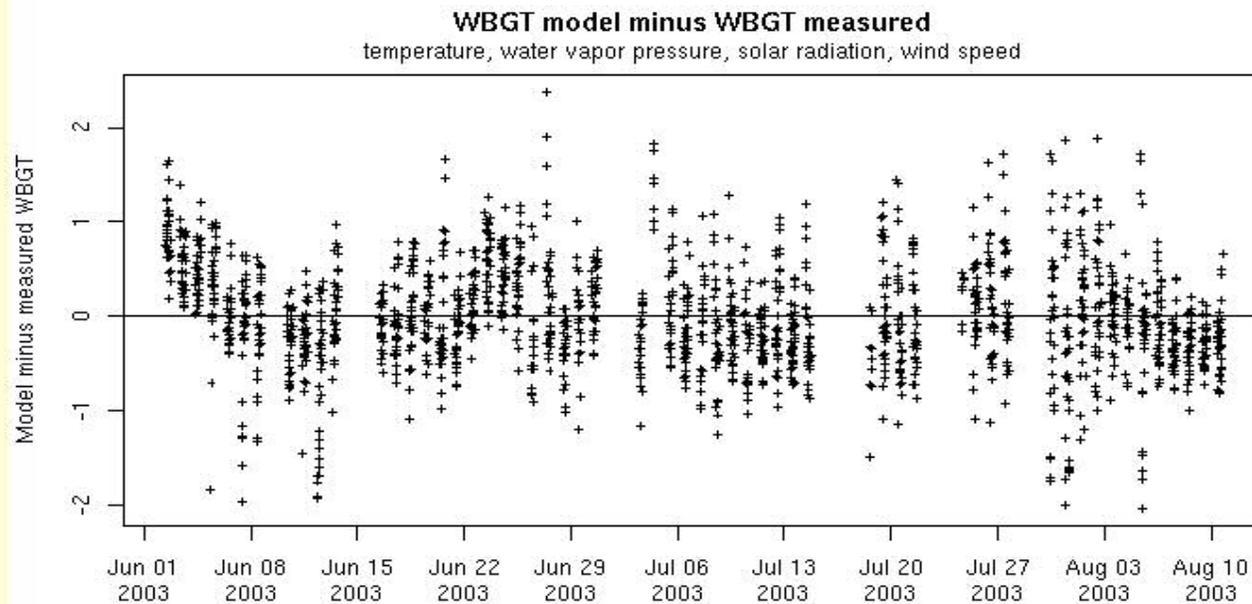
E = Water vapor pressure (hPa)

Vw = Wind Speed (m/s)

Rs = Solar Radiation (mW/m²)

Data taken @ 15 min. from 9:30AM to 5:30PM

1. Model data from LLNL meteorological tower
2. Measured data from QuestTemp 36 Heat Stress meter



Model Summary:

Each data point resulted from a modeled value determined using information from the LLNL meteorological tower minus measured data taken adjacent to the meteorological tower using a calibrated QuestTemp model 36 Heat Stress meter.

Percentiles of matched intervals, Model minus measured data are:

0%	2.5%	10%	25%	50%	75%	90%	97.5%	100%
-2.05	-1.15	-0.65	-0.36	-0.05	0.35	0.75	1.15	2.38

Middle 95% of values are between -1.15 to 1.15 °C-WBGT

Middle 80% are between -0.65 to 0.75 or +/- 0.7 °C-WBGT

Residual standard error: 0.58 on 1747 degrees of freedom

Multiple R-Squared: 0.97

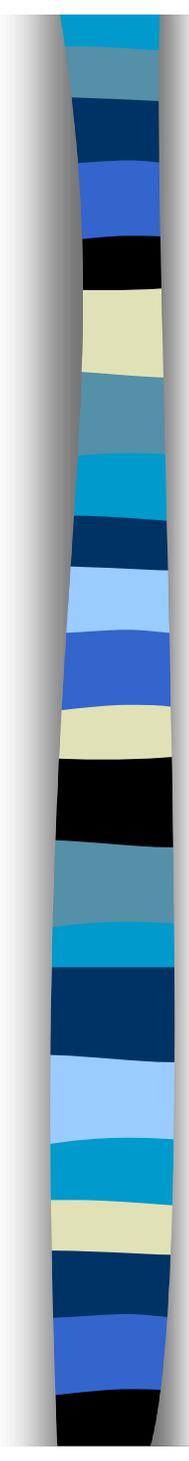
R-Squared: Describes the improvement in prediction over having no model

Scale:

1 = perfect correlation

0 = no correlation

Fri Apr 23 16:03:49 2004



Contact information:

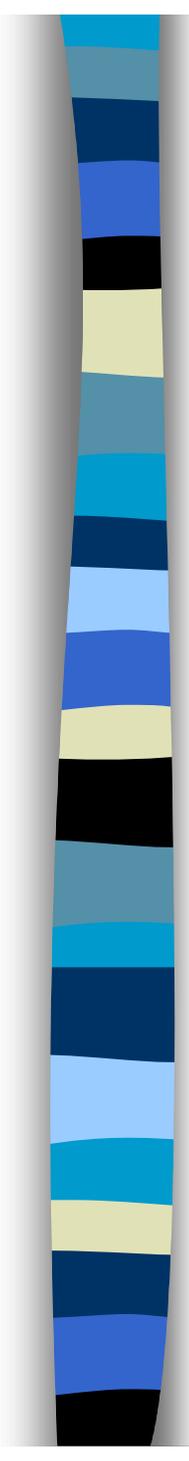
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