KEEP YOUR COOL

PREVENTING HEAT STRESS IN THE WORKPLACE

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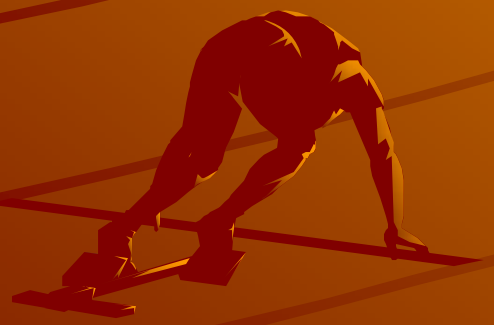
Presentation Outline:

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

Body’s Response to Heat



Coping with Heat

- How does the body cope with heat?
  - The body tries to maintain a constant internal temperature of 98.6°F
- When the internal temperature rises, the body attempts to get rid of excess heat by:
  - Increasing blood flow to skin surface
  - Releasing sweat onto skin surface

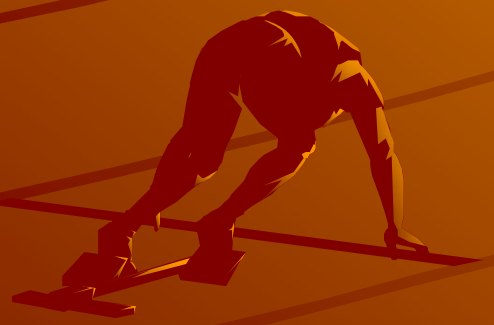
Effects of Body's Response

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

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



Environmental Factors

- Temperature
- Relative humidity
- Radiant heat
- Air velocity

Individual Factors

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

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

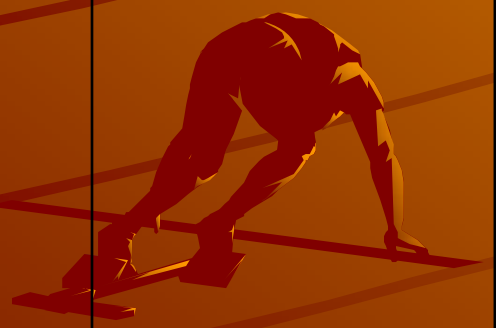
Signs, Symptoms, Prevention, and Treatment

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

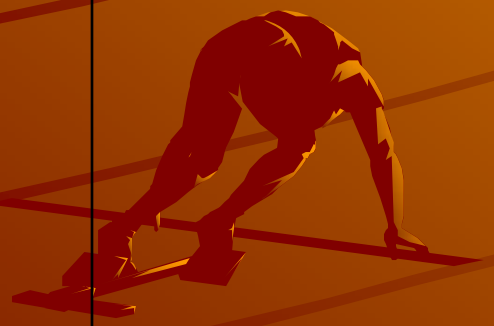
Sunburn

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

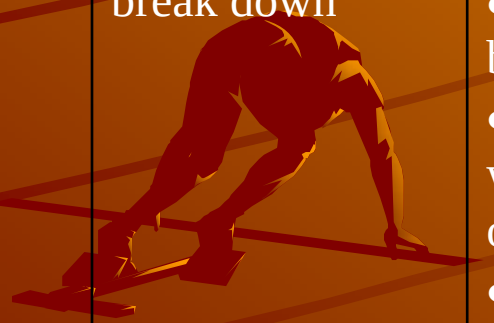


Heat Syncope

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 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: o weakness o the person is confused, upset or acting strangely o hot, dry, red skin o a fast pulse o 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

Body Heat Balance Equation

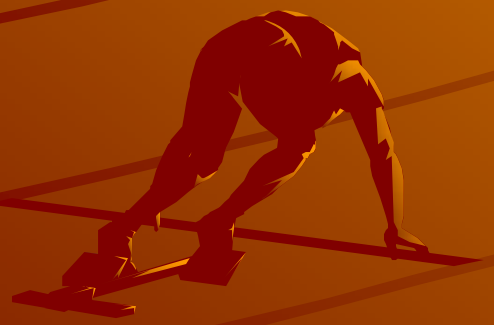
$$S = (M - W) \pm C \pm R \pm K - E - Res$$

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

How to Modify Environmental and Metabolic Heat Factors

- Environmental heat load (C, R, and E) can be modified by
  - Engineering controls (e.g., ventilation, air conditioning, screening, insulation, and modification of processes or operations) and
  - Protective clothing and equipment
- Metabolic heat production (M) can be modified by
  - Adjusting work load (W) and
  - Using labor-reducing devices

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

NOAA NWS Tulsa WBGT

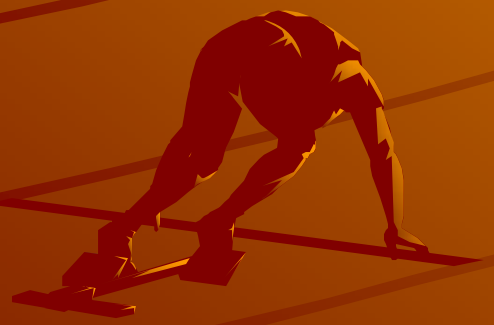
- Wet Bulb Globe Temperature (WBGT) takes into account:
  - temperature
  - humidity
  - wind speed
  - sun angle
  - cloud cover (solar radiation)

  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

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)

GDC Elements

- OSHA will cite an employer under the General Duty Clause for heat-related hazards
- To prove a violation of the general duty clause, OSHA must establish that:

  (1) a condition or activity in the workplace presented a hazard;

  (2) the employer or its industry recognized the hazard;

  (3) the hazard was likely to cause death or serious physical harm; and

  (4) a feasible and effective means existed to eliminate or materially reduce the hazard
- OSHA must also establish that the employer knew, or with the exercise of reasonable diligence could have known, of the hazardous condition

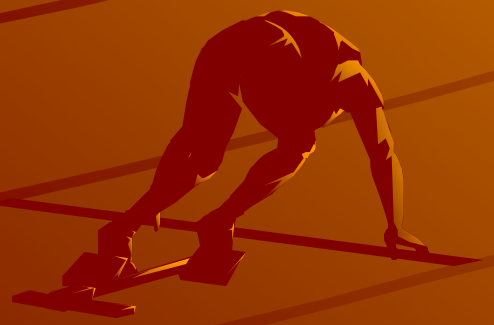
Heat Exposure Citations

- OSHA has issued GDC citations for heat exposures in the following industries:
  - Landscaping
  - Roofing
  - Farming
  - Construction/paving
  - Tree cutting
  - Garbage collection
- 20 Citations issued 2012–2013

Related Standards

- Personal Protective Equipment (29 CFR 1910.132)
- Sanitation (29 CFR 1910.141)
  - Requires employers to provide potable water
- Medical Services and First Aid (29 CFR 1910.151)
  - Requires onsite personnel to be adequately trained if medical facilities are not close by
- Recordkeeping (29 CFR 1904.7(b)(5))

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

NOAA's National Weather Service

Heat Index

Temperature (°F)

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										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

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

OSHA Caution Labels

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 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."

ACGIH® TLVs®

- 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

TLV WBGT Values

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

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."

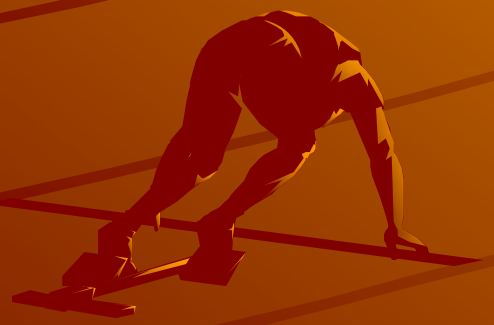
Sample Data – TLV

- Obtain the WBGT value
- Adjust the WBGT for work demands, clothing, wind speed, and sun exposure
  - (1) Calculate the TLV WBGT value = 81°F
  - (2) Clothing adjustment factor is "0"
  - (3) Job entails "light work"
- TLV WBGT "action level" for light work is 82.4°F
  - "Is 81°F less than the action level?" Yes
  - No further action is recommended
- However, if the WBGT = 89°F, then, for light work, the recommended cycle of work and recovery would be between 50-75%

Sample Data Results – OSHA HI and TLV WBGT

Temp (°F)	Dew Point (°F)	RH (%)	WBGT Sky (%)	WBGT Wind (mph)	WBGT Clo	OSHA Heat Index (°F)	TLV WBGT (°F)
90	65	42	65	13	0	92	81
90	65	42	5	13	0	92	83
90	65	42	5	3	0	92	89

Heat Prevention Program Elements



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

OSHA Heat Prevention Plan Elements

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)		✓	✓	✓

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

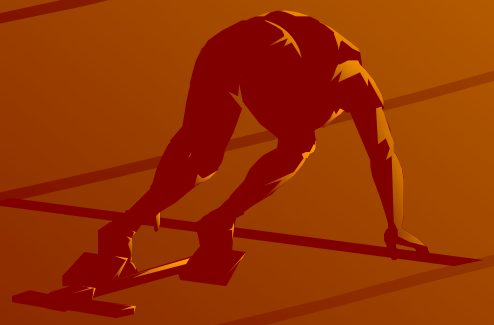
Preventing Heat-Related Illness – Employers

- 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

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

Case Studies



OSHRC – Duriron Case

- Since 1983, the OSHRC has upheld GDC citations as the result of exposure to heat-related hazards. (OSHRC Docket No. 77-2847 Sec'y of Labor v. Duriron Co. dated 4/27/1983)

OSHRC – Duriron (cont'd)

- Duriron manufactured iron and steel castings
- Ave temp 95°F; hourly ave 92°F – 99°F; peak of 115°F
- Exceeded WBGT limits recommended by NIOSH, OSHA, and ACGIH TLVs
- Employee "passed out"
- Initially vacated by the ALJ – "unlikely that employee would fall into molten metal."
- OSHRC reversed – $200

OSHRC – USPS Case

- OSHRC determined that the Secretary had established a *prima facie* violation of the Act (OSHRC Docket No. 13-0217 Sec'y of Labor v. USPS dated 9/24/2014)

OSHRC – USPS Case (cont'd)

- 55 yr. old male, 27 yrs. exp., RTW after a 5 week absence
- 7/23/2012, KS, Missouri, NWS issued heat warning
- 7/23/2012: 104°F, 24% RH, HI 105°F
- 7/24/2012: 102°F, 28% RH, HI 104°F
- 7/24/2012: letter carrier dies; core temp 108.7°F
- Willful – $70,000

OSHRC – Sturgill Case

- In the Sturgill case, the OSHRC determined that the temperature exceeded 80°F every day, except for one, and that OSHA guidance is to implement a heat stress program "when the heat index is at or above 80°F" (OSHRC Docket No. 13-0224 Sec'y of Labor v. A.H. Sturgill Roofing, Inc. dated 2/23/2015)

OSHRC – Sturgill (cont'd)

- Background
  - Miamisburg, OH
  - July 23 – August 1, 2012
  - Removing Styrofoam & rubber materials
  - Materials weighed 1-10 lbs.
  - Lift 39-inches to throw into dumpster below
- Weather on August 1, 2012
  - Occasional scattered clouds
  - Temp: 72 – 83°F
  - Some shade on roof
  - Large AC units on roof
  - Break areas on ground with shade
  - Heat Index: 85°F

OSHRC – Sturgill (cont'd)

- M.R.
  - 60 year old male
  - 10 years temporary worker
  - Most recently worked the night shift in an air conditioned printing facility
  - Claimed he had roofing experience
  - Wore all black clothing
  - Unacclimatized worker
  - Pre- and post-employment tests detected no alcohol or drugs
  - Core temp: 105.4°F

OSHRC – Sturgill (cont'd)

- Foreman
  - Showed M.R. warning lines, water coolers, break areas
  - Assigned M.R. least strenuous work
  - Did not train M.R. on heat-related hazards or how to recognize their signs and symptoms

OSHRC – Sturgill (cont'd)

- Two Citations / Violations (Serious)
  - GDC: $4,410
  - Training: $4,410
- Penalty Factors
  - Size of company
  - Gravity of violation
  - Employer's good faith
  - Prior history of violations

OSHRC – Aldridge

- Background
  - Worksite: Chicago, Ill.
  - Electrical subcontractor
    - Outdoor work
    - Two workers, lifting, carrying, and gluing PVC pipe, ~20 lbs.
- Aldridge Electric, Inc.
    - Had a Heat Illness Prevention Plan that included
      - Health effects of heat
      - Acclimatization – essential for new workers
      - Work / rest regimen once WBGT reached 91°F
      - Buddy rule
    - Based on NIOSH, AIHA, and California
    - Trained employees and supervisors

OSHRC – Aldridge (cont'd)

- Decedent
  - 36 year old male
  - Had a DOT medical certificate, renewal date 6/15/14
  - Reported to work, 6/24/13 at 7:00 am; attended new hire / safety orientation from 8:00 to 9:30 am
  - Coroner report – heat stroke with a contributing factor obesity
  - OSHA 301 log decedent "started showing signs of confusion and disorientation"
  - Core temperature – 108.8°F

OSHRC – Aldridge (cont'd)

Date	Time	T	RH	Clouds	Wind	HI
6/24/2013	7:51 AM	73	76	Few	13	NA
	10:51 AM	73	71	Few	13	NA
	11:51 AM	76	64	few	9	NA
	12:10 PM	Lunch				
	12:51 PM	83	48	Few	15	83.5
	1:51 PM	84	49	Few	11	84.9
	2:51 PM	84	57	Scattered	13	86.7

OSHRC – Aldridge (cont'd)

- The judge noted (stipulated facts) that Aldridge followed OSHA's guidance by taking these steps:
  - Employees at the worksite were permitted to take as many rest breaks as they wanted
  - A tool box talk on heat illness was given to workers
  - Heat illness prevention and acclimatization of workers were topics discussed during the safety orientation
  - Aldridge had developed a heat illness prevention plan and trained its employees about heat stress
  - Aldridge obtaineda pre-employment medical certificate indicating the worker was qualified to perform work in extreme temperatures

OSHRC – Aldridge (cont'd)

- Did the Secretary establish by the preponderance of the evidence that a hazard, as defined by the OSH Act and case law, existed in this case?

- [OSHRC Docket No. 13-2119, Sec'y of Labor v. Aldridge Electric, dated 12/2/2016]

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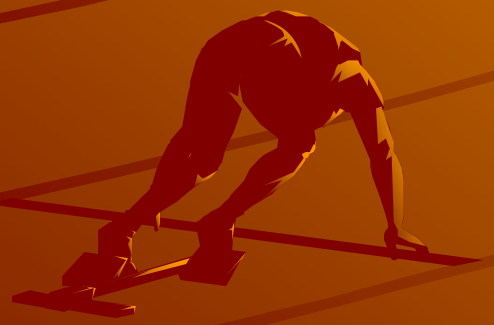
Questions