STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE	PROCEDURE	PAGE No.
December 18, 2023	Heat Illness Prevention	715	Page **1** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	PREPARED BY Keith Westin, CIH Manager, Office of Safety	

TABLE OF CONTENTS

I. **Introduction**
II. **Policy**
III. **Scope**
IV. **Purpose**
V. **Standards**
VI. **Definitions**
VII. **Heat-related Illness**
VIII. **Responsibilities**
IX. **Heat Illness Prevention Procedure minimum elements**
X. **Heat Exposure Risk Assessment tools and action level criteria.**

A. Primary tool for Assessing Heat Related risks.

A.1. Heat Stress Assessment Option 1: Using the National Oceanic and Atmospheric Administration/National Weather Service Heat Index app (NOAA/NWS

A.2. Heat Stress Assessment Tool Option 2: Determine WBGT Using **Wet Bulb Global Temperature** (WBGT).

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **2** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

I. Introduction

Employee exposure to heat can result in several illnesses, increase the risk of injury, decrease productivity and extreme cases can be fatal. This procedure is designed to provide the information and guidance necessary to protect employees against the risk of heat induced illnesses and injuries.

Heat-related fatality cases show that workplaces with temperatures above 70 degrees Fahrenheit may have a heat hazard present when work activities are at or above a moderate workload. Assessing worker exposure in conditions that may present a heat hazard is critical for knowing when to implement a heat-related illness prevention program.

II. Policy

The following document describes the requirements for assessing heat related risks; development of a heat illness prevention procedure; and compliance with Administrative Order 7-48, heat illness prevention policy. It is the goal of this program to provide information to establish preventive procedures to keep employees and on County properties from experiencing heat stress illness.

III. Scope

This procedure is applicable to all Miami-Dade County employees.

IV. Purpose

The purpose of this document is to establish a consistent instructional policy for the application, location, maintenance, and various other components described herein involving a heat illness prevention management program. The goal of this program is to minimize potential detrimental health effects for Miami Dade County employees, resulting from excessive heat that may result from working outdoors or within indoor environments with elevated temperatures. This document establishes guidelines to assess and minimize health risks resulting from heat stress exposure.

V. Standards

There is currently no specific Occupational Safety and Health Administration (OSHA) Standard for heat stress. However, OSHA recognizes that jobs involving operations in hot environments have the potential to induce heat stress in employees. These operations include those which involve radiant heat sources, high humidity, direct contact with hot objects, or strenuous activities. The National Institute of Occupational Safety and Health (NIOSH), the Centers for Disease Control and Prevention (CDC), the American Conference of Governmental Industrial Hygienists (ACGIH) and the Environmental Protection Agency (EPA) have promulgated recommended safety guidelines for working in hot environments.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **3** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

VI. Definitions

Acclimatization is the adaptation to a new climate, such as a new temperature, altitude, or environment. For extreme temperatures, acclimatization is the temporary adaptation of the body to work in the heat that occurs gradually when a person is exposed to it. Acclimatization peaks in most people within four to fourteen days of regular work for at least two hours per day in the heat.

Conduction is the transfer of heat between materials that contact each other. Heat passes from warmer material to the cooler material. For example, a worker's skin can transfer heat to a contacting surface if that surface is cooler, and vice versa.

Convection is the transfer of heat in a moving fluid. Air flowing past the body can cool the body if the air temperature is cool.

Dry bulb (DB) temperature is measured by a thermal sensor, such as an ordinary mercury-in-glass thermometer, that is shielded from direct radiant energy sources.

Electrolytes are various ions, such as sodium, potassium, or chloride, required by cells to regulate the electric charge and flow of water molecules across the cell membrane. Muscle contraction is dependent upon the presence of calcium, sodium, and potassium. Without sufficient levels of these key electrolytes, muscle weakness or severe muscle contractions may occur.

Engineering Controls: means an aspect of the work area or a device that removes or reduces hazardous conditions or creates a barrier between the employee and the hazard. Examples of engineering controls that may be effective at minimizing the risk of heat illness in a particular work area include, but are not limited to, isolation of hot processes, isolation of employees from sources of heat, air conditioning, cooling fans, cooling mist fans, evaporative coolers, natural ventilation where the outdoor temperature or heat index is lower than the indoor temperature or heat index, local exhaust ventilation, shielding from a radiant heat source, and insulation of hot surfaces.

Evaporative cooling takes place when sweat evaporates from the skin. High humidity reduces the rate of evaporation and thus reduces the effectiveness of the body's primary cooling mechanism.

Metabolic heat is a by-product of the body's activity.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **4** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Radiation is the transfer of heat energy through space. Hot surfaces and infrared light sources radiate heat that can increase the body's heat load.

Natural Wet bulb (NWB) temperature is measured by exposing a wet sensor, such as a wet cotton wick fitted over the bulb of a thermometer, to the effects of evaporation and convection.

Heat Index The heat index (HI) or humiture or humidex is an index that combines air temperature and relative humidity to determine the human-perceived equivalent temperature — how hot it feels. The result is also known as the "felt air temperature" or "apparent temperature". For example, when the temperature is 90 °F with very high humidity, the heat index can be about 105 °F.

The Wet Bulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation).

VII. Heat-related Illness

Although heat hazards are common in indoor and outdoor work environments, heat-related illness and fatalities are preventable. Many risk factors contribute to the risk for heat-related illness (see Figure 1.). A heat-related illness occurs when there is an increase in the worker's core body temperature above healthy levels. As the core temperature rises, the body is less able to perform normal functions. As core temperature continues to increase, the body releases inflammatory agents associated with damage to the liver and muscles. This process may become self-sustaining and generate a run-away inflammatory response, the "systemic inflammatory response" syndrome that often leads to death.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **5** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

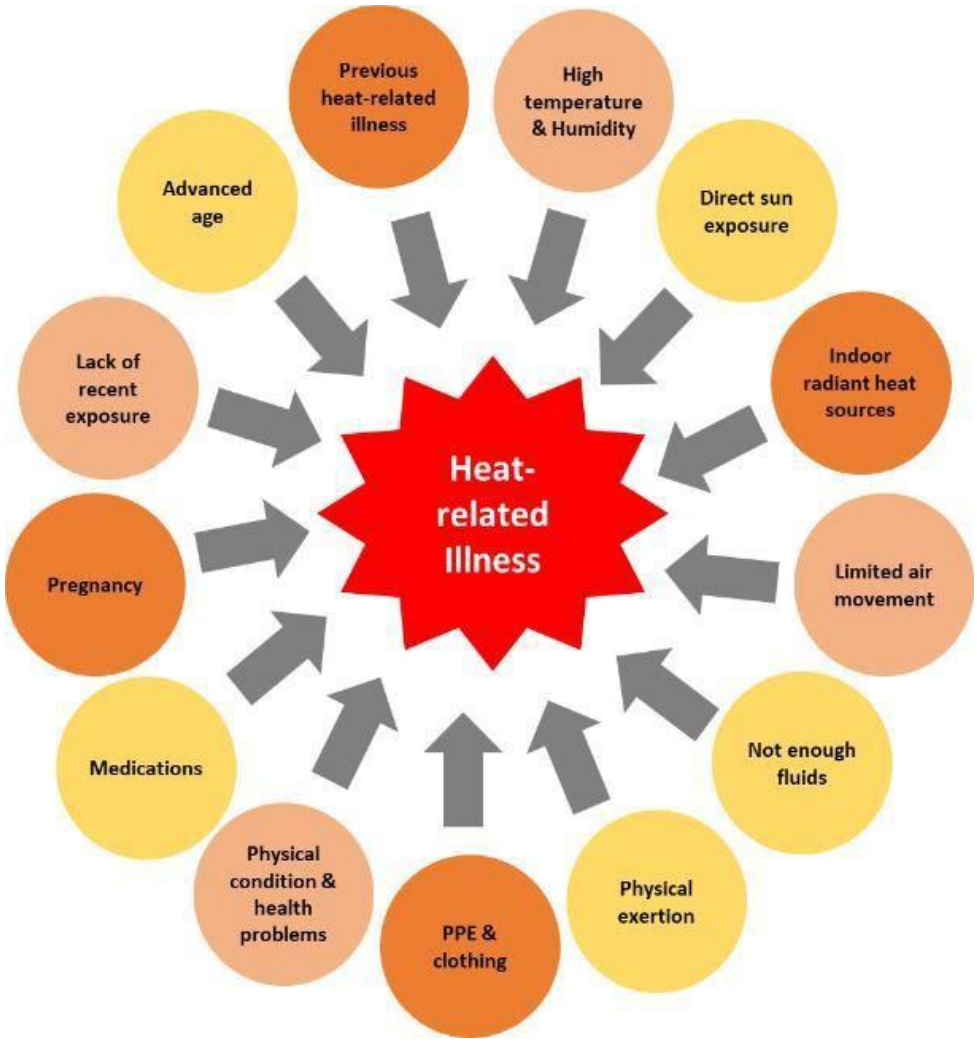

Figure 1. Heat-related illness risk factors (NIOSH 2016)

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **6** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

A new US law, the **Pregnant Workers Fairness Act** that went into effect in June 2023, requires employers with more than 12 employees to make reasonable accommodations for employees who have a known limitation due to pregnancy, childbirth, or related medical conditions, unless the accommodation poses an undue hardship to the employer.[1] Under this law, pregnant and postpartum employees who work for employers with 15 or more employees can ask for accommodations such as extra rest or water breaks, cooling accommodation, or temporary transfers in hot weather.

The terms **heat stress** and **heat strain** represent the relationship and difference between external factors and the body's core temperature control mechanisms:

Heat Stress – The net heat load to which a worker is exposed. Physical exertion, environmental factors, and clothing worn all contribute to heat stress.

Heat Strain – The body's physiological response to heat stress (e.g., sweating).

The body's natural way to keep the core body temperature from rising to unhealthy levels is through an increase in heart rate and sweating. When these are not enough to keep the core body temperature from rising, the result is heat-related illness or death. Elevated core body temperatures may cause the following illnesses:

- Heat Stroke
- Heat Exhaustion
- Heat Cramps
- Heat Syncope
- Heat Rash
- Rhabdomyolysis

Heat Stroke is the most serious heat-related illness and should be treated as a medical emergency. Heat stroke occurs when the body becomes unable to adequately dissipate heat, losing the ability to regulate core body temperature. The core body temperature rises rapidly, the sweating mechanism may fail, and the body is unable to cool down. When heat stroke occurs, the body temperature can rise to (106°F) or higher within 10 to 15 minutes. Thinking clearly, perception, planning, and other mental processes become impaired, and the worker may be unable to recognize dangerous situations. Heat stroke can cause death or permanent disability if emergency medical treatment

[1] See, for example, A Better Balance for more information: https://www.abetterbalance.org/resources/final-text-the-pregnant-workers-fairness-act/

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **7** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

is not given. Symptoms include confusion, clumsiness, slurred speech, fainting/unconsciousness, hot dry skin, profuse sweating, seizures, and high body temperature.

- **Prevention:** Acclimatization, close monitoring for signs of heat illness, medical screening and drinking plenty of water. Adequate water and salt intake at meals; take shaded or cooled rest breaks under excessive heat conditions.
- **Cause:** Partial or complete failure of sweating mechanism. The body cannot get rid of excess heat.
- **Treatment: Medical emergency**. Call 911 and start cooling the victim immediately. Remove the victim to a cool area. Soak clothing and skin with cool water and use a fan to create air movement. Shock may occur. **Medical treatment is imperative.**

Heat Exhaustion is often a precursor to heat stroke. It is often accompanied by elevated core body temperatures around (100.4°F–102.2°F). Symptoms may include headache, nausea, dizziness, fatigue, weakness, thirst, heavy sweating, irritability, and a decreased urine output.

- **Prevention:** Acclimatization, drinking plenty of water, avoiding standing in one place and intermittent activity to avoid blood pooling. Adequate water intake and salt at meals; take shaded or cooled rest breaks under excessive heat conditions.
- **Cause:** Dehydration causes blood volume to decrease. Blood pools in dilated blood vessels of the skin and lower body, making less blood available to the brain.
- **Treatment:** Move the victim to a cool area, have the victim rest and drink fluids.

Heat Syncope usually occurs after prolonged standing or sudden rising from a sitting or supine position. Heat syncope symptoms include light-headedness, dizziness, and fainting. Dehydration and inadequate acclimatization often contribute to heat syncope.

- **Prevention:** Acclimatization, drinking plenty of water, avoiding standing in one place and intermittent activity to avoid blood pooling. Adequate water and salt intake at meals; take shaded or cooled rest breaks under excessive heat conditions.
- **Cause:** Dehydration causes blood volume to decrease. Blood pools in dilated blood vessels of the skin and lower body, making less blood available to the brain.
- **Treatment:** Move the victim to a cool area, have the victim rest and drink fluids.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **8** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Heat Cramps are caused by the body's depleted salt and water levels from excessive sweating resulting in muscle cramps or spasms. They usually occur in the muscles used during work. The symptoms include spastic contractions and pain in voluntary muscles mainly in the arms, legs, or torso.

- **Prevention:** Adequate water intake and salt intake at meals; take shaded or cooled rest breaks under excessive heat conditions.
- **Cause:** May be due to a loss of salt from sweating. Dehydration is a factor.
- **Treatment:** Resting, drinking water, and increasing salt intake (through foods is preferred) or safe electrolyte drinks.

Heat Rash is skin irritation caused by excessive sweating. Excessive moisture and sweat obstructs sweat ducts and form itchy and painful red pimple/blister clusters and skin lesions. It is exacerbated in hot and humid weather and common on the neck, chest, groin, armpits, elbow creases, and behind the knees.

- **Prevention:** Showering after working in a hot environment. Keeping skin dry.
- **Treatment:** Keeping skin clean and dry.

Rhabdomyolysis is a medical condition, sometimes caused by heat stress and prolonged physical exertion, in which muscle fibers rapidly break down, die, and release electrolytes and proteins into the bloodstream. Left untreated, this can lead to kidney damage, seizures, irregular heart rhythms, and death. Symptoms include muscle cramps, muscle pain, dark urine, weakness, inability, or decreased ability to perform physical exercise at the normally expected level or duration (i.e., exercise intolerance), and joint pain/stiffness.

Rhabdomyolysis is usually diagnosed when hospitalized using a test that measures elevated levels of a muscle protein called creatine kinase in the blood, abbreviated CK or CPK.

VIII. Responsibilities:

It is management's responsibility to provide a safe workplace for employees as provided by Administrative Order (AO) 7-14 Safety and Loss Prevention and the County Safety Manual. It is incumbent upon department management to ensure all activities of County employees are taken into consideration while recognizing the high heat environment of Miami-Dade County. Department management shall assess the workplace to establish the risk of heat exposure. It is recommended that at least two heat assessments be undertaken using the OSHA-NIOSH heat index Safety Tool app. The two initial screenings will be taken during the hottest average temperature month (August/84.2 °F[2]) and the coolest average temperature month (January/68.6 °F[2]) in Miami-Dade County.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **9** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

If unsure on how to assess, contact the Office of Safety, Risk Management to obtain guidance on how to determine if heat stress hazards are present or likely to be present that would necessitate the use or engineering controls, administrative controls, or Personal Protective Equipment (PPE).

[2] U.S. National Oceanic and Atmospheric Administration (NOAA) U.S. Climate Normals data. (www.ncei.noaa.gov)

Department Directors:

- Ensure heat stress management within their units meets the requirements of this heat illness prevention Standard Operating Procedure and complies with AO 7-48 heat illness prevention Policy.
- Provide fiscal, professional, and administrative resources for the implementation of their unit specific heat stress management procedures. Ensure that all personnel within their departments potentially affected by heat risks receive proper training and where necessary, proper controls to avoid heat related illness incidents.

Department Safety Representatives:

- Attend Risk Managements' Office of Safety's Training course or equivalent course on heat stress assessments.
- Conduct hazard evaluations of heat stress environments to assess all department activities initially, upon request and make recommendations for management of at-risk activities. Perform an assessment of heat risk(s) utilizing Job Hazard Analysis criteria for your department based on the requirements of this procedure and the tools recommended in this SOP.
- Heat stress screening assessments should be performed during both the annual average highest (August) and lowest (January) temperature months to ensure accurate evaluation of actual exposure risks.
- Develop a written department heat illness prevention Standard Operating Procedure (SOP), if the job hazard analysis/risk assessment indicates existing heat stress risks, implement the procedure, and review it on an annual basis. (Risk Management's Office of Safety can provide a base SOP template).
- Provide heat stress training to all affected new employees with annual refresher training in the spring of each year.
- Assist all divisions in the department in the selection, documentation of appropriate equipment and procedures established to control heat stress environments and protect all covered in the scope of this procedure.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **10** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Supervisors:

- Attend training on the requirements of the department specific heat illness prevention procedure, if applicable.
- Ensure personnel who require heat stress training have received the proper training **before** allowing work to commence in a heat stress environment. Ensure compliance with the acclimatization protocols of your department's procedures.
- Understand and follow the requirements of this procedure and your departmental procedures.
- Report and complete a Supervisor Incident Investigation Report for any employee heat related injury or illness.

Affected Employees:

- Attend training on the requirements of the department specific heat illness prevention procedure(s).
- Know and understand the hazards and warning signs of Heat Stress/Heat Illness.
- Understand and follow the requirements of department/division specific heat stress management procedures, developed to comply with this SOP No. 715.
- Report and document any heat related injury or illness and seek treatment promptly.
- Comply with applicable safety and regulatory requirements.
- Wear or use prescribed protective equipment.
- Report hazardous conditions and dangers to their supervisor.
- Promptly notify your supervisor of any medical condition, or if they are taking over-the-counter medications that might put them at special risk for heat related illness or injury. Alternate means of protection from heat stress should be devised that accommodate the employee's reported concerns.

IX: Heat illness prevention procedure minimum required elements:

The Department heat stress procedure will at a minimum include:

1. Identification of safety positions with responsibility to perform heat stress assessment(s) and training.
2. Identification of job descriptions that are affected by the department procedure.
3. Annual refresher training for affected employees.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **11** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

4. Development of an acclimatization program and criteria for the risks of the tasks in the department.
5. Establishment of Heat Stress controls and measures.
6. Management of heat risk assessment and training records.
7. Employee training on all aspects of the procedures.
8. Criteria and frequency for assessing Job and Employee Heat Stress Risks. (Minimum of initial and annual screening and assessing new projects & operations).

The most important component of the Department heat stress prevention program is employee training. At risk employees and their supervisory personnel shall be trained regarding the risks of heat stress and how it is reduced, as well as how to recognize heat illnesses and treat them. Specific components of the training should include:

- The hazards of heat stress.
- Acclimatization schedules.
- Precautions that can be taken to reduce heat stress, e.g., shading, access to water, electrolytes, breaks schedules.
- Predisposing factors for, danger signs of, and symptoms of heat stress conditions and illnesses
- Dangers of using medicines, alcohol, and drugs in hot work environments,
- Awareness of first-aid procedures for, and the potential health effects of, heat stroke in themselves and others.
- Personal responsibilities in avoiding heat stress,
- Typical engineering and administrative controls implemented to reduce heat stress,
- Use of personal protective equipment.

X. **Heat Exposure Risk Assessment tools and action level criteria.**

A. Assessing Heat Related risks:

Heat related illness risk **must be evaluated for all personnel** who work inside or outside in non-air-conditioned environments. Miami-Dade County year-round temperatures are high enough to create risk at any time of year outside of climate-controlled workspaces. One of the below assessment tools and techniques must be used to assess employee heat-related risks. There are several methods to assess heat stress. Two are presented from readily available and simple methods to increasingly accurate assessment tools and associated criteria that will require experienced trained professionals and calibrated equipment to accurately assess risks. The great majority of activities will be able to be assessed using **option 1, the NWS/OSHA app Heat Index app,** that provides current conditions using nearby weather information and ambient conditions to provide risk levels and precautions to avoid heat illness.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **12** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Complex operations such as closed rooms and wearing of additional protective clothing may require more detailed assessment **using the heat stress Wet Bulb Global Temperature tool listed here in option 2**.

Miami-Dade County Management and Safety Professionals are responsible for assessing every job/project to determine if it is likely to pose heat stress risks. ISD Risk Management's Office of Safety will provide departmental safety personnel with heat illness assessment training course opportunities, training materials, and an SOP template for developing departmental procedures. The Office of Safety is available for technical assistance at 305-876-8000 or via email OfficeofSafety-ISD@miamidade.gov.

Examples of Miami-Dade County work locations where heat stress risks can exist. Operations involving high air temperatures, radiant heat sources, high humidity, contact with hot objects, wearing of special protective clothing or other Personnel Protective Equipment (PPE) or strenuous physical activities have a high potential for inducing heat stress in employees. Indoor operations such as electrical utilities (particularly boiler(s) or mechanical rooms) are all potential heat stress risk operations. Outdoor operations at all Departments, including emergency response, conducted in hot weather are also likely to cause heat stress among exposed workers. Whenever heat stress is possible, employees are empowered to request such controls if heat stress is expected or encountered and not previously identified or assessed.

A.1 Heat Stress Assessment Option 1: Using the National Oceanic and Atmospheric Administration/National Weather Service Heat Index app (NOAA/NWS).

- There are several different ways to evaluate environmental heat stress risks for employees. The most common method used is the National Weather Service Heat Index (See figure 2: NWS Heat Index). The NOAA/NWS Heat Index tool measures ambient temperature and humidity levels. Radiant heat sources, and air movement must also be taken into consideration when assessing the potential for heat stress hazards. **Note: When using this tool assessors must review and implement the heat stress control precautions as indicated by the Heat Index app**. The following link to the Department of Health and Human Services (DHSS)/ NIOSH Recommended Heat Stress work/rest schedules can be utilized for establishing uniform HS prevention criteria. Heat Stress: Work/Rest Schedules (cdc.gov)
- The heat index is a measure of how hot it feels when relative humidity is considered along with the actual air temperature. It is important to note that, since heat index values were devised for shady, light wind conditions, exposure to full sunshine can increase heat index values by up to 15°F.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **13** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

- The National Weather Service uses the heat index values to issue heat alerts to the public. However, workers in hot environments experience heat stress from a combination of environmental factors and metabolic heat from the tasks they are performing. Therefore, OSHA-modified heat index cutoffs, used in the app, create heat index-associated protective measure specifically for worksites.

- The NWS heat index and online OSHA-NIOSH Heat Safety Tool app (see app image below). The OSHA-NIOSH app can be used as a screening tool at any time, so that management and safety professionals can more easily recognize when additional preventive options should be implemented. The app is available for download via the app store at https://www.cdc.gov/niosh/topics/heatstress/heatapp.html.

OSHA-NIOSH heat stress app

MIAMI-DADE COUNTY

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **14** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

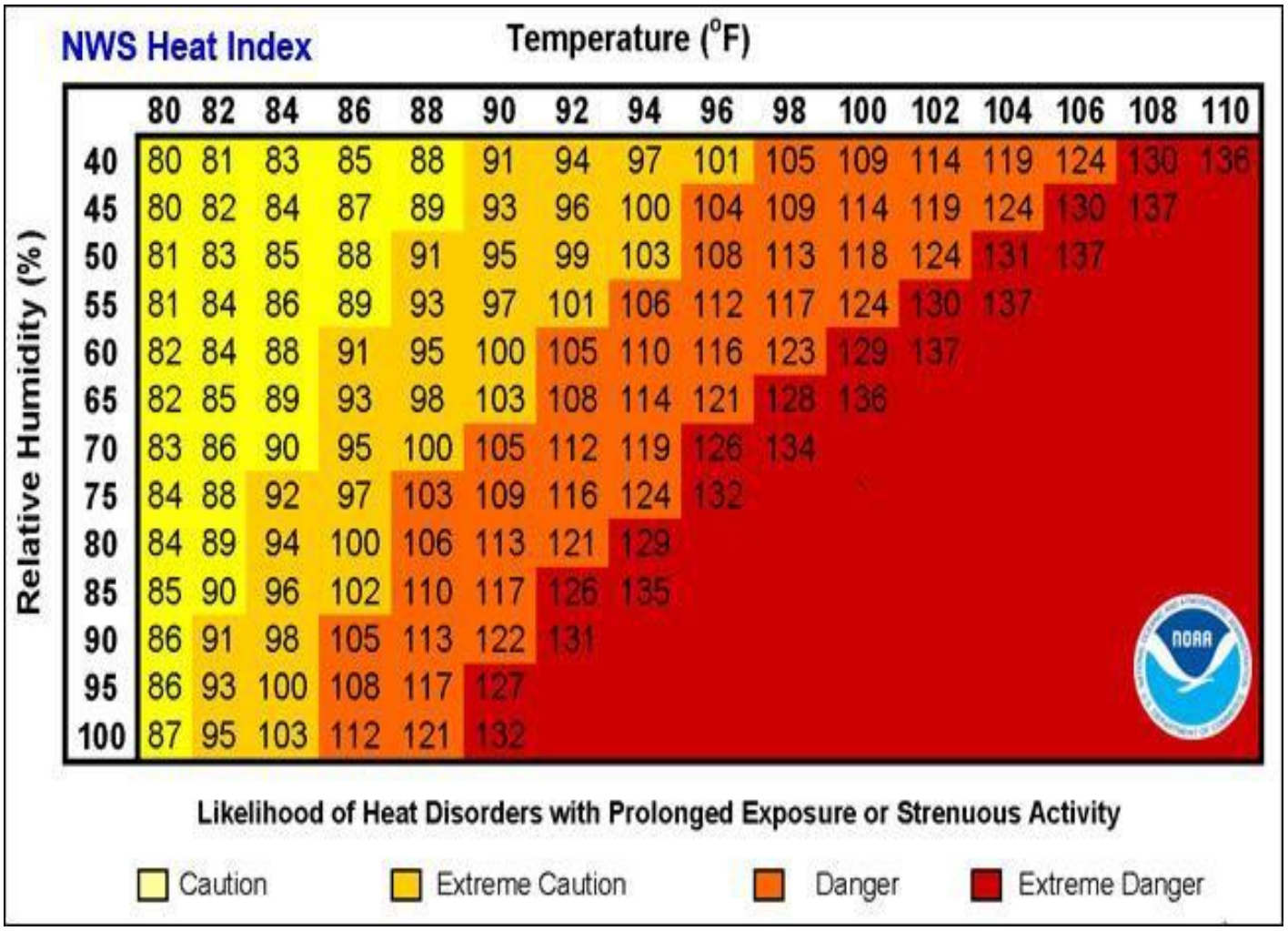

Figure 2: NWS Heat Index

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **15** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

A.2. Heat Stress Assessment Tool Option 2: Determine WBGT Using **Wet Bulb Global Temperature** (WBGT).

Occupation Safety and Health Administration (OSHA) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) for Heat Stress Criteria Using **Wet Bulb Global Temperature** (WBGT).
Note, specific WBGT measuring tools are necessary to provide a more accurate assessment of heat stress. It is recommended that personnel with training and experience use this option or seek industrial hygienists with experience in heat stress assessments. Link to the OSHA guidance webpage; https://www.osha.gov/otm/section-3-health-hazards/chapter-4.

- In addition to the use of WBGT measuring tools, assessment professionals will consider environmental factors (e.g., humidity, wind, temperature, and radiant heat), clothing, and workload (i.e., metabolic rate) when determining if there is a heat hazard present in an indoor or outdoor workplace.

- The American Conference of Governmental Industrial Hygienists (ACGIH®) has established **Action Limits (AL)** for un-acclimatized workers and a **Threshold Limit Value (TLV®)** for acclimatized workers, see Tables 1 & 2.

- **After the Wet Bulb Global Temperature (WBGT) is measured; assessing personnel will use the ACGIH TLV & Action Limit tables (see Tables 1 & 2**) to determine the risk for exposure to heat stress above the **Action Limit (AL)** for un-acclimatized workers or the **(TLV**) for acclimatized workers. These limits, which vary by WBGT and metabolic rate, are intended to maintain the core body temperature to within 2.5 °F of normal (98.6 °F for most people). ACGIH provides guidance for maintaining awareness about when workers may be exposed to heat stress above the AL or TLV so that preventive actions are taken to reduce the exposure. Heat-related illness prevention programs can include policies for using these guidelines to implement environmental controls, plan work schedules, and use personal protective equipment (PPE).

- ACGIH's Screening Criteria for TLV and Action Limit for Heat Stress tables (see Tables 1 and 2) are an initial screening tool to evaluate whether a heat stress situation may exist based on WBGT, workload and work/rest regimen.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **16** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Table 1. Threshold Limit Values (TLVs) (ACGIH) (acclimatized workers)

% Work	**Workload**			
	Light	**Moderate**	**Heavy***	**Very Heavy***
75 to 100% (Continuous)	86°F (31.0°C)	82°F (28.0°C)	N/A	N/A
50 to 75%	86°F (31.0°C)	83°F (29.0°C)	81°F (27.5°C)	N/A
25 to 50%	89°F (32.0°C)	85°F (30.0°C)	83 F°(29.0°C)	82°F (28.0°C)
0 to 25%	90°F (32.5°C)	88°F (31.5°C)	86°F (30.5°C)	85°F (30.0°C)

*Criteria values are not provided for Heavy/Very Heavy work for continuous and 25% rest because of the extreme physical strain. Detailed job hazard analyses and physiological monitoring should be used for these cases rather than these screening criteria.

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **17** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Table 2. Action Limits (Als)(ACGIH) (unacclimatized workers)

% Work	**Workload**			
	Light	**Moderate**	**Heavy***	**Very Heavy***
75 to 100% (Continuous)	82°F (28.0°C)	77°F (25.0°C)	N/A	N/A
50 to 75%	83°F (28.5°C)	78°F (26.0°C)	75°F (24.0°C)	N/A
25 to 50%	85°F (29.5°C)	80°F (27.0°C)	77°F (25.5°C)	76°F (24.5°C)
0 to 25%	85°F (30.0°C)	83 F°(29.0°C)	80°F (28.0°C)	80°F (27.0°C)

*Criteria values are not provided for Heavy/Very Heavy work for continuous and 25% rest because of the extreme physical strain. Detailed job hazard analyses and physiological monitoring should be used for these cases rather than these screening criteria.

MIAMI-DADE COUNTY

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **18** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
		PREPARED BY Keith Westin, CIH Manager, Office of Safety	

Table 3: Workload Definitions **APPROXIMATE WORKLOAD LEVELS**

Light	Sitting at ease, writing/typing, sorting light materials, inspecting crops, driving mobile equipment on paved roads, piloting spray aircraft
Moderate	Using a chain saw, off-road operation of mobile equipment, periodic handling of moderately heavy materials, weeding, hoeing, picking fruits or vegetables, air blast and boom spraying, knapsack spraying on level ground, pushing, or pulling light-weight carts or wheelbarrows, washing vehicles, walking 2-3 mph
Heavy	Transferring heavy materials, shoveling, digging, hand mowing, loading sacks, stacking hay, planting seedlings, hand-sawing wood, pushing or pulling loaded hand carts or wheelbarrows, moving irrigation pipe, laying cinder blocks, knapsack spraying on rough ground or an incline, walking 4 mph

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **19** of **21**
MAJOR AREAS AFFECTED All County employees.	APPROVED BY Baunie J. McConnell, JD Division Director Risk Management, ISD	New	
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Figure 3: Waterless wet-bulb meter

A WBGT meter is the most accurate tool for adjusting the temperature for heat stress factors including humidity, air movement (i.e., wind), radiant heat, and temperature.

An effective heat-related illness prevention program will ensure taking environmental heat measurements at least hourly, during the hottest portion of each work shift, during the hottest months of the year, and when a heat wave occurs or is predicted.

WBGT measurements are most reliable when taken at, or as close as possible to, the work area. When a worker moves between two or more areas with different environmental conditions, or when the conditions vary substantially in the work area, assess the heat hazard using representative measurements for the different conditions.

WBGT meters have three sensors that input data into a calculation that adjusts the temperature to represent the impact humidity, wind, and radiant heat have on heat strain cooling effectiveness.

Dry-bulb thermometer: A Thermometer that measures temperature without impact from other factors.

Natural (static) wet-bulb thermometer: Wetted thermometer used to measure sweat's effectiveness in cooling the body. It represents increased sweat evaporation potential when wind speed increases, and decreased sweat evaporation potential when there is more moisture in the air.

Black globe thermometer: Thermometer with hollow copper sphere painted on the outside with a matte black finish to measure the radiant energy from direct sunlight or other sources (e.g., machinery and hot structures near the workplace).

Some meters will also measure WBGT without the need to wet a bulb to determine wind and humidity adjustments (see Figure 3.). The waterless wet-bulb meter is a tested and validated alternative to the traditional natural wet-bulb sensor. The meter uses a mathematical model to determine the waterless wet-bulb calculation through a combination of dry-bulb temperature, globe temperature, relative humidity, and air flow sensors.

Although all the sensors measure temperature in Celsius and/or Fahrenheit, they represent different heat stress factors. The meter automatically calculates adjusted temperature using the sensor data inputs and programed equations. There are two different equations depending on whether the measurement is taken indoors (i.e., radiant heat unlikely or not solar) or outdoors (i.e., solar radiant heat likely). The data inputs are:

Tdb = the dry-bulb temperature

Tnwb = the natural wet-bulb temperature

Tg = the globe temperature

For outdoor environments, the meter uses all sensor data inputs in the following equation that weighs the wet bulb 70%, globe 20%, and dry bulb 10% of the weighted average:

$$WBGTout = 0.7Tnwb + 0.2Tg + 0.1Tdb$$

For indoor environments, the meter does not use the dry-bulb temperature since the globe and the dry-bulb should be equal without radiant heat. The globe temperature is used since it will also detect non-solar radiant heat sources if they are present. The equation weighs the wet-bulb 70% and the globe 30% of the weighted average:

$$WBGTin = 0.7Tnwb + 0.3Tg$$

These equations show the significant impact that changes in the wind speed and/or humidity can have on the WBGT. Also, for conditions with significant radiant heat source (i.e., sunny outdoors, foundries, glass manufacturers, boilers, etc.), the WBGTout will more accurately represent the environmental heat stress.

To calculate the WBGT for continuous all-day or several hour exposures, use the average WBGT over a 60-minute period. For intermittent exposures or exposures at different heat levels throughout a workday,

STANDARD OPERATING PROCEDURE

EFFECTIVE DATE	PROCEDURE TITLE Heat Illness Prevention	PROCEDURE 715	PAGE No. **21** of **21**
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average the temperature over a 60 to 120-minute period, depending on the exposure duration. The average WBGT (WBGTavg) is calculated using the following equation:

$$WBGT_{avg} = \frac{(WBGT_1)(t_1) + (WBGT_2)(t_2) + \ldots + (WBGT_n)(t_n)}{(t_1) + (t_2) + \ldots + (t_n)}$$

where t_n = time in minutes

[1] Bruce Bekkar, Susan Pacheco, Rupa Basu, and Nathaniel DeNicola, "Association of air pollution and heat exposure with preterm birth, low birth weight, and stillbirth in the US: a systematic review," *JAMA Network Open* 3, no. 6 (2020). See also "Reducing Prenatal Exposure to Toxic Environmental Agents," The American College of Obstetricians and Gynecologists (ACOG) Committee Opinion Number 832, July 2021, https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2021/07/reducing-prenatal-exposure-to-toxic-environmental-agents [1] See, for example, A Better Balance for more information: https://www.abetterbalance.org/resources/final-text-the-pregnant-workers-fairness-act/