

# Asia Pacific Air Quality Group Real-Time WBGT Monitoring

# Occupational Heat Stress

- Heat stress occurs when accumulation of heat in the body exceeds the body's ability to remove the excess heat
- Outdoor – construction, military, athletes, firefighters, agricultural
- Indoor – boiler rooms, factory, welders, kitchen





# Occupational Heat Stress - Factors

- Combination of environmental factors, metabolic heat and clothing
- Vulnerability increased by:
  - Exposure to high temperatures
  - High humidity
  - Low air movement
  - Direct radiation
- Higher metabolic heat from physical exertions
- Clothing affects perspiration



# Occupational Heat Stress - Risks

- Rising temperature increases risk of workplace heat injuries
- Higher susceptibility in local hot and humid climate
- Hot work environment



# Occupational Heat Stress - Monitoring

- Management of heat stress can be aided by monitoring relevant indexes
- Quick and accurate understanding of conditions and assessment of overall risks achievable through real-time monitoring
- Most commonly assess WBGT index as primary approximation





# Why Monitor Heat Stress

- Risk control measures
- Reduce risk of heat injuries, accidents, illnesses and deaths
- Reduce productivity losses
- Real-time evaluation of operative thermal conditions and timely definition of work:rest times
- Improve ESG performance



# ESG Performance

- Reducing heat stress ensures employee safety
- Optimize work-rest cycles
- Improves productivity
- Reduces injuries
- Improves employee satisfaction and engagement
- Overall improvement in social aspect



*Fig 1: Heat Stress Management (Managing Heat Stress in the Workplace, WSH Council)*

# Real-time WBGT Monitoring

- WBGT index widely used for evaluating heat stress
- Monitors physical quantities for assessment using actual high-quality sensors
- Portable or permanent systems
- Deployed in indoor and/or outdoor conditions
- Real-time calculate, store and display results





# Types of Real-time WBGT Monitoring

- Portable device
- Permanent indoor systems
- Permanent outdoor system



# Real-time WBGT Monitoring System Standard

- Compliance to relevant ISO standards
  - ISO7143:2017 - methodology to produce WBGT heat index calculations
  - ISO7726 - minimum characteristics of instruments for measuring physical quantities of thermal environment



# Real-time WBGT Monitoring Parameters

- Other relevant indexes
  - WBGT Effective
  - WBGT Reference
  - Heat Index
  - WBGT with/without solar load





# ISO 7243:2017 – Scope

- Assessment of heat stress using WBGT index
- Screening method for evaluating heat stress
- Screening method for establishing presence or absence of heat stress



# ISO 7243:2017 – Scope

- Applies to evaluation of effect of heat on a person during total exposure over the working day, up to 8 hours
- Applies to assessment of indoor and outdoor occupational environments
- Does not apply for very short exposures to heat



# ISO 7243:2017 – WBGT Index

- Wet bulb globe temperature (WBGT) index represents the thermal environment to which an individual is exposed
- WBGT index is easy to determine in most environments
- Screening method to establish presence/absence of heat stress
- Combines measurement of natural wet-bulb temperature ( $t_{nw}$ ), black globe temperature ( $t_g$ ) and air temperature ( $t_a$ )





# ISO 7243:2017 – Formula

- WBGT with solar load
  - $WBGT = 0.7t_{nw} + 0.2t_g + 0.1t_a$
- WBGT without solar load
  - $WBGT = 0.7t_{nw} + 0.3t_g$
- $T_g$  is affected by air temperature, mean radiant temperature and air velocity,  $T_{nw}$  is found to be affected by relative humidity



# ISO 7243:2017 – Factors

- Degree of heat stress to which a person is exposed to depends on:
  - Characteristics of environment governing heat transfer between ambient environment and body
  - Production of heat inside the body as a result of physical activity
  - Clothing worn which modifies the exchange of heat with the environment



# ISO 7243:2017 – WBGT Indexes

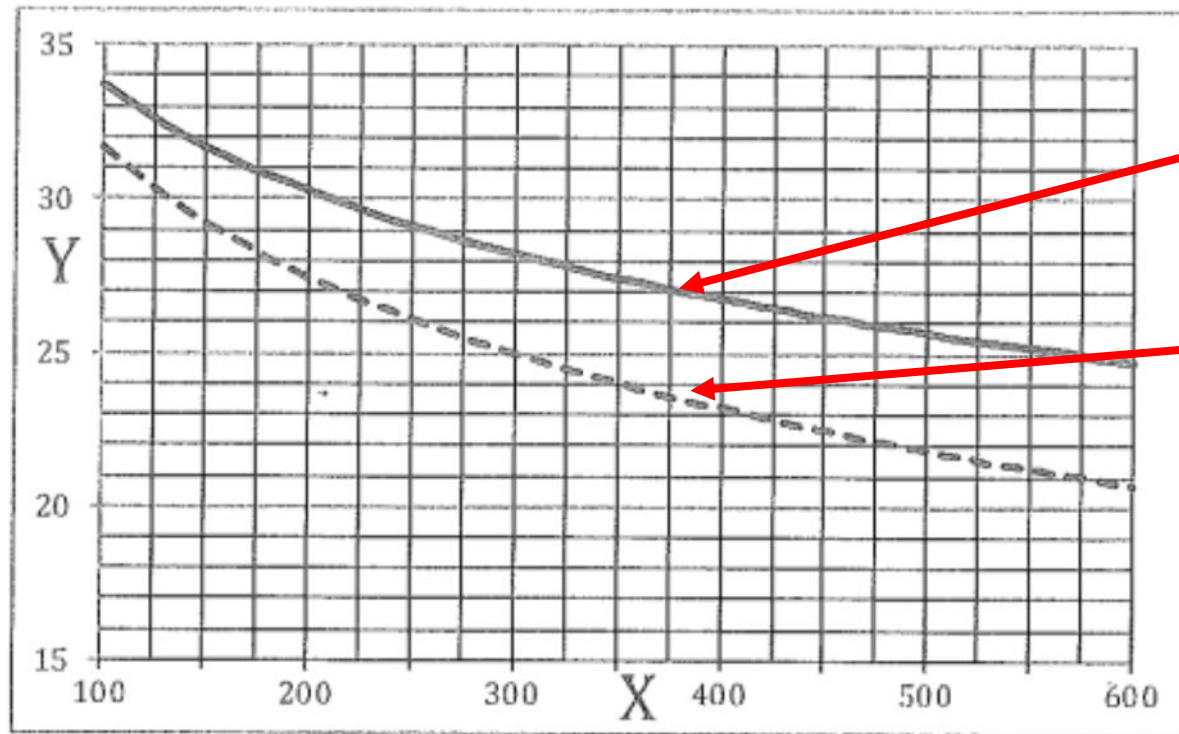
- WBGT Effective ( $WBGT_{eff}$ ) – WBGT value adjusted for the effects of clothing considering Clothing Adjustment Value (CAV)
  - $WBGT_{eff} = WBGT + CAV$
- WBGT Reference ( $WBGT_{ref}$ ) – WBGT limit value for acclimatized and not-acclimatized subjects according to metabolic rate and activity level
- If  $WBGT_{eff} > WBGT_{ref}$ , further actions are required





# ISO 7243:2017 – WBGT Reference

- Different limit values for acclimatized and not-acclimatized subjects according to metabolic rate:



Acclimatized Person

Not Acclimatized Person

# ISO 7726:1998 – Scope

- Specifies minimum **characteristics of instruments** for measuring physical quantities of thermal environment
- Specifies **methods** for measuring the physical quantities
- To standardize process of recording information leading to determination of indices
- Reference to establish specifications for manufacturers and users



# ISO 7726:1998 – Siting

- WBGT normally measured at abdomen level
- When parameters in the surrounding space not homogeneous, measurement made at position where heat stress is highest
- If not possible to situate sensors at normal place of work, place them where they are exposed to the same influence from the environment





# Globe Temperature Sensor

- Globe temperature assesses the total radiant heat load from the sun and other sources
- Globe temperature sensor is a 150mm-diameter copper sphere painted matte black with a thermometer in the middle.
- Other diameter sizes requires correction formula which requires air speed value – additional sensor and more error introduced
- Minimum 0.95 emission coefficient



# Wet Bulb Temperature Sensor

- Natural wet bulb temperature,  $t_{nw}$ , assesses the lowest air temperature obtainable from evaporative cooling
- $T_{nw}$  sensor is a thermometer enclosed inside a cotton sock wetted by water from a water tank, with natural ventilation
- Temperature sensor should be protected against direct sunlight
- Water tank should be protected against warming by sunlight



# Wet Bulb Temperature Sensor

- Direct real measurement of  $t_{nw}$  from actual sensor recommended and preferable
- “Water-free” solution not advisable as such calculation is neither simple nor reliable, especially when air velocity is low
- Calculated  $t_{nw}$  values would have associated measurement errors that would accumulate in calculation of WBGT index





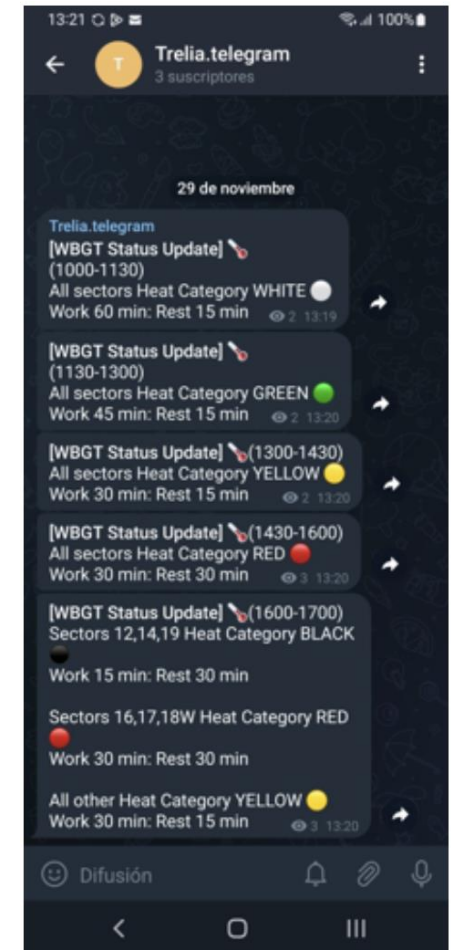
# Air Temperature Sensor

- Measures dry bulb temperature
- Sensor must be protected from direct solar radiation such as radiation screen
- WMO-compliant sensor would ensure highest accuracy



# Data and Alerts from Real-Time Monitoring

- Real-time remote data transmission via wireless router such as via MQTT/FTP protocols
- Data viewing on local SCADA/DCS
- Data display online dashboard
- Telegram channel broadcast
- Integration with application
- Trigger local/remote alarms



# Data and Alerts from Real-Time Monitoring







# Types of Real-time WBGT Monitoring

- Portable device
- Permanent indoor system
- Permanent outdoor system



# Portable Hand-Held Heat Stress Device

- Suitable for surveying and short-term monitoring campaign, indoor or outdoor
- Stand-alone models or with built-in radio for simultaneous wireless monitoring in different locations/heights
- Data display on screen
- Mountable on tripod





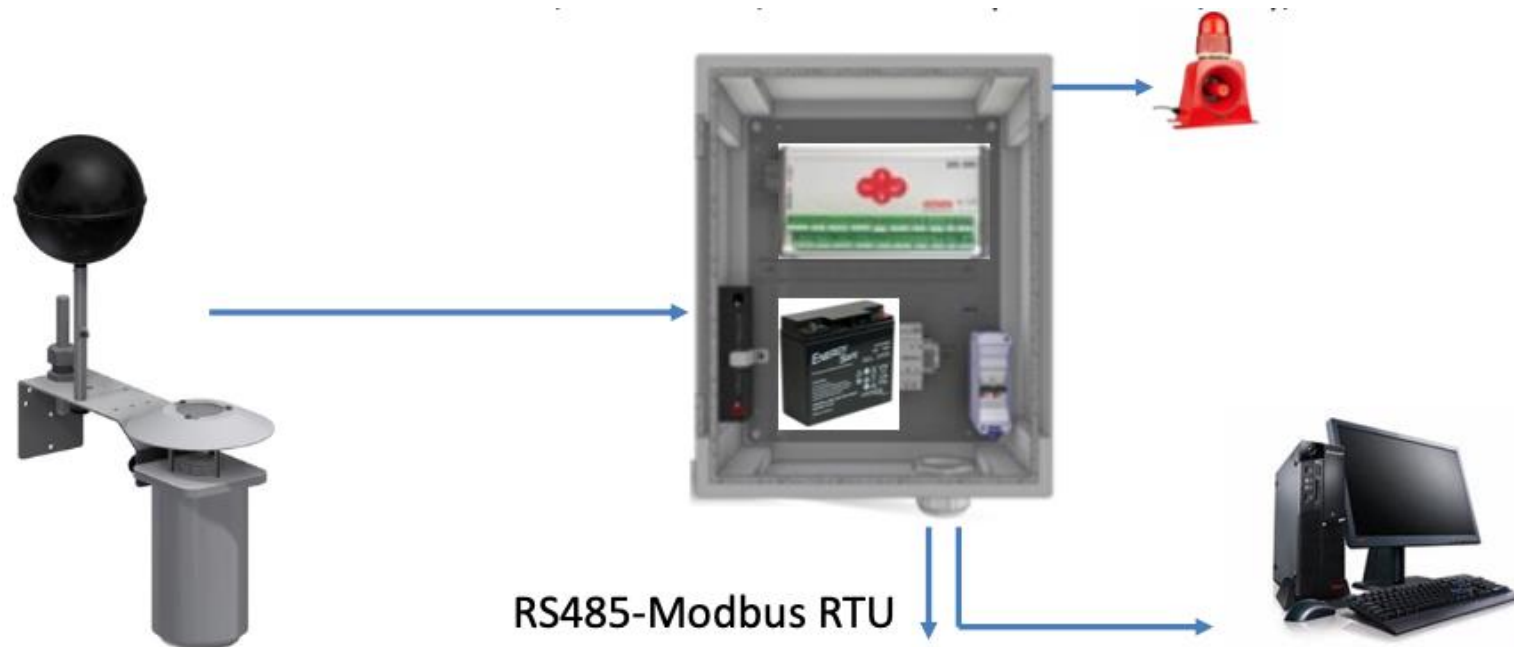
# Portable Heat Stress Device

- Real-time portable system on a tripod
- Suitable for short-term monitoring outdoors
- Meteorological grade sensors
- Data logger and battery in weatherproof enclosure
- Data display on screen



# Standalone Single-Position Indoor Solution

- Real-time dashboard on PC (local)
- Data reporting on PC (local or remote)
- Connection to local SCADA via Modbus RTU
- Connection to local PC



# Standalone Multi-Position Indoor Solution

- Permanent multiple positions indoor installation
- Built-in radio and repeaters if necessary





# Standalone Outdoor Solution

- Meteorological grade sensors
- Made for harsh environments
- Can be solar-powered
- Can be dismantled and assembled easily – transportable to various locations



# Standalone Outdoor Solution



- Meteorological grade sensors
- Made for harsh environments
- 24/7 operation
- Can be solar-powered

# Reference: NEA Heat Stress Network

- Using 'WBGT Index' to evaluate heat stress.
- >10 stations around sports facilities





# Challenges and Workarounds

- Siting of the monitoring system – choose as representative as possible
- Accuracy of measurements – high quality sensors and data logger designed to be compliant to ISO standards
- Maintenance and calibration – periodic calibration every 2 years by accredited laboratories
  - Sensor accuracy verification



# Thank you!

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Air Quality Matters