An Improved Simplified Heat Stress Management Approach for the Non-Technical User

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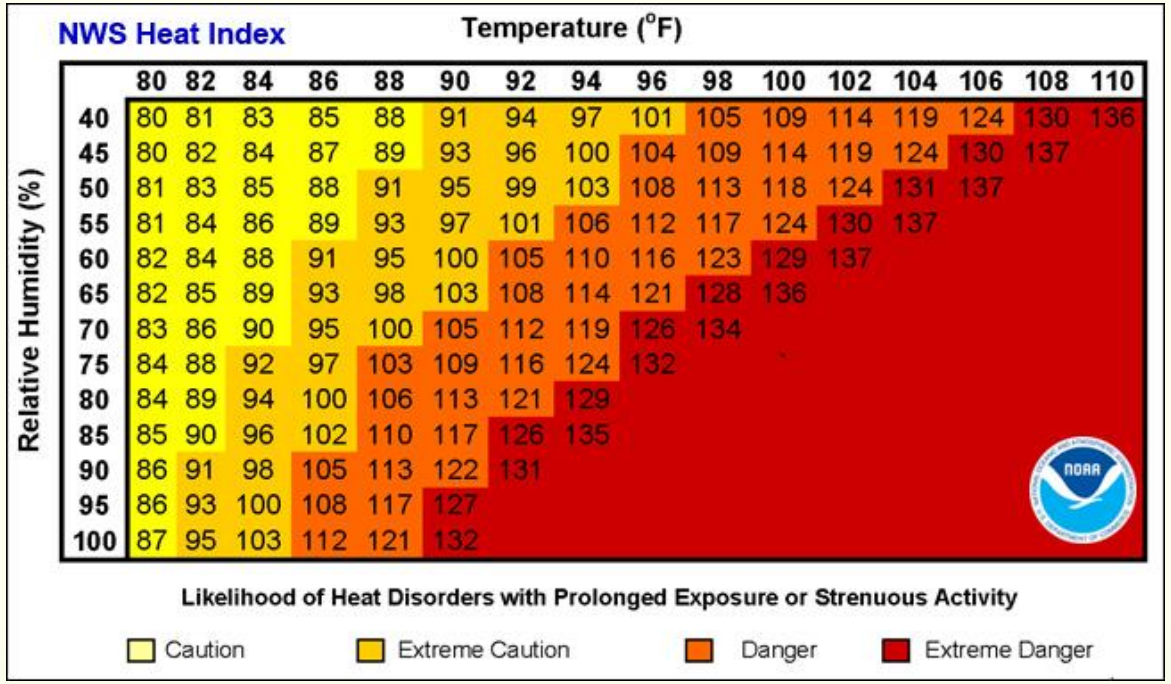
OSHA issues citations re Heat Stress

- In 2016 and 2017, OSHA issued five citations to the United States Postal Service (USPS) alleging Heat Stress violations in:
  - San Antonia and Houston, Texas;
  - Des Moines, Iowa;
  - Charleston, West Virginia; and
  - Benton, Arkansas.
- OSHA introduced the National Weather Service (NWS) heat index chart into the trial record and pointed to it as evidence.

National Weather Service Heat Index Chart



Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

(Source: US National Weather Service)

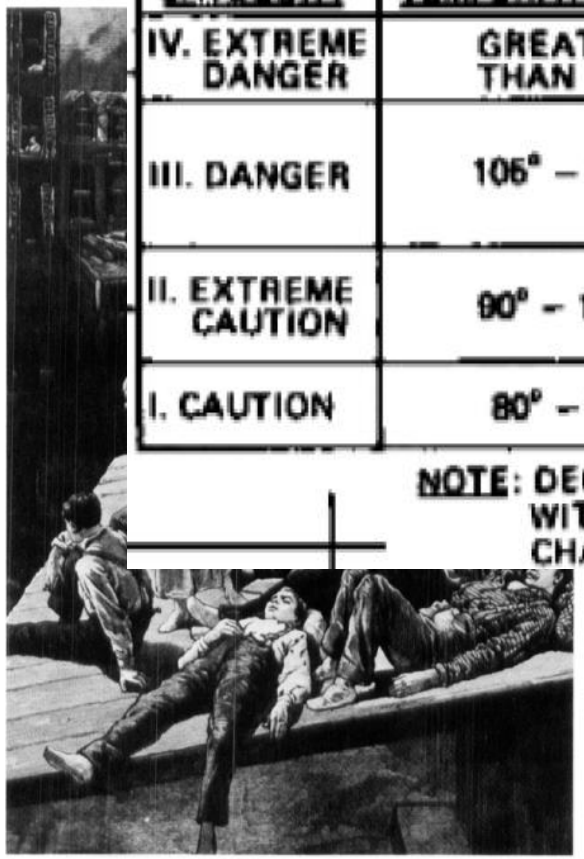
HEAT STRESS

A Com

GENERAL HEAT STRESS INDEX

DANGER CATEGORY	APPARENT TEMPERATURE (°F)	HEAT SYNDROME
IV. EXTREME DANGER	GREATER THAN 130°	HEATSTROKE OR SUNSTROKE IMMINENT
III. DANGER	105° – 130°	SUNSTROKE, HEAT CRAMPS, OR HEAT EXHAUSTION LIKELY. HEATSTROKE POSSIBLE WITH PROLONGED EXPOSURE AND PHYSICAL ACTIVITY.
II. EXTREME CAUTION	90° – 105°	SUNSTROKE, HEAT CRAMPS AND HEAT EXHAUSTION POSSIBLE WITH PROLONGED EXPOSURE AND PHYSICAL ACTIVITY.
I. CAUTION	80° – 90°	FATIGUE POSSIBLE WITH PROLONGED EXPOSURE AND PHYSICAL ACTIVITY.

NOTE: DEGREE OF HEAT STRESS MAY VARY WITH AGE, HEALTH, AND BODY CHARACTERISTICS.



miles per hour can increase heat stress in a shaded area by adding more heat to the body. Nevertheless, when the body is exposed to direct sunlight the effect of wind is nearly always to reduce heat stress (exposure to full sunshine can increase apparent temperature by 13°F). Radiant heating can be mitigated by shielding or by moving away from the

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source (for example, seeking shade). Atmospheric pressure is not usually a significant factor; however, at very high elevations, decreased pressure (and therefore decreased air supply) can contribute to heat exhaustion.

July without considering relative humidity, insolation or wind.

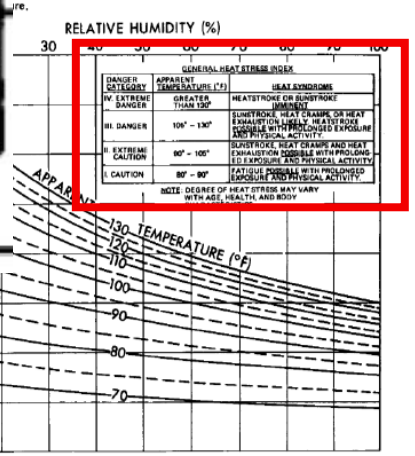
During periods of heat waves, the apparent temperature may be about 15°F to 20°F higher and can be as much as 30°F higher than ambient air temperature in urban areas, thus compounding the heat stroke problem. Deaths are listed in the most recent, comprehensive, in Several earlier experience ment of apparire was origi-1959) with ally, Watson, tion in 1979 based primarily ville, Florida,

the 1979 version was considered generally applicable to hot, humid weather. A graph of the 1979 version is shown in Figure 4.

Other Indices

The most familiar heat stress index is probably the discomfort index (Thom, 1959), which came into use in the 1950s. It was renamed temperature-humidity index (THI) and used experimentally by the Weather Bureau in the late 50s. THI is not particularly sensitive to small but significant humidity changes (Masterson, Richardson, 1979). It is still sometimes used unofficially in the U.S., but since the discomfort range is so low (70 to 80 in terms of Fahrenheit index values), most of the public do not understand it, and use has been limited. A THI graph

of air temperature and relative humidity to apparent temperature, is graph can be used for various combinations of temperature and with low relative humidities, the apparent temperature tends to be re.



tion of what a given apparent temperature feels like may vary from one person to another, the differences among various apparent temperatures are objective and based on physiological research. At low relative humidities, the apparent temperature will be lower than the ambient air temperature.

Figure 2 is a map of the average midsummer (July) noon apparent temperatures for the contiguous U.S. Adjustment has been made for average wind speed and insolation in addition to relative humidity. Figure 3 is a map of the normal daily maximum temperatures for

Court Ruling of Judge Calhoun

- *“no evidence was presented to establish the scientific basis for the risk categories depicted on the NWS heat index chart.”*

In Addition, OSHA had failed to provide any

- *“….supporting data … for why the levels of risk [indicated by the chart’s color coding and legend] are attributed to their respective temperatures.”*

Three tired approach

1. A basic heat stress risk assessment questionnaire or a simple index
2. If a potential problem is indicated from the initial step, then the progression to a second level rational index.
3. Where the allowable exposure time is less than 30 minutes or there is a high involvement level of personal protective equipment (PPE), then some form of physiological monitoring should be employed.

The Challenge

Early 2021

- Mining/exploration company in the WA East Pilbara region was looking for a similar model.
  - Easy to use in the field
  - Suitable for non-technical personnel
  - Require minimal technical equipment
  - Based on substantive physiological model

<u>Most important.</u>

It had to be simple!

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Step 1 - **Develop a reference table based on a valid physiological base.**

International standard - ISO 7933 Predicted Heat Strain

Required inputs:

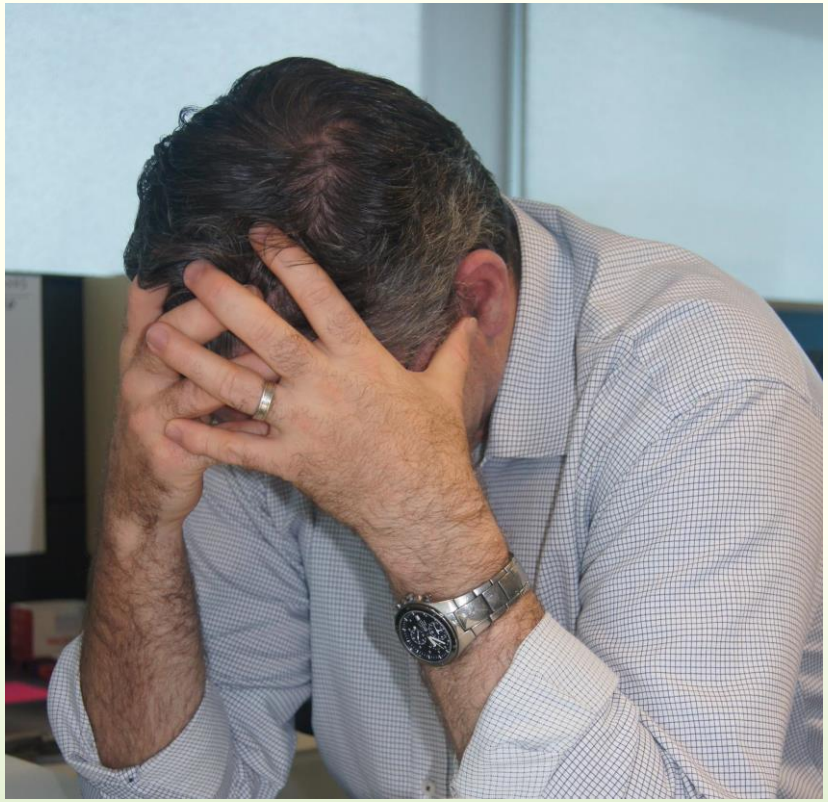
1. Dry bulb temperature (°C) → Site Weather Station
2. Air Velocity m/s → Site Weather Station
3. Relative humidity (%) → Site Weather Station
4. Globe Temperature (°C) → Calculated from Solar Radiation (w/m^2)
5. Clothing insulation factor (clo) → Standard Cotton Drill - ISO 9920
6. Metabolic workrate (w/m^2) → Physical demand assessment – ISO 8996
7. Posture → Sitting, Standing, Crouched
8. Acclimatisation

Environmental Data Calculations

- Four variable data sets
- Every day for two months – December & January
- 12 hours of data each day – 0600 -1800hrs
- Averaged over 15 minutes

48 samples X 62 Days X 24 variable configurations

= Lots & lots of data sets



Three key decisions were made at this point

a) Data would be averaged hourly instead of 15 minutes for three key periods of the work shift, morning, midday and afternoon.

b) Three tables would be developed rather than one, based on set metabolic loads.

   I. High workload (230 W/m^2)

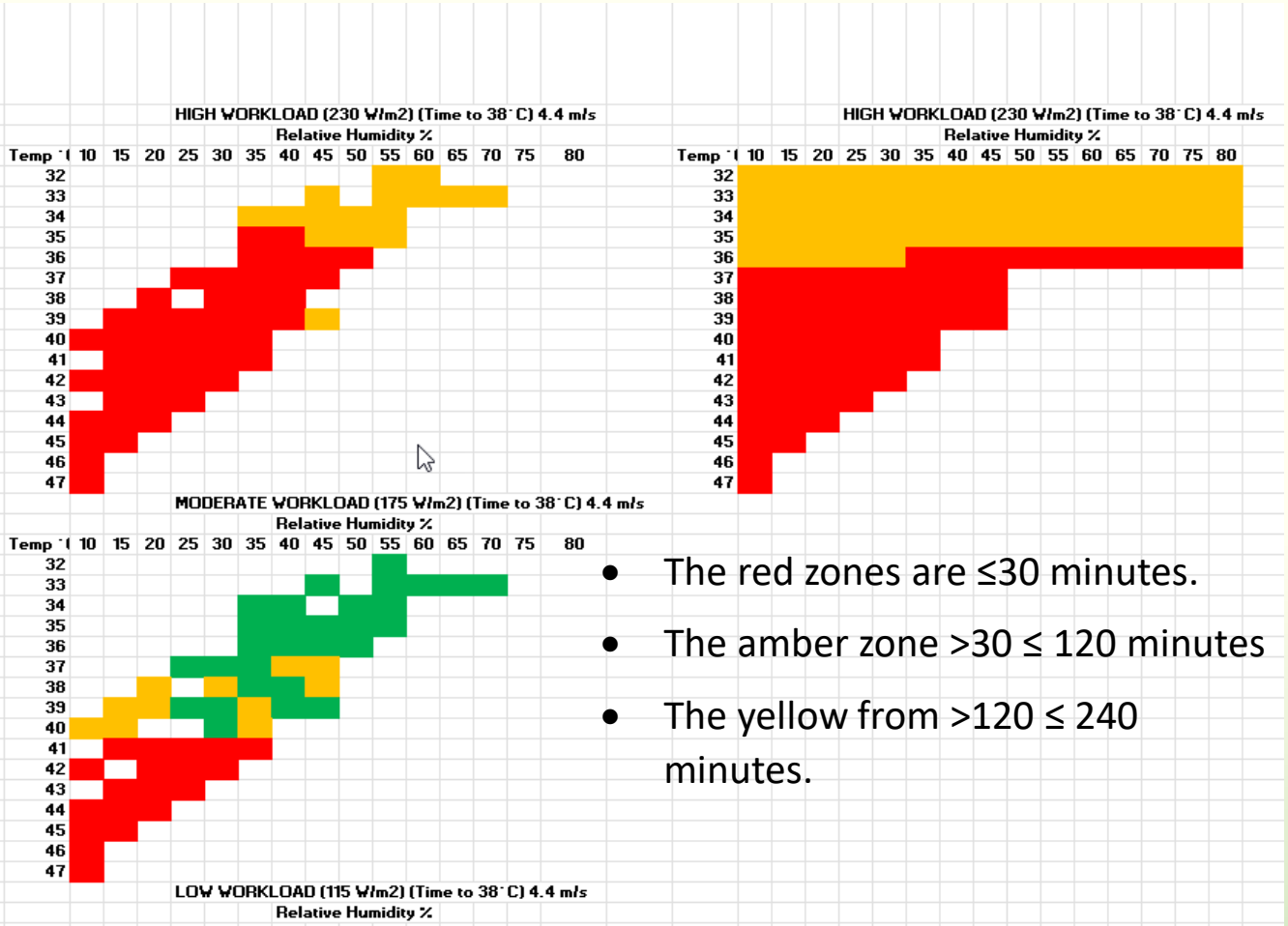
   II. Medium workload (175 W/m^2)

   III. Low Workload (115 W/m^2)

c) Instead of using all the varying air velocities, one based on the average air velocity.

The Table Build

Ta	GT	RH%	High 4.4m/s Core T 38 (min)	High 4.4m/s Fluid Loss (mls)	Mod 4.4m/s Core T 38 (min)	Mod 4.4m/s Fluid Loss (mls)	Low 4.4m/s Core T 38 (min)	Low 4.4m/s Fluid Loss (mls)
30	36	61.1						
31	36	61.5						
31	38	61.4						
32	38	59.2	54	7169	NE	5586	NE	3981
32	39	63.9	61	7634	NE	5962	NE	4292
32	39	56.2	47	7392	NE	5824	NE	4214
32	40	55.4	43	7745	NE	6148	NE	4505
32	37	55.6	53	6791	NE	5265	NE	3708
33	39	63.6	60	7835	NE	6111	NE	4406
33	37	59.5	60	6925	NE	5301	NE	3692
33	35	55.9	57	6342	NE	4796	NE	3255
33	37	53.1	47	6934	NE	5377	NE	3797
33	43	43	33	8377	NE	6827	NE	5174
34	42	57	42	8677	NE	6906	NE	5138
34	38	51	42	7180	NE	5592	NE	3983
34	38	50.8	42	7174	NE	5589	NE	3982
34	43	53.4	37	8820	NE	7099	NE	5347
34	44	36	30	8592	NE	7057	NE	5398
34	42	47.4	35	8269	NE	6657	NE	4980
34	36	41	40	6413	NE	4958	NE	3453
35	43	46	31	8350	NE	6806	NE	5155
35	44	52.0	36	9270	NE	7481	NE	5678
35	40	48.7	38	7831	NE	6183	NE	4511
35	45	35	29	8930	NE	7362	NE	5671
35	41	54.3	40	8475	NE	6706	NE	4948
35	43	52	37	8936	NE	7169	NE	5390
35	40	46.4	36	7746	NE	6134	NE	4483
35	40	51.6	40	7956	NE	6256	NE	4554
35	38	48	39	7214	NE	5612	NE	3994
35	41	48.1	36	8108	NE	6454	NE	4765
35	41	43.7	35	7958	NE	6365	NE	4711
35	40	49.1	38	7845	NE	6192	NE	4516
35	49	41.8	28	10398	NE	8678	NE	6858
36	44	41.8	31	8920	NE	7256	NE	5523
36	44	41	29	8592	NE	7052	NE	5389
36	45	42	31	9253	NE	7565	NE	5806
36	51	43.9	28	11412	75	9358	NE	7662
36	42	45.0	34	8432	NE	6752	NE	5035
36	46	37	29	9372	NE	7737	NE	5995
36	42	42.2	33	8320	NE	6684	NE	4992



- The red zones are ≤30 minutes.
- The amber zone >30 ≤ 120 minutes
- The yellow from >120 ≤ 240 minutes.

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PHS Tables

Temp °C	10	15	20	2
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				

MEDIUM WORKLOAD (175 W/m2)			
Temp °C	10	15	20
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			

HIGH WORKLOAD (230 W/m2) (Time to 38°C)														
	Relative Humidity %													
Temp °C	10	15	20	25	30	35	40	45	50	55	60	65	70	75
32														
33														
34														
35														
36														
37														
38														
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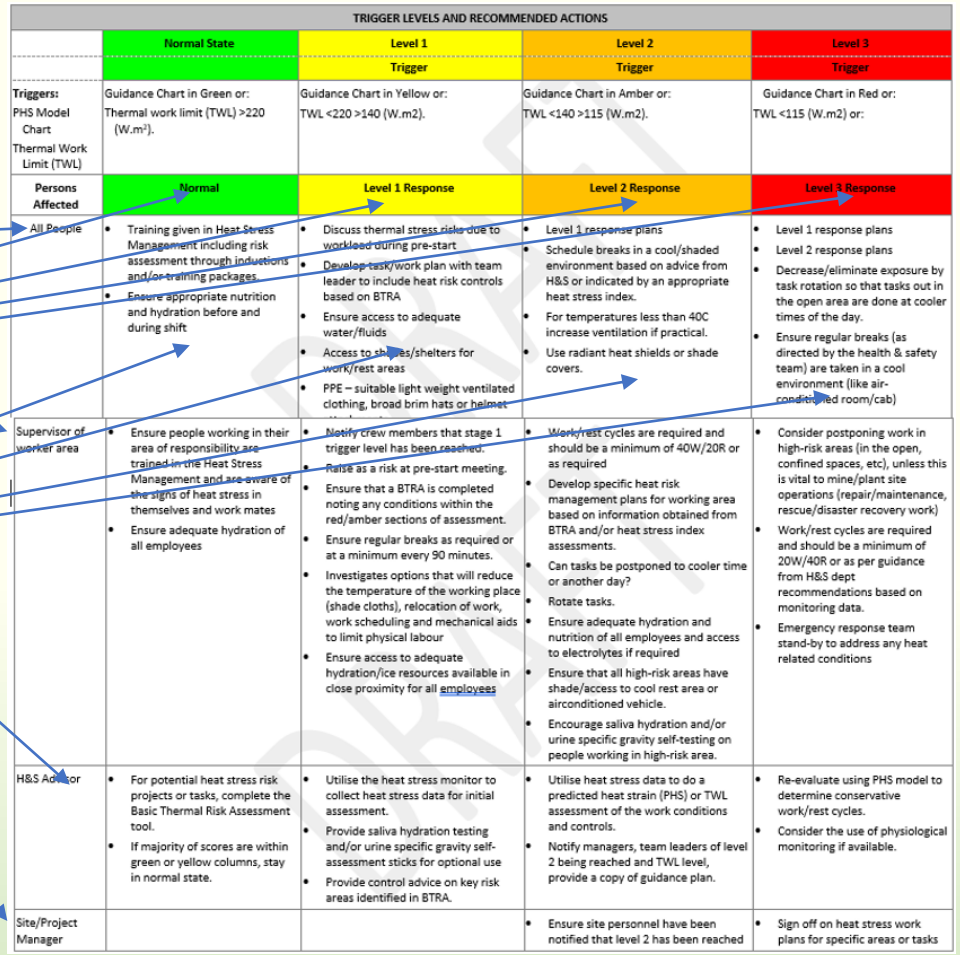
47														

Trigger Action Response Guide

A key component of the process.

- It sets out who does what, and
- The criteria for when it is required.
- Each column details the appropriate controls for the specific coloured condition.
- Requires an understanding of the controls available.
- Needs to be syndicated with the users.



TRIGGER LEVELS AND RECOMMENDED ACTIONS				
	Normal State	Level 1 Trigger	Level 2 Trigger	Level 3 Trigger
Triggers: PHS Model Chart Thermal Work Limit (TWL)	Guidance Chart in Green or: Thermal work limit (TWL) >220 (W.m²).	Guidance Chart in Yellow or: TWL <220 >140 (W.m2).	Guidance Chart in Amber or: TWL <140 >115 (W.m2).	Guidance Chart in Red or: TWL <115 (W.m2) or:
Persons Affected	**Normal**	**Level 1 Response**	**Level 2 Response**	**Level 3 Response**
All People	• Training given in Heat Stress Management including risk assessment through inductions and/or training packages. • Ensure appropriate nutrition and hydration before and during shift	• Discuss thermal stress risks due to workload during pre-start • Develop task/work plan with team leader to include heat risk controls based on BTRA • Ensure access to adequate water/fluids • Access to shades/shelters for work/rest areas • PPE – suitable light weight ventilated clothing, broad brim hats or helmet	• Level 1 response plans • Schedule breaks in a cool/shaded environment based on advice from H&S or indicated by an appropriate heat stress index. • For temperatures less than 40C increase ventilation if practical. • Use radiant heat shields or shade covers.	• Level 1 response plans • Level 2 response plans • Decrease/eliminate exposure by task rotation so that tasks out in the open area are done at cooler times of the day. • Ensure regular breaks (as directed by the health & safety team) are taken in a cool environment (like air-conditioned room/cab)
Supervisor of worker area	• Ensure people working in their area of responsibility are trained in the Heat Stress Management and are aware of the signs of heat stress in themselves and work mates • Ensure adequate hydration of all employees	• Notify crew members that stage 1 trigger level has been reached. • Raise as a risk at pre-start meeting. • Ensure that a BTRA is completed noting any conditions within the red/amber sections of assessment. • Ensure regular breaks as required or at a minimum every 90 minutes. • Investigates options that will reduce the temperature of the working place (shade cloths), relocation of work, work scheduling and mechanical aids to limit physical labour • Ensure access to adequate hydration/ice resources available in close proximity for all employees	• Work/rest cycles are required and should be a minimum of 40W/20R or as required • Develop specific heat risk management plans for working area based on information obtained from BTRA and/or heat stress index assessments. • Can tasks be postponed to cooler time or another day? • Rotate tasks. • Ensure adequate hydration and nutrition of all employees and access to electrolytes if required • Ensure that all high-risk areas have shade/access to cool rest area or airconditioned vehicle. • Encourage saliva hydration and/or urine specific gravity self-testing on people working in high-risk area.	• Consider postponing work in high-risk areas (in the open, confined spaces, etc), unless this is vital to mine/plant site operations (repair/maintenance, rescue/disaster recovery work) • Work/rest cycles are required and should be a minimum of 20W/40R or as per guidance from H&S dept recommendations based on monitoring data. • Emergency response team stand-by to address any heat related conditions
H&S Advisor	• For potential heat stress risk projects or tasks, complete the Basic Thermal Risk Assessment tool. • If majority of scores are within green or yellow columns, stay in normal state.	• Utilise the heat stress monitor to collect heat stress data for initial assessment. • Provide saliva hydration testing and/or urine specific gravity self-assessment sticks for optional use • Provide control advice on key risk areas identified in BTRA.	• Utilise heat stress data to do a predicted heat strain (PHS) or TWL assessment of the work conditions and controls. • Notify managers, team leaders of level 2 being reached and TWL level, provide a copy of guidance plan.	• Re-evaluate using PHS model to determine conservative work/rest cycles. • Consider the use of physiological monitoring if available.
Site/Project Manager			• Ensure site personnel have been notified that level 2 has been reached	• Sign off on heat stress work plans for specific areas or tasks

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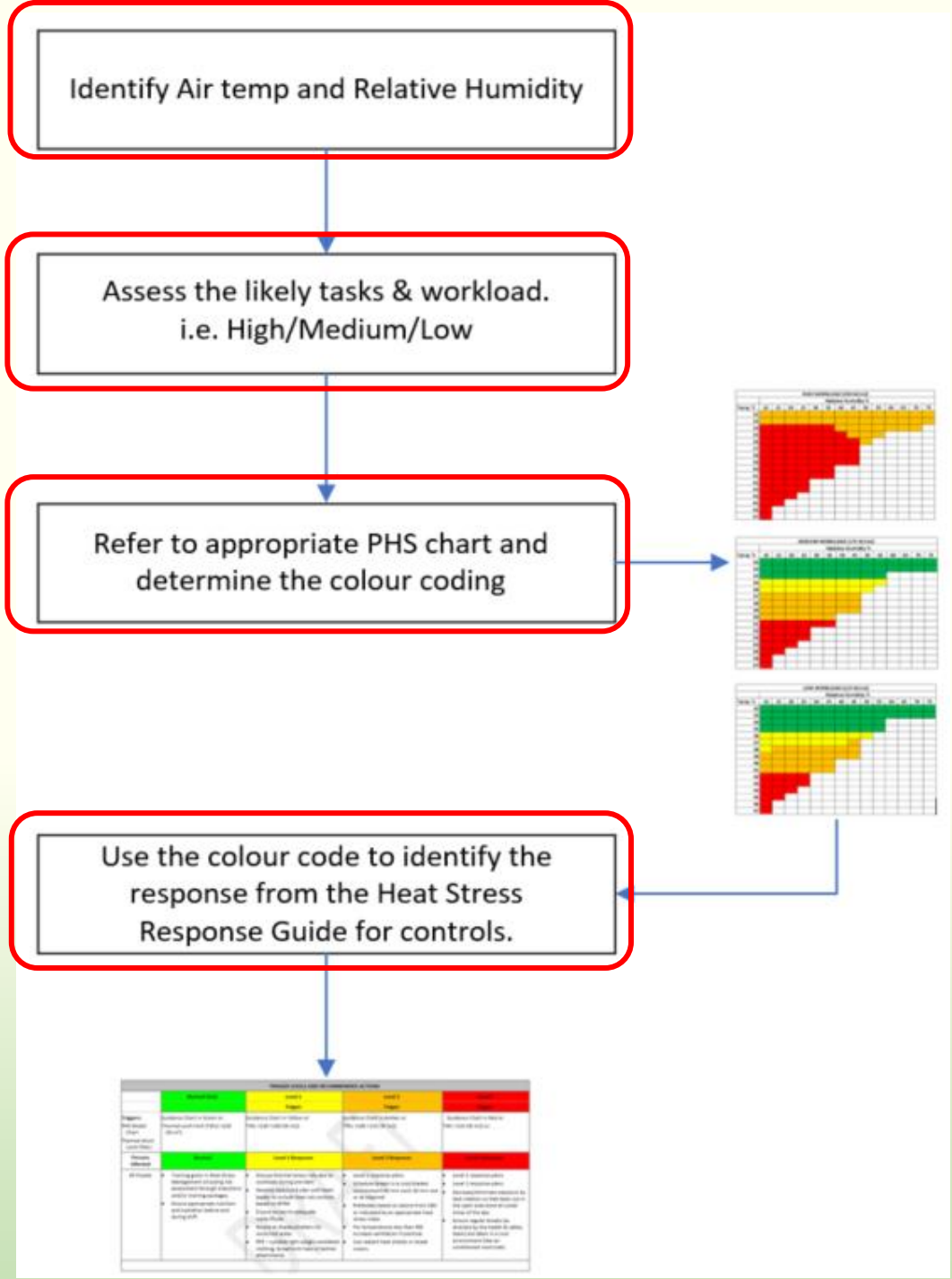
Simplified Heat Stress Chart System

- Similar to the National Weather Service HSI Charts but is based on ISO 7933 for physiological risk.
- Only requires knowledge of:
  - Air temperature,
  - Humidity, and
  - estimated workload.



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Results from first year use in the field

- Feedback indicated that process met simplicity criteria
- Suitable for the first level assessment for planning
- Overall reduction in heat related incidence from **forty** in previous year to **four**.
- Still some further development & validation required in different environments

Limitations

1. Heat stress index calculations are based on fit, healthy participants, 90kg, 1.8m.
2. Globe temperatures were calculated from meteorological data.
3. An averaged air velocity for the period was used rather than multiple variables.
4. Data from two months of the year: a larger database would have been preferred.
5. Posture was limited to standing.
6. ISO 7933 has not been fully validated for some of the extreme conditions experienced.

Important Caveats