KEEP YOUR COOL

PREVENTING HEAT STRESS IN THE WORKPLACE

Presentation Outline:

1. Body's Response to Heat
2. Risk Factors
3. Signs, Symptoms, Prevention, and Treatment
4. Measuring Heat Stress
5. Heat-Related OSHA Standards
6. Recommended Heat Stress Exposure Limits
7. Heat Stress Prevention Program Elements
8. Case Studies – Occupational Safety and Health Review Commission
9. Review

BODY'S RESPONSE TO HEAT

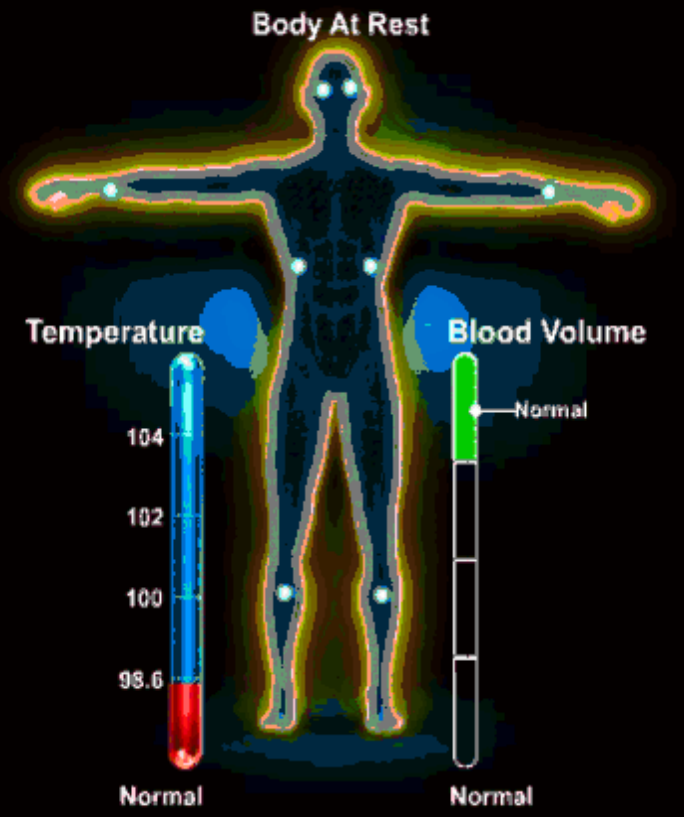
- Reduced blood flow to brain
  - Reduced mental alertness and comprehension
- Reduced blood flow to active muscles
  - Fatigue, loss of strength
- Increased sweating
  - Slipperiness

Coping with Heat

Effects of Body's Response

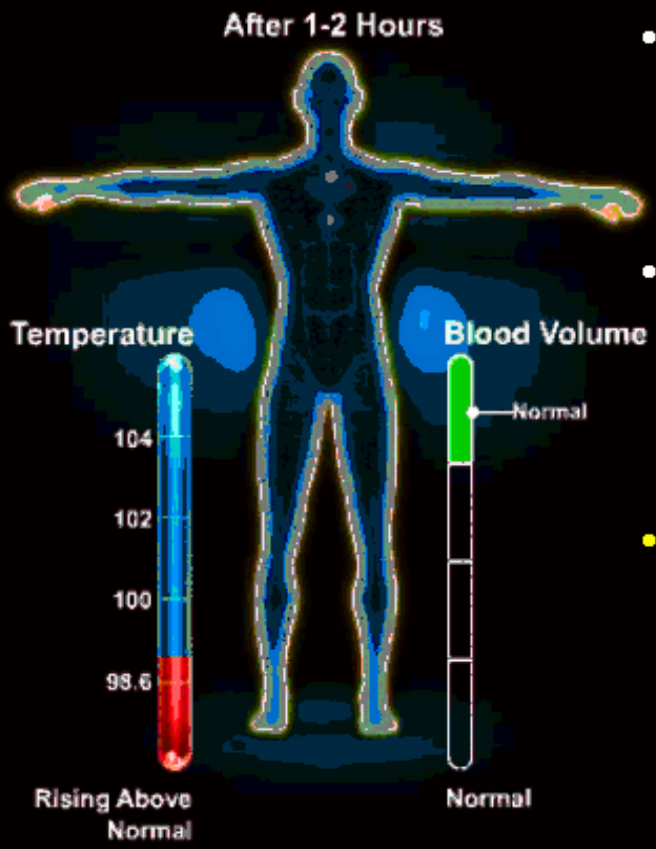
- Reduced blood flow to brain
  - Reduced mental alertness and comprehension
- Reduced blood flow to active muscles
  - Fatigue, loss of strength
- Increased sweating
  - Slipperiness

Physiology of Heat Stress



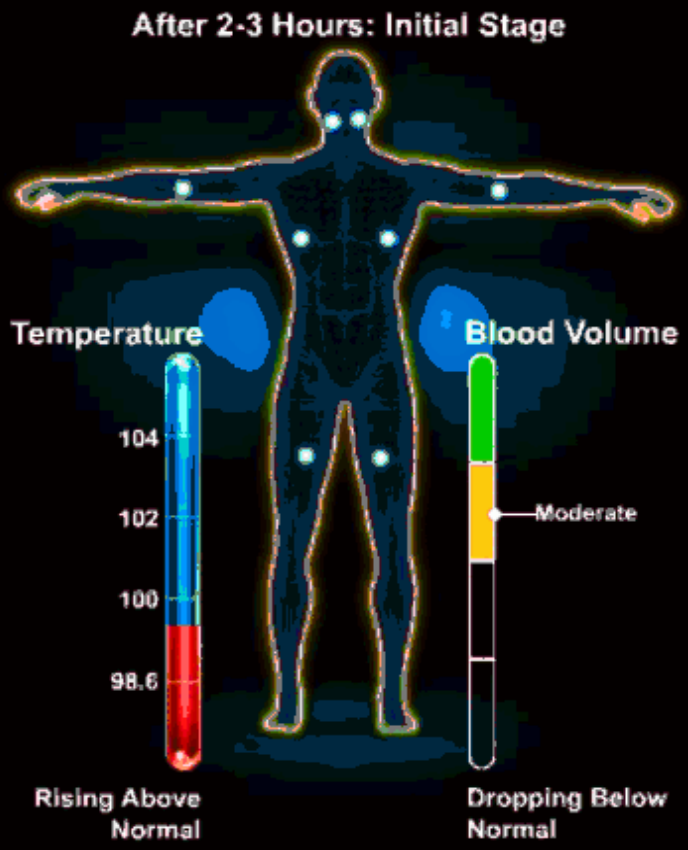
During both rest and activity, the human body tries to maintain an internal temperature of 98.6 F.

Physiology of Heat Stress



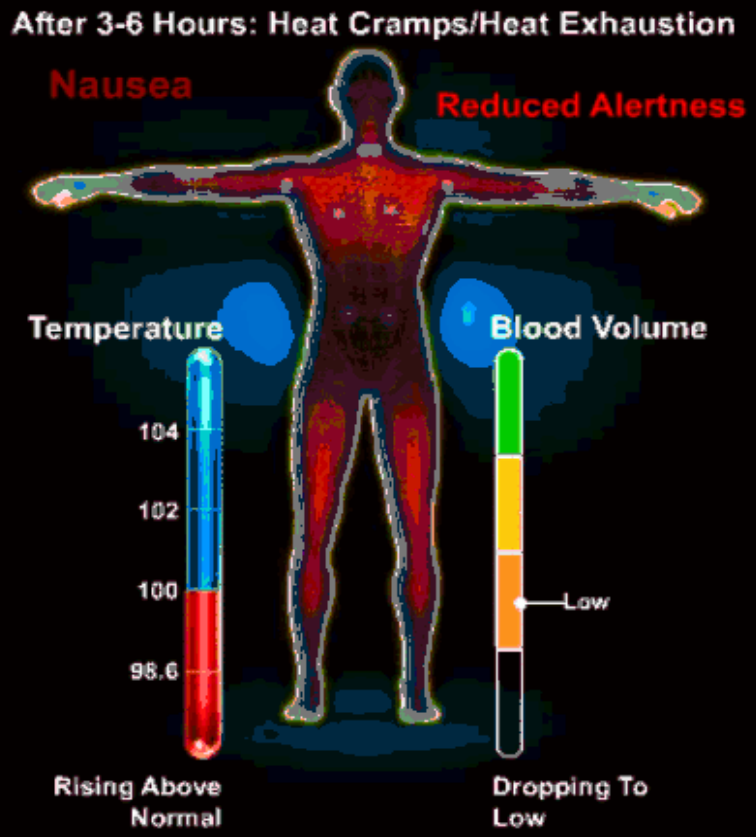
- Hot weather, heat sources, and hard work raise the body's core temperature.
- Heated blood is pumped to the skin's surface, where body heat transfers to the environment, if cooler.
- If heat has to be shed faster, sweat carries it outside skin and evaporates to aid cooling.

Physiology of Heat Stress



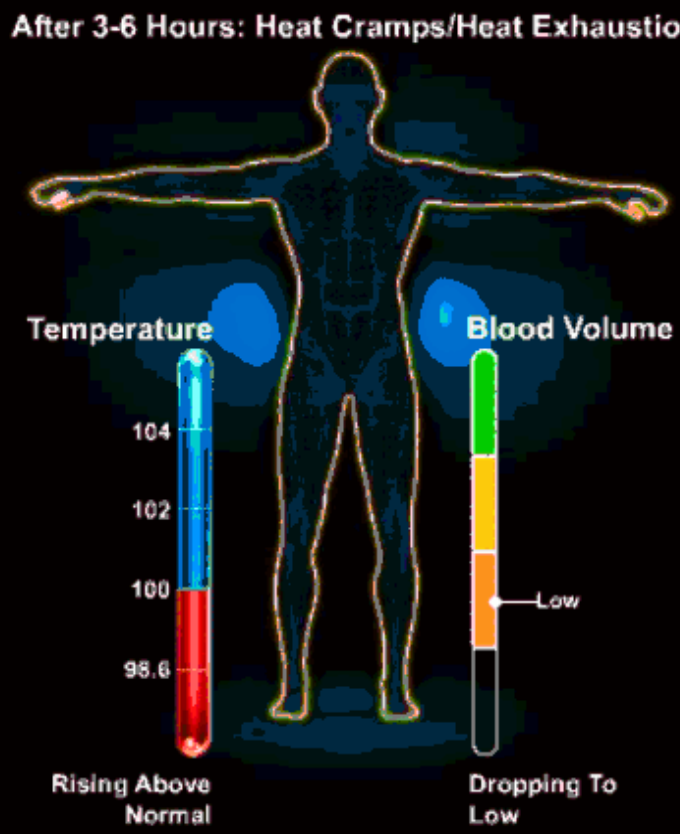
- During heavy work, a body can lose 1-2 liters of water per hour.
- After 2-3 hours of fluid loss, a person is likely to:
  - Lose endurance
  - Become uncomfortable
  - Feel hot
  - Become thirsty

Physiology of Heat Stress



- The longer a body sweats, the less blood there is to carry excess heat to skin or oxygen and nutrients to muscles.
- After 3 hours, a dehydrated worker may experience:
  - Headaches
  - Muscle fatigue
  - Loss of strength
  - Loss of accuracy and dexterity
  - Heat cramps
  - Reduced alertness
  - Nausea

Physiology of Heat Stress



- Water is key to cooling body and combatting heat stress.
- Without fluid replacement during an extended period of work, the body is at risk of exhaustion.
- Untreated heat exhaustion may lead to heat stroke.

Temperature (F) versus Relative Humidity (%)

°F	90%	80%	70%	60%	50%	40%
80	85	84	82	81	80	79
85	101	96	92	90	86	84
90	121	113	105	99	94	90
95		133	122	113	105	98
100			142	129	118	109
105				148	133	121
110						135

HI	Possible Heat Disorder:
80°F - 90°F	Fatigue possible with prolonged exposure and physical activity.
90°F - 105°F	Sunstroke, heat cramps and heat exhaustion possible.
105°F - 130°F	Sunstroke, heat cramps, and heat exhaustion likely, and heat stroke possible.
130°F or greater	**Heat stroke highly likely with continued exposure.**

When Cooling Mechanisms Fail

- High air temperature reduces effectiveness of the cooling system
- High humidity reduces evaporation rate of sweat
- Excess loss of sodium
- Dehydration

RISK FACTORS

Body Heat Balance Equation

$$S = (M — W) \pm C \pm R \pm K - E - Res$$

- S = the change in heat content of the body
- M = heat produced by metabolism
- W = rate of mechanical work accomplished
- C = net heat exchange by convection
- R = net heat exchange by radiation
- K = net heat exchange involving direct transfer
- E = body heat loss by evaporation
- Res = rate of heat exchange by respiration

- Temperature
- Relative humidity
- Radiant heat
- Air velocity

Environmental Factors

- Individual variability
- Acclimatization
- Age
- Overweight / body fat Drugs
- Caffeine
- History of heat-related illness

Individual Factors

Work-related Factors

- Workload
  - Type of work
  - Level of physical activity
  - Time spent working
- Clothing
  - Weight (heavy vs. breathable)
  - Color (dark vs. light)
  - PPE and protective gear / clothing

Work-related Clothing and PPE

- Protective gear – police and emergency responders
- PPE and clothing adjustment factors
  - –Level A suit without microclimate cooling: 50°F

Guide for the Selection of Personal Protective Equipment for Emergency First Responders, 2nd Edition, DHS Security Guide 102-06 January 2007

Signs, Symptoms, Prevention, and Treatment

Heat Rash

Cause	Signs/ Symptoms	Treatment	Prevention
Hot humid environment and plugged sweat glands	Red bumpy rash with severe itching	Change into dry clothes Avoid hot environments Rinse skin with cool water	Wash frequently to keep skin clean and dry

Sunburn

Cause	Signs/ Symptoms	Treatment	Prevention
Over-exposure to the sun	Red, painful, or blistering and peeling skin	For skin blisters, seek medical aid Use skin lotions (avoid topical anesthetics) and work in the shade	Work in the shade: cover skin with clothing; use suntan lotions with a sun protection factor of at least 15

Heat Cramps

Cause	Signs/ Symptoms	Treatment	Prevention
Muscle spasms that result from lack of water replenishment	Painful cramps in arms, legs, or stomach which may occur suddenly at work or later at home	Move to a cool area; loosen clothing and drink cool salted water (1 tsp. salt per gallon of water) or commercial fluid replacement beverage If severe or if they don't go away, seek medical aid	Drink water and / or carbohydrate-electrolyte liquids

Cause	Signs/ Symptoms	Treatment	Prevention
Not enough blood flowing to the head, causing loss of consciousness	Sudden fainting after at least two hours of work Cool moist skin Weak pulse	Fainting may be due to a heart attack or other illness GET MEDICAL ATTENTION Assess need for CPR Move to a cool area Loosen clothing Make person lie down If conscious, offer sips of cool water	Reduce activity levels and/or heat exposure Drink fluids regularly Gradual acclimatization of workers Workers should check on each other to help spot the symptoms which often precede heat stroke

Heat Syncope

Heat Exhaustion

Cause	Signs/ Symptoms	Treatment	Prevention
Inadequate salt and water intake causes a person's body's cooling system to start to break down	Heavy sweating Cool moist skin Body temperature over 100.4°F Weak pulse Normal or low blood pressure Person is tired, weak, clumsy, upset or confused Person is very thirsty Panting or breathing rapidly Vision may be blurred	GET MEDICAL AID This condition can lead to heat stroke Move the person to a cool shaded area Loosen or remove excess clothing Provide cool water to drink (salted if possible) Fan and spray with cool water	Reduce activity levels and/or heat exposure Drink fluids regularly Workers should check on each other to help spot the symptoms which often precede heat stroke

Heat Stroke

Cause	Signs/ Symptoms	Treatment	Prevention
If a person's body has used up all its water and salt, it will stop sweating, which can cause body temperature to rise	High body temperature (over 105.8°F) and any one of the following: ○ weakness ○ the person is confused, upset or acting strangely ○ hot, dry, red skin ○ a fast pulse ○ headache or dizziness In later stages, a person may pass out and have convulsions	CALL AMBULANCE This condition can be fatal Remove excess clothing Fan and spray the person with cool water Offer sips of cool water if the person is conscious Do NOT send home or leave unattended unless approved by a physician	Reduce activity levels and/or heat exposure Drink fluids regularly Workers should check on each other to help spot the symptoms which often precede heat stroke

Temperature, Humidity and Body Cooling

- Humans perspire as a means of cooling the body.
- The higher the relative humidity, the less perspiration can be evaporated, reducing the cooling effect of evaporation and increasing heat load in the body.
- The combination of rising temperature and work demands can lead to heat stress situations for workers.

Acclimatization

- Acclimatization is the ability of our body to adapt to working in a hot environment.
- Initial benefits occur within a few days. Longer-term benefits take a few weeks of exposure in a hot environment.
- Acclimatization can be lost quickly (for example, over a long weekend). Loss of acclimatization due to short absences (2 days or less) can be made-up quickly, but longer absences take up to a week to be made-up.
- Often, outdoor workers are considered not to be acclimatized because they don't work at higher enough temperatures for long enough.

Acclimatization Regimens

- For workers who have had experience working in a hot environment:

Day 1	Day 2	Day 3	Day 4
50% exposure	60% exposure	80% exposure	100% exposure

- For workers who have not had experience working in a hot environment:

Day 1	Day 2	Day 3	Day 4	Day 5
20% exposure	40% exposure	60% exposure	80% exposure	100% exposure

Re-Acclimating

- **After long absences**
  - 50% exposure on day back
  - 20% per day increase for the next 2 days
  - Final 10% on the 3rd day

Heat Stress Management

- Heat stress policy (or sun safety policy)
- Heat stress program or hot weather plan (could be part of a sun safety program):
  - Risk assessment process
  - Control measures: general controls and job specific controls
  - Training and education of workers
  - Incident response, reporting and investigation including first aid
  - ‘Check’ elements: workplace inspections, annual audits, documentation

Heat Stress Risk Assessment

1. **Operational Review**: to gain an understanding of the operational environment and risk factors for heat stress
2. **Job Safety Analysis**: for specific positions/tasks which may have elevated risk
3. **Daily Assessment**: during summer, assessment undertaken when pre-determined trigger values are reached (for example, humidex = 30°C, Environment Canada Heat Advisory's):
   - **WBGT** (web bulb globe temperature) assessed using 'heat stress monitor' or **humidex** assessed using 'thermal hygrometer'
   - Adjustments for clothing, radiant heat, work rate, work/rest cycle
   - Need a monitoring plan: who, where, when, how

General Control Measures

- Provide heat stress information and training through verbal and written instructions, annual heat stress training, orientation training, safety talks, etc
- Encourage workers to keep hydrated: drink 1 cup of water every 20 minutes
- Workers to report symptoms of heat stress
- Encourage self-limitation of exposure when supervisor is not present
- Workers to look out for signs and symptoms of heat stress in co-workers
- Additional training for high risk workers
- Encourage healthy lifestyles

Humidex 1 (°C)	Response Actions	Humidex 2 (°C)
25 – 29	Supply water to workers on an 'as needed' basis	32 – 35
30 – 33	Post 'Heat Stress Alert' notice Encourage workers to drink extra water Start recording hourly temperature and relative humidity	36 – 39
34 – 37	Post 'Heat Stress Warning' notice Notify workers that they need to drink extra water Ensure workers are trained to recognize symptoms	40 – 42
38 – 39	Work with 15 minutes of relief per hour can continue Provide adequate quantities of cool (10 – 15°C) water At least one cup (250mL) of water every 20 minutes per worker Workers with symptoms should seek medical attention	43 – 44
40 – 41	Work with 30 minutes of relief per hour can continue, in addition to previously listed actions	45 – 46*
42 – 44	If feasible, work with 45 minutes of relief per hour can continue, in addition to previously listed actions	47 – 49*
> 45*	Only medically supervised work can continue	> 50*

Humidex 1:

- Unacclimatized, moderate work rate
- Acclimatized, heavy work rate

Humidex 2:

- Unacclimatized, light work rate
- Acclimatized, moderate work rate

Job Specific Control Measures

- Provide barriers to shield workers from radiant heat exposure.
- Provide cooling fans when air temperature is below skin temperature (35°C) and the humidity is below 70%. Above these levels causes more heating.
- Consider cooling or dehumidifying the workplace.
- Provide mechanical aids for material handling — dollies, carts, lifting devices — to reduce physical activity. Organize the work to reduce the pace of activity.

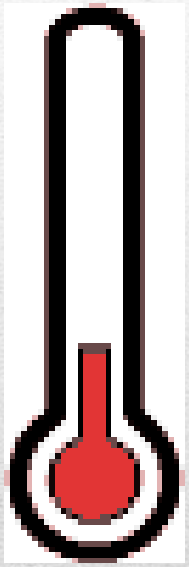
Job Specific Control Measures

- If possible, postpone strenuous work until a cooler time of the day.
- If work is done outside, ensure that shaded areas are available.
- Rotate workers in and out of hot work areas whenever possible.
- Consider cooling vests, if feasible and effective for the worker.

Protection Measures Workers Should Take

Engineering Control

- The five major types of engineering controls
  1. Ventilation
  2. Air cooling
  3. Fans
  4. Shielding
  5. Insulation



Engineering Controls

- General ventilation is used to dilute hot air with cooler air (generally cooler air that is brought in from the outside)
- Air treatment/air cooling differs from ventilation because it reduces the temperature of the air by removing heat (and sometimes humidity) from the air

Engineering Controls

- Air conditioning is a method of air cooling, but it is expensive to install and operate
- Local air cooling can be effective in reducing air temperature in specific areas

Engineering Controls

- Heat conduction methods include insulating the hot surface that generates the heat and changing the surface itself
  - Shields, can be used to reduce radiant heat, i.e. heat coming from hot surfaces within the worker's line of sight

Work Practice Controls

- **Work rate**
  - The fastest way to decrease the rate of heat production is to decrease the work rate.
- **Age** – (over 40)
  - The maximum possible output of heat decreases with age.
  - Older people start sweating later and at a lower rate.
- **Body size**
  - Skin area to weight ratios

Administrative Controls & Work Practices

- Knowledge of the hazards of heat stress
- Recognition of predisposing factors, danger signs, and symptoms
- Awareness of first-aid procedures for, and the potential health effects of, heat stroke
- Employee responsibilities in avoiding heat stress

- Dangers of using drugs, including therapeutic ones, and alcohol in hot work environments
- Use of protective clothing and equipment
- Coverage of environmental and medical surveillance programs and the advantages of worker participation in such programs

Administrative Controls & Work Practices

Work Monitoring Programs

- **Personal monitoring**
  - Heart rate
  - Recovery heart rate
  - Oral temperature
  - Extent of body water loss

Training

- Knowledge of hazards
- Predisposing factors – age, etc.
- Signs and symptoms
- PPE
- First aid
- Health effects of heat stroke

Measuring Heat Stress

NOAA NWS Meteorological Measurements

- Temperature
  - Three thermometers
  - 5-minute averages using two-second readings from each thermometer
- Relative humidity
  - A single relative humidity sensor
  - 5-minute averages

Wet Bulb Globe Temperature (WBGT) Devices

- WET BULB (WB) THERMOMETER
  - WB is measured with a thermometer that has a wet wick, which takes into account RH and wind speed (evaporative cooling)
- GLOBE (G) THERMOMETER
  - G indicates radiant heat exposure
  - A temperature sensor is placed inside a blackened copper sphere
- DRY BULB (DB) THERMOMETER
  - DB is the ambient air temperature

Personal Monitors

- HS Index devices [Temp and RH] Body temperature
  - Ear sensor
  - Skin sensor
  - Note: OSHA does not view ear canal or skin sensors as sufficiently reliable to use in compliance evaluations.

OSHA Heat Safety Phone App

- Uses NOAA NWS data
- Allows workers and supervisors to calculate the OSHA heat index for their worksite
- Displays a risk level for outdoor work

OSHA Heat Safety Phone App

https://www.osha.gov/SLTC/heatillness/heat_index/heat_app.html

- Wet Bulb Globe Temperature (WBGT) takes into account:
  - temperature
  - humidity
  - wind speed
  - sun angle
  - cloud cover (solar radiation)

- Note: The WBGT differs from the OSHA heat index [OSHA HI takes into consideration T & RH and is calculated for shady areas].
- Military services, agencies, many nations, and a few states use the WBGT as a guide to managing workload in hot environments

NWS WBGT Prototype

http://www.weather.gov/tsa/wbgt

NOAA NWS Tulsa WBGT

HEAT-RELATED OSHA STANDARDS

General Duty Clause

- OSHA does not have a specific standard that covers working in hot environments

- General Duty Clause, Section 5(a)(1): in addition to compliance with hazard-specific standards, all employers must provide a work environment “free from recognized hazards that are causing or are likely to cause death or serious physical harm” to employees. 29 U.S.C. § 654(a)(1)

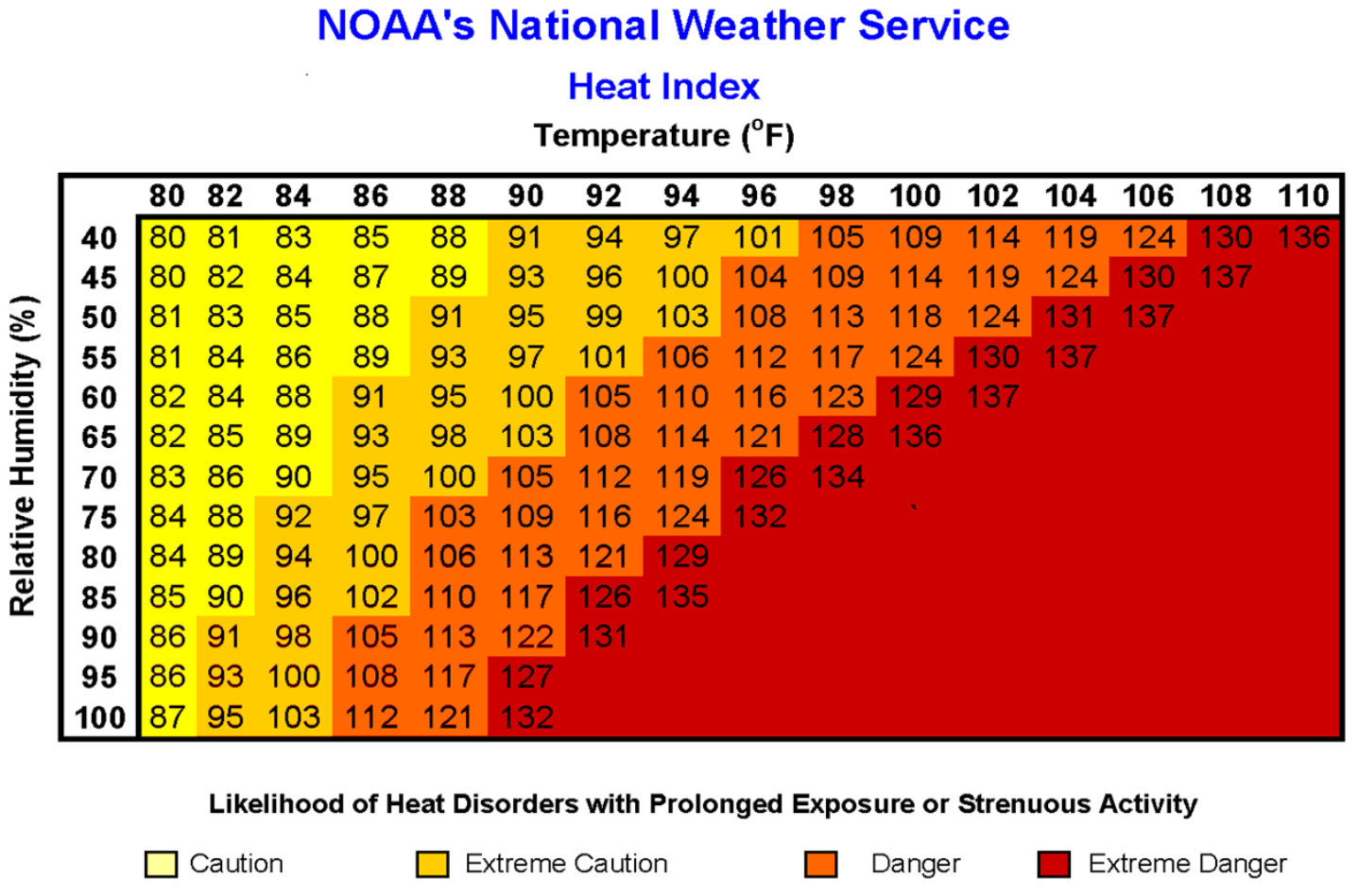
Heat Exposure Citations

- OSHA has issued GDC citations for heat exposures in the following industries:
  - Landscaping
  - Roofing
  - Farming
  - Construction/paving
  - Tree cutting
  - Garbage collection
- 35 Citations issued 2015–2016

RECOMMENDED HEAT STRESS EXPOSURE LIMITS

Exposure Limits

- NOAA's National Weather Service Heat Index
- OSHA's Modified NWS Heat Index ACGIH TLVs for Chemical Substances
- and Physical Agents (Thermal Stress) Heat Stress and Heat Strain



NOAA's National Weather Service Heat Index

OSHA Guidance for Heat Stress

- Based on a modification of NOAA's National Weather Service (NWS) Heat Index System
  - NOAA's system relates a given heat index to a “caution level”
  - The NOAA NWS heat index is calculated from two numbers: the air temperature and the relative humidity
  - OSHA points out that NOAA devised the heat index values for shaded conditions and light winds

Heat Index	Risk Level	Protective Measures
Less than 91°F	Lower (Caution)	Basic heat safety and planning
91°F to 103°F	Moderate	Implement precautions and heighten awareness
103°F to 115°F	High	Additional precautions to protect workers
Greater than 115°F	Very High to Extreme	Triggers even more aggressive protective measures

OSHA Caution Labels

OSHA Explanation of Caution Labels

- OSHA does not provide an explanation as to how it modified the NOAA NWS heat index or how to adjust the heat index based upon the amount of sunshine or level of work.
- Here is what OSHA does say -
  - –"**Full sunshine can increase heat index values by up to 15° Fahrenheit**. Strenuous work and the use of heavy or specialized protective clothing also have an additive effect. As a result, the risk at a specific heat index could be higher than that listed in the [table] if the work is in direct sunlight without a light breeze, or if work involves strenuous tasks or the use of heavy or specialized protective clothing. Extra measures, including implementing precautions at the next risk level, are necessary under these circumstances."

- Assumes that nearly all acclimatized, fully clothed workers with adequate water and salt intake can work without exceeding a deep body temperature of 100.4°F
- Measurement of deep body temperature is impractical for monitoring the workers' heat load
- WBGT is the simplest and most suitable technique to measure the environmental factors

ACGIH® TLVs®

Allocation of Work in a Cycle of Work and Recovery	TLV [WBGT values in °F]				Action Limit [WBGT values in °F]			
	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
75 to 100%	87.8	82.4	-	-	82.4	77.0	-	-
50 to 75%	87.8	84.2	81.5	-	83.3	78.8	75.2	-
25 to 50%	89.6	86.0	84.2	82.4	85.1	80.6	77.9	76.1
0 to 25%	90.5	88.7	86.9	86.0	86.0	84.2	82.4	80.6

TLV WBGT Values

Comparison – ACGIH and OSHA

	ACGIH	OSHA
Measured in the sun	✓	✗
Measured in the shade	✗	✓
Uses Temperature	✓	✓
Uses RH	✓	✓
Uses Wind	✓	✗
Uses Cloud Cover	✓	✗
Uses Sun Angle	✓	✗

Sample Data – OSHA Guidance

- The NOAA NWS HI relies on only two variables, T and RH
  - Obtain Temperature = 90°F
  - Obtain Relative Humidity = 42%
  - Use the NOAA NWS Heat Stress table, interpolate to obtain the result
  - Compare the result with OSHA Guidance

- A OSHA HI of 92°F = "Moderate Risk Conditions"

- Note: For light work, in clear skies, in accordance with OSHA Guidance, the heat index may be increased 0 – 15°F. For our example, the clothing adjustment factor is "0."

OSHA Guidance Approach

- Develop your plan before heat index levels rise
- Train workers before it gets hot Track the weather daily to assess risk
- Implement heat stress plan when HI >80°F
- Take protective measures appropriate for the risk level

Preventing Heat-Related Illness – Employers

- Employers should establish a program that includes:
  - Training for supervisors and employees
  - Heat acclimatization
  - Proper hydration
  - Work/rest regimens
  - Access to shade or cool areas
  - Prompt medical attention to workers who show signs of heat-related illness
  - Monitoring weather reports
  - Scheduling jobs to cooler parts of the day

Plan Element	Heat Index Risk Level			
	Lower (Caution)	Moderate	High	Very High/Extreme
Supplies (ensuring adequate water, provisions for rest areas, and other supplies)				
Emergency planning and response (preparing supervisors and crews for emergencies)				
Worker acclimatization (gradually increasing workloads; allowing more frequent breaks as workers adapt to the heat)				
Modified work schedules (establishing systems to enable adjustments to work schedules)				
Training (preparing workers to recognize heat-related illness and preventive measures)				
Physiological, visual, and verbal monitoring (using direct observation and physiological monitoring to check for signs of heat-related illness)				

OSHA Heat Prevention Plan Elements

Elements of a Heat Stress Prevention Plan

- Designate a person to develop, implement, and manage the program
- Monitor the temperature (e.g., heat index and wet bulb globe temperature) at the worksite
- Provide water and rest breaks in a shaded, cool area
- Acclimatize workers by gradually increasing the exposure to heat or a hot environment
- Modify work schedules as necessary to reduce workers' exposure to heat
- Train workers on the signs and symptoms of heat illness
- Monitor workers for signs of heat stress Plan for emergencies and response

Preventing Heat-Related Illness – Employees

- Workers should do the following:
  - Drink water and other liquids
  - Eat during lunch and breaks
  - Wear light colored, loose-fitting, breathable clothing (e.g., cotton)
  - Wear wide-brimmed hats
  - Take breaks in shade or cool area
  - Monitor your condition and that of co-workers
  - Tell supervisor if you have symptoms
  - Talk with your doctor about medications

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