HEAT STRESS

Heat Stress

- The general term which describes a variety of symptoms produced when the human body is exposed to a combination of heat and work which interferes with the body’s ability to dissipate the heat energy.

How hot is too hot?

- 30º ?
- 35º ?
- 35º with10% humidity?
- 35º with 85% humidity?
- 35º with 85% humidity, and a breeze?
- 40º ?

There is no single number which can define heat stress

- There is no one heat stress index or temperature may be adopted as the solution to the needs of all industry
- Di Corletto, Coles, Firth – Heat Stress Standard and Documentation Developed for Use in the Australian Environment – AIOH 2003

Physiology of Heat Stress

Factors affecting heat load

- Temperature
- Humidity
- Air velocity
- Radiant heat
- Clothing
- Physical activity level

Heat Gain and Loss

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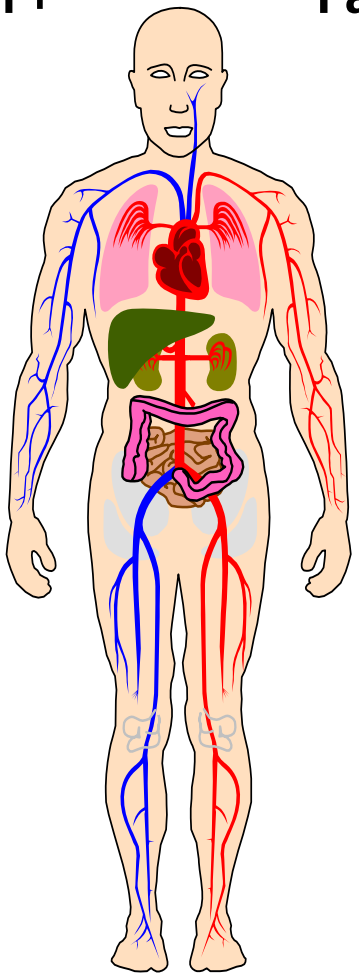
Factors Affecting Heat Gain +

(a) Physical Activity

(b) Air Temperature

(c) Radiant Heat



Factors Affecting Heat Loss -

(a) Sweating

(b) Acclimatisation

(c) Air Movement

(d) Humidity

(e) Clothing including Protective Clothing

Physical activity

- Imposes a heat load which is:
- inescapable,
- extremely variable, and
- sometimes very large
  - Basal rate 70 Watts
  - Walking 350 Watts
  - Strenuous activity 1000 Watts +

Response to Heat

- Heat loss through skin
- Blood flow to the skin is increased
- Sweating
- The evaporation of 1 litre of sweat will remove heat at the rate of 700 W
- During strenuous work, a worker may need to sweat more than 10 litres in a work shift

Heat Stress

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Effects of Heat on the Body

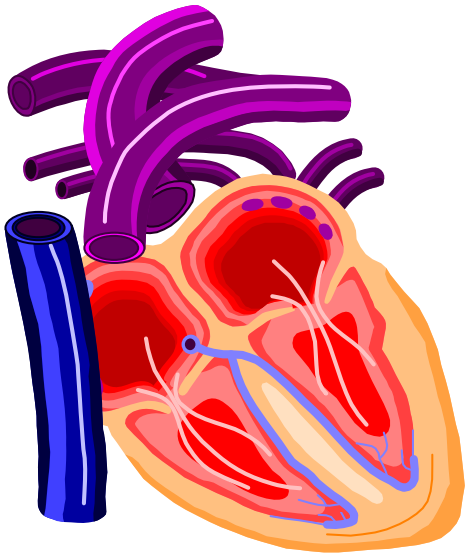
- cardiovascular load
- dehydration
- heat syncope
- heat stroke
- skin problems

Heat Stress

Effects of Heat on the Body

- Dehydration
- Increased work
- Increased blood flow
- through skin

INCREASED HEART RATE



Heat Stress

Effects of Heat

- heat illness
- aggravation of pre-existing disability
- induce unsafe acts
- discourage use of protective equipment
- increase exposure to hazards

Heat Stroke

- **This is a life threatening condition.**
- The patient has a temperature in excess of 40°C
- sweating often stops
- the skin is hot, and often dry
- pulse rate is rapid
- may be dizziness, weakness, headache, nausea and visual disturbances.
- The patient may be aggressive and irrational and convulsing.
- **URGENT medical attention must be sought.**

Personal factors

- cardiovascular disease
- febrile illness, for example the “flu”
- acclimatisation
- obesity
- medication
- dehydration

Drugs predisposing to heat stress

Drugs that inhibit sweating by inhibiting cholinergic action

- Antihistamines
- Beta blockers (propranolol, timolol etc)
- Anticholinergic drugs (atropine, scopolamine)
- Phenothiazine derivatives (chlorpromazine, promethazine, trifluoperazine, and prochlorperazine.)

Drugs that increase heat load by stimulating metabolism

- Thyroid preparations
- Amphetamines

Miscellaneous

- Tricyclic antidepressants
- Monoamine oxidase inhibitors
- Diuretics

Assessment of Heat Stress

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Temperature

- The aim is to make an assessment of body core temperature.
- Rectal temperature provides a more accurate reflection of body core temperature, but is not practical in the work situation.
- Temperature is usually taken in the mouth or the arm pit, and 0.5°C must be added to approximate core temperature.
- Ear drum temperature – continuous monitoring

Heat Stress

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Temperature

- **>** 39.5° oral/axillae - very high risk of heat stroke.
- **>** 38.5° oral/axillae - significant risk of heat stroke.

Fluid replacement

- Ensure that ample supplies of cool water are readily available.
- In arduous conditions, doing manual labour, employees should consume approximately:
  - 6 litres of water during the working day, and
  - 1-1½ litres overnight to maintain a suitable level of hydration.

Urinary Output

- Urinary output is a reasonably sensitive indicator of hydration and renal function.
- When an individual becomes dehydrated, their urinary output falls. Adequate urinary output is a sign of adequate hydration.

Alcohol and dehydration

- Alcohol has a diuretic effect - makes you pass urine
- Does not replace fluid - tends to increase dehydration
- Certainly have a beer, but drink water as well to replace lost fluid

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Assessment of Heat Stress in the Working Environment

Heat Stress Indices

- ISO 9866
- WBGT – ACGIH
- Predicted Heat Strain
- Thermal Work Limit (Brake Donoghue and Bates 1998)
- Corrected Effective Temperature
- Required Sweat Rate
- Fantus Test (urinary Cl^-)

ACGIH Heat Stress

WBGT = Wet Bulb Globe Temperature

- Outdoors with solar load
- WBGT = 0.7 NWB + 0.2 GT + 0.1 DB
- Indoors, or outdoors with no solar load
- WBGT = 0.7 NWB + 0.3 GT

- Too conservative, does not take sufficient account of airflow

ACGIH Heat Stress

Hourly activity	Light	Moderate	Heavy	Very Heavy
100% work	29.5ºC	27.5 ºC	26.0 ºC	25.0 ºC
75% work; 25% rest	30.5 ºC	28.5 ºC	27.5 ºC	26.5 ºC
50% work; 50% rest	31.5 ºC	29.5 ºC	28.5 ºC	27.5 ºC
25% work; 75% rest	32.5 ºC	31.0 ºC	30.0 ºC	29.5 ºC

ACGIH Heat Stress

In 1999 Notice of intended changes, the ACGIH has adopted a different philosophy.

- Where tabulated guidelines are exceeded,
- When impermeable clothing is worn
- When very heavy manual work is undertaken

Then additional controls are required

No longer are levels considered absolute.

ACGIH Heat Stress

Additional controls included

- Review of working conditions, to see if conditions can be alleviated
- Personal monitoring
- Supplemental training
- Implementation of modified work-rest regimes as may still be required

Personal monitoring

- Measurement of core body temperature
  - Ear (aural measurement)
- recovery heart rate times
- aural temperatures
- end-of-shift weight loss (to determine level of dehydration)
- Urinary concentration

AIOH Australian Recommendation

Developed for the Australian Institute of Occupational Hygienists by the Heat Stress Working Group - Ross Di Corletto, Jerry Coles, Ian Firth - March 2003

AIOH Procedure

1. Initial risk assessment
2. Screening for impermeable clothing
3. Detailed analysis
4. Evaluation of heat strain on individuals
5. Heat stress management and controls

Worked Example of Basic Thermal Risk Assessment

An example of the application of the basic thermal risk assessment would be as follows. A fitter is working on a pump out in the plant at ground level that has been taken out of service the previous day. The task involves removing bolts and a casing to check the impellers for wear, approximately 2 hours work. The pump is situated approximately 25 metres from the workshop. The fitter is acclimatised, has attended a training session, is wearing a standard single layer long shirt and trousers, and a respirator is not required. The work rate is light, there is a light breeze and the WBGT temperature has been measured at 27°C.

Using the above information in the risk assessment and we have:

HAZARD TYPE	**Assessment Point Value**		
	1	**2**	**3**
Hot surfaces	Contact neutral ☑	Hot on contact ❑	Burn on contact ❑
Exposure period	< 30 min ❑	30 min - 2 hours ☑	> 2 hrs ❑
Confined space	No ☑		Yes ❑
Task complexity	Simple ❑	Moderate ☑	Complex ❑
Climbing, ascending, descending	None ☑	Moderate ❑	Significant ❑
Distance from cool rest area	<50 Metres ☑	50-100 Metres ❑	>100 Metres ❑
Distance from drinking water	<30 Metres ☑	30-50 Metres ❑	>50 Metres ❑
Clothing (permeable)	Single layer (light) ☑	Single layer (mod) ❑	Multiple layer ❑
Understanding of heat strain risk	Training given ☑	❑	No training given ❑
Air movement	Windy ❑	Some wind ☑	No wind ❑
Resp. protection (-ve pressure)	None ☑	Half Face ❑	Full Face ❑
Acclimatisation	Acclimatised ☑		Unacclimatised ❑
	9	6	0
SUB-TOTAL A			15
	2	**4**	**6**
Metabolic work rate*	Light ☑	Moderate ❑	Heavy ❑
SUB-TOTAL B			2

	1	**2**	**3**	**4**
Wet Bulb Globe Temperature	< 24°C ❑	>24°C ≤ 27°C ☑	>27°C ≤ 30°C ❑	> 30°C ❑
SUB-TOTAL C				2

A = 15; B = 2; C = 2; therefore

Total = (15+2) x 2 = 34

As the total lies between 28 and 60 there is a potential for heat induced illness occurring if the conditions are not addressed, and further analysis of heat stress risk is required.

Preventative Strategies

- Prevent heat transfer
- Cooling
- Education
- Fluid replacement
- Work scheduling
- Acclimatization
- Medical screening

Physiological Monitoring

- Medical surveillance may be required — determination of general fitness, presence of medical conditions and use of medications that may predispose employee to heat strain
- Persons at risk of heat stress can be monitored at workplace for signs of heat illness and to ensure work-rest and hydration regimes are followed
- Monitoring may also include assessment of:
  - recovery heart rate times
  - aural temperatures
  - end-of-shift weight loss (to determine level of dehydration)
  - Urinary concentration

Personal factors

Remember

- Different individuals will have different levels of tolerance
- An individual's tolerance may vary over time because of short-term factors, including
  - febrile illness, for example the "flu"
  - acclimatisation
  - obesity
  - medication
  - Dehydration (most commonly alcohol induced)

Self-Assessment

"Self assessment should be used as the highest priority system during exposures to heat stress. This allows adequately trained individuals to exercise their discretion in order to reduce the likelihood of over exposure to heat stress. No matter how effectively a monitoring system is used, it must be recognised that an individual's physical condition can vary from day to day. This can be due to such factors as illnesses, acclimatisation, alcohol consumption, individual heat tolerance and hydration status."

AIOH 2003

Never ignore anyone's signs or symptoms of heat related disorders!

How can individuals prevent heat-related illnesses?

- Stay indoors in air-conditioned areas when possible.
- Drink plenty of water before starting an outdoor activity. Drink extra water all day.
- Drink less tea, coffee and alcoholic beverages.
- Wear lightweight, light-coloured, loose-fitting clothes.
- Protect yourself from the sun by wearing a hat or using an umbrella.
- Increase the time you spend in daily outdoor activities slowly and gradually.
- Schedule vigorous outdoor activities for cooler times of the day.
- Try to avoid spending time outdoors during the hottest hours of the day: 10am to 6pm.
- During an outdoor activity, take frequent breaks and drink water or other fluids every 15 to 20 minutes, even if you don't feel thirsty. If you have clear, pale urine, you are probably drinking enough fluids.
- If you have a chronic medical problem, ask your doctor about drinking extra fluids and about your medicines.

Control with Effective Temperature

- Adapted from US Bureau of Mines
- Measurement taken in work area, Effective Temperature calculated
- Orange box - miners informed, measurement repeated in 1 hr
- If measurements no better - leave
- Red box - miners leave workplace