HEAT STRESS

Prevention Tools and Strategies

2024 EDITION

HEAT STRESS Toolkit

About this Guide

OHCOW partnered with CROSH to review and update the existing *Heat Stress Awareness Guide* that was developed by OHSCO back in 2009. With the support of the Ontario Health and Safety Prevention System partners (through the Occupational Illness Prevention Steering Committee) and local labour unions, we identified areas that required improvement or revision and the concept of a toolkit was born!

HEAT STRESS Toolkit

Land Acknowledgment

The writers and contributers of this guide recognize that our work takes place on traditional Indigenous territories across the province. We acknowledge that there are 46 treaties and other agreements that cover the territory now called Ontario. We are thankful to be able to work and live in these territories. We are thankful to the First Nations, Métis and Inuit people who have cared for these territories since time immemorial and who continue to contribute to the strength of Ontario and to all communities across the province.

Funding Acknowledgment

This guide was funded by the Ontario Ministry of Labour, Immigration, Training and Skills Development (MLITSD). The views expressed in this guide are those of the contributors and do not necessarily reflect those of the MLITSD.

We developed the *Heat Stress Toolkit* to help those supporting and protecting heat exposed workers including:

• employers • managers • supervisors • fellow workers

• Joint Health & Safety Committee (JHSC) members

• health and safety representatives

• workplace union representatives

Unions, employer associations, and health and safety professionals may also find this information useful.

The *Heat Stress tToolkit* includes this updated *Heat Stress Prevention Tools and Strategies*, a *Heat Stress Physiological Monitoring Guide*, and a new *Heat Stress Awareness Guide*. It also includes several posters and infographics, videos, and an updated, online *Heat Stress Calculator*.

A list of additional resources is also available online on the project webpage.

Disclaimer

The information in this reference guide is for information and reference purposes only and not intended as legal or professional advice. Laurentian University (LU), the Centre for Occupational Safety and Health (CROSH), and Occupational Health Clinics for Ontario Workers (OHCOW) recognize that individual companies must develop heat stress policies and plans that apply to their workplaces and comply with appropriate legislation. While information provided is current at the time of printing, including references to legislation and established practice, it may become out of date or incomplete with the passage of time.

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TABLE OF CONTENTS

INTRODUCTION

Why is this guide necessary?

Reflect on your own **experience** and ask around – everyone knows someone who has been affected by heat stress. Whether it's the rash you get during the first hot days in the spring; the dizziness you feel when getting up too quickly in hot weather; the cramps in your muscles when working hard in the heat; feeling your muscles give out in exhaustion; being dehydrated with a bad headache; or even experiencing "sunstroke" (heat stroke). Everyone has experienced heat stress to some degree, or at least knows someone else who has. With global warming accelerating, we expect these experiences to become more frequent.

The effect of climate change on the current and future experience of heat stress by Ontario workers is well documented in the Ontario Provincial Climate Change Impact Assessment Technical Report. Compared to the years 1980 and 2010, "Regionally, Extreme Hot Days are already prevalent in Southwest, Central and Eastern Ontario (all averaging around 8.6 to 9.1 [days/year with maximum daily temperature over 30°C])." *(CRI, 2023)*. As illustrated in this graph, for the years 2022 & 2023, the number of days per year with a maximum daily temperature above 30°C have been above this average number.

Under the current legislation, employers have a general duty under Section 25(2)(h) of the Occupational Health and Safety Act "to take every precaution reasonable in the circumstances for the protection of a worker." For compliance purposes, the Ministry of Labour, Immigration, Training and Skills Development (MLITSD) bases their interpretation of what is reasonable in the circumstance as meeting the current Threshold Limit Value (TLV) for heat stress and strain, as published by the American Conference of Governmental Industrial Hygienists (ACGIH), any future heat stress regulation will expectedly be based on the ACGIH TLV.

These values are based on preventing unacclimatized workers' core temperatures from rising above 38°C.

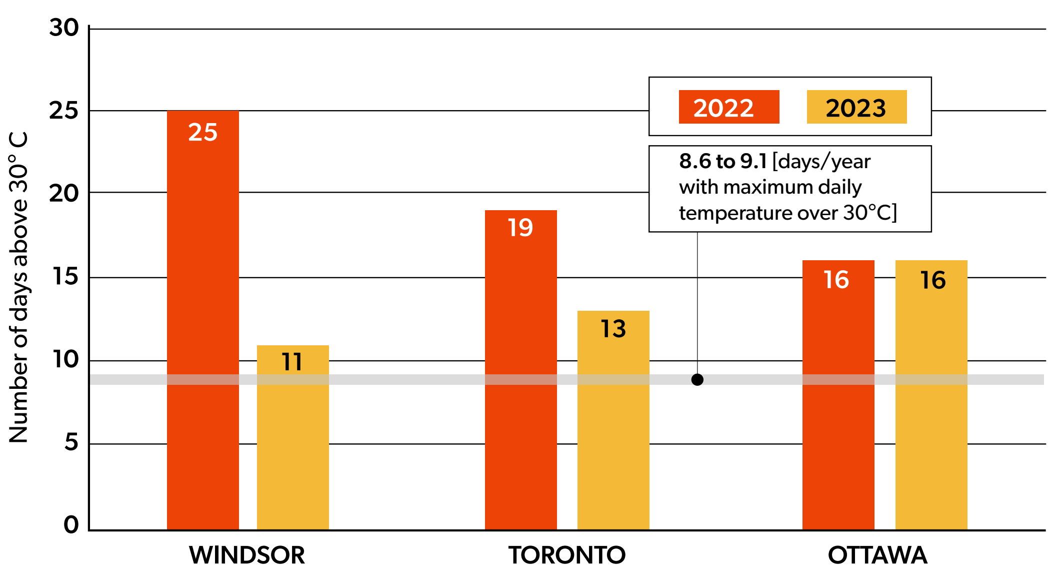


Figure 1. Number of days with a maximum daily temperature above 30°C in three cities in Ontario, where the yellow line indicates the average of 8.6-9.1 days/year with the maximum daily temperature over 30°C (CRI, 2023).

To assist in this process OHCOW, CROSH, the health and safety associations (HSAs) and representatives of various unions and have provided an update to the original heat stress prevention tool, developed by the **Occupational Health and Safety Council of Ontario** (OHSCO) more than 25 years ago. Maintaining the core objectives of the earlier document, this Heat Stress Toolkit responds to a need from many workplaces for a simpler approach to managing heat stress.

In addition to the updated basic information provided in the 2009 OHSCO awareness guide, this booklet provides **additional tools** for different workplace situations, but all co-ordinated and based on the **2023** ACGIH Heat Stress/Heat Strain TLV (Threshold Limit Value). *The Heat Stress Toolkit* includes an online calculator to effectively monitor and manage heat stress.

Who is this guide for?

The intended audience of this Prevention Tool are those supporting and protecting heat exposed workers. This includes employers, managers, supervisors, fellow workers, Joint Health & Safety Committee (JHSC) members, health and safety representatives, and workplace union representatives. Unions, employer associations, and health and safety professionals may also find this information useful.

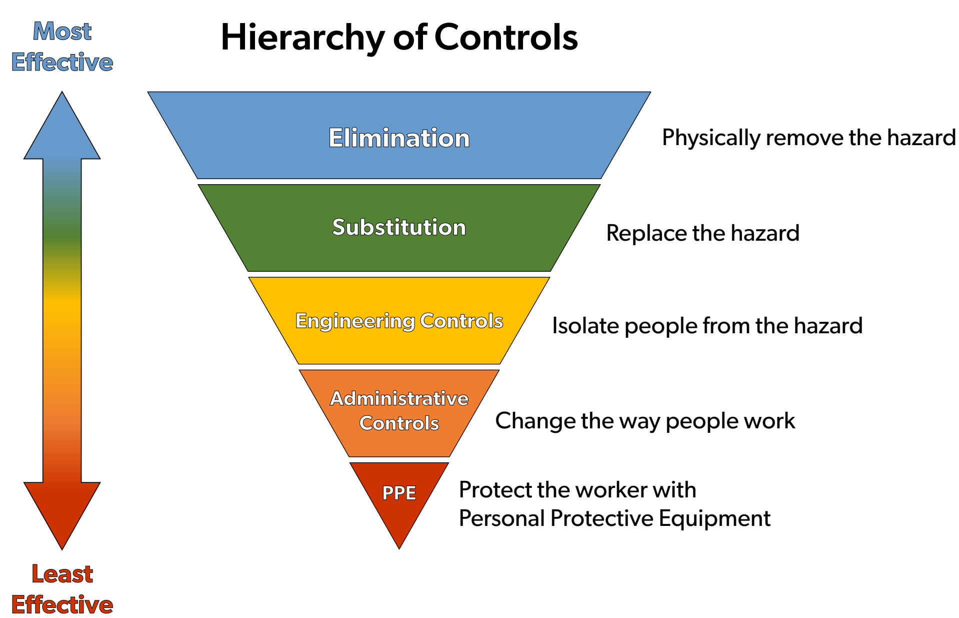
Fundamentals of heat stress prevention

The concept of the hierarchy of controls is a fundamental approach in occupational health and safety management, aimed at eliminating and controlling risks associated with hazards, including heat stress. Heat stress occurs when the body cannot get rid of excess heat, leading to heat-related illnesses such as heat rash, heat cramps, heat exhaustion, and heat stroke. Managing heat stress effectively in the workplace involves implementing controls based on the hierarchy of controls, prioritizing methods that protect everyone by eliminating the hazard or reducing exposure.

At the top of the hierarchy is elimination and substitution. In the context of heat stress, elimination involves removing the heat source or substituting processes to reduce heat generation. However, in many work environments, such as outdoor construction sites or foundries, eliminating the source of heat may not be feasible. Substitution might involve using less heat-generating equipment or scheduling work at cooler times of the day.

The next level is engineering controls, which focus on isolating people from the hazard through physical means. This can include increasing ventilation, using air conditioning in indoor spaces, or installing heat shields and reflective barriers in outdoor settings. Engineering controls aim to reduce the ambient temperature and the exposure to direct heat sources.

Administrative controls and personal protective equipment (PPE) are the next tiers in the hierarchy. Administrative controls involve changing how or when work is done to reduce heat exposure. This can include rotating job roles to limit time in hot environments, more frequent breaks in cool rest areas, re-scheduling work for cooler times of the day, and ensuring workers are hydrated and aware of the signs of heat-related illnesses. Personal



protective equipment, while being the last resort, is crucial in providing individual protection against heat stress. This includes wearing appropriate clothing that allows for effective sweat evaporation and using cooling vests or hydration packs to help maintain body temperature.

The hierarchy of controls for heat stress emphasizes a top-down approach, starting with the most effective measures that protect the broader workforce by addressing the hazard at its source, and ending with personal protective measures that rely on individual worker behavior. Implementing a combination of these controls tailored to the specific workplace and environmental conditions can significantly reduce the risk of heat stress among workers.

The ACGIH TLV *(2023)*, requires a Heat Illness Prevention Plan to include general and job specific controls to effectively manage and prevent heat stress. According to the ACGIH the developed Heat Illness Prevention Plan should include the following:

- Training employees on recognizing the symptoms of heat-related illnesses. Provide verbal and written instructions for pre-job and annual training programs with information about heat stress and strain, heat-related illnesses, a mitigation plan, and an emergency response plan in a language that is understood by workers and supervisors. Ensure workers are able to practice the skills they've been taught.
- Hydration, self monitoring of symptoms, maintaining a good health status, access to shade or air-conditioned space for breaks,
- Heat stress policies or heat stress management plan, acclimatization plan, early recognition of signs and symptoms of other workers and what actions to take (buddy system), Self management with proper training. The JHSC should be consulted with the development of policies and procedures.
- Wearing lightweight, loose-fitting clothing and using personal protective equipment designed to prevent overheating can help mitigate the risk of heat stress.
- Environmental surveillance (monitoring the temperature, relative humidity, Humidex and/or WBGT)
- The ACGIH recommended medical clearance and counselling by a healthcare provider.
- Having an emergency response plan. When a worker appears to be confused, disoriented, irritable, has malaise, chills, or seizures, this should be managed as a medical emergency and needs aggressive cooling, emergency transportation and continuous observation.

Proper training of supervisors and workers on heat stress prevention and awareness is crucial for protecting workers. If supervisors and workers don't recognize signs and symptoms and take appropriate action, workers could die!

When it comes to addressing heat stress in the workplace, implementing job-specific controls is crucial to ensuring the safety and well-being of employees. These controls are tailored to the specific tasks and conditions within each job role to effectively manage heat stress risks.

Job-specific controls *(ACGIH TLV, 2023)* may include:

- Engineering controls such as ventilation and cooling systems in hot work areas, as well as, controls that reduce the metabolic rate, reduce process heat and water vapor release, provide shade, shield radiant heat, among others.
- Adjusting work schedules to avoid the hottest parts of the day, providing shaded rest areas for breaks, rotating workers to reduce prolonged exposure to heat, ensuring adequate hydration by providing easy access to water.
- Personal protective equipment such as cooling vests or hats can also be utilized to help mitigate heat stress for workers in high-temperature environments.
- Physiological monitoring can also be used as a job specific control, where excessive heat stress exposures are known to occur, such as in jobs like fire fighting.

The Heat Illness Prevention Plan should also be written in English and in the language understood by the majority of employees. It should be available to employees at the worksite, as well as to safety professionals upon request. It may be integrated into the employer's Injury and Illness Prevention Program.

Understanding *Heat Stress Prevention Tools and Strategies*

The Wet Bulb Globe Temperature (WBGT) is a combination of three temperature measurements that assess the effect of temperature, humidity, wind speed, and solar radiation on workers. It's considered a best practice for assessing the risk of heat stress in outdoor and indoor environments. The WBGT index incorporates three different temperature readings: the natural wet-bulb temperature (which reflects humidity and air temperature), the black globe temperature (which measures solar radiation), and the dry bulb temperature (which is essentially the air temperature).

Just the air temperature alone, does not fully capture the impact of humidity or the intensity of the sun. By including these factors, the WBGT offers a more accurate assessment of heat stress risks, guiding decisions related to outdoor and indoor work activities, work/rest cycles, and the need for hydration and cooling measures.

When workplaces become aware of how complicated and expensive measuring the WBGT can be, they usually look for a simpler way. The Humidex plan provided a simple way of translating the WBGT criteria into Humidex which is more easily understood. Based on their experiences with the OHSCO Humidex Plan, workplaces told us there seemed to be a **natural progression** in their management of heat stress. After workplaces adopted the Humidex Plan, they eventually realized that workers could quite accurately predict the level of prevention required by "listening to their bodies" (we'll refer to this as "self-calibration" – synchronizing your body's heat reactions with heat measurements). As this progressed, they no longer needed to check the thermometer or hygrometer (which measures relative humidity) because their bodies would "tell" them what was needed to cool them down (drinking more water, slowing down their work pace, finding shade, taking breaks, etc.). If the work process allowed it, and supervisors supported them, workers were able to self-manage their exposure to the hot conditions. Thus, what started off with measurements often ended up in workers self-managing their heat stress.

This point was raised in the 1992 Coroner's Inquest into the heat stroke death of Brian Freeman; a student just starting his summer job who died of heat stroke in 1990 at the age of 21. During that Inquest, Professor Jim Smith testified as an expert witness, and he suggested that one cannot fully rely on the ACGIH TLV **numbers** alone to fully protect workers such as Brian Freeman from the health consequences of heat stress – Brian had a condition (unknown to him) called malignant hyperthermia which prevented his body from adequately adapting to the heat load he was exposed to. Dr. Smith recommended that supporting workers to listen to their bodies and self-manage the prevention of heat strain was essential for worker protection when the numbers could not.

This approach can work in a lot of workplaces, however, there are work situations that do not allow for such self-management (such a fixed speed line processes). Also, some workplaces have additional sources of heat such as ovens, molten metal/glass, etc., and/or they may have source of additional humidity such as steam, dryer exhaust, the circulation of large volumes of water-based solutions (like some metal working fluids), etc. In these cases, the simplified approach to heat stress management may not be sufficient and it is advised that the full ACGIH Heat Stress and Strain TLV be applied.

Based on this experience, we have described below the different levels of heat stress management practices and illustrated how they can develop from one level to another:

Supported Self-Management

Knowledgeable workers who have demonstrated they are able to recognize early signs & symptoms and, supported by their supervisors, are provided the latitude to manage their work rate and their fluid intake. **Caution!! This level of heat stress management cannot be followed without proper heat stress awareness and prevention training.**

Humidex/WBGT Estimate Based Heat Respond Plan (Simplified TLV)

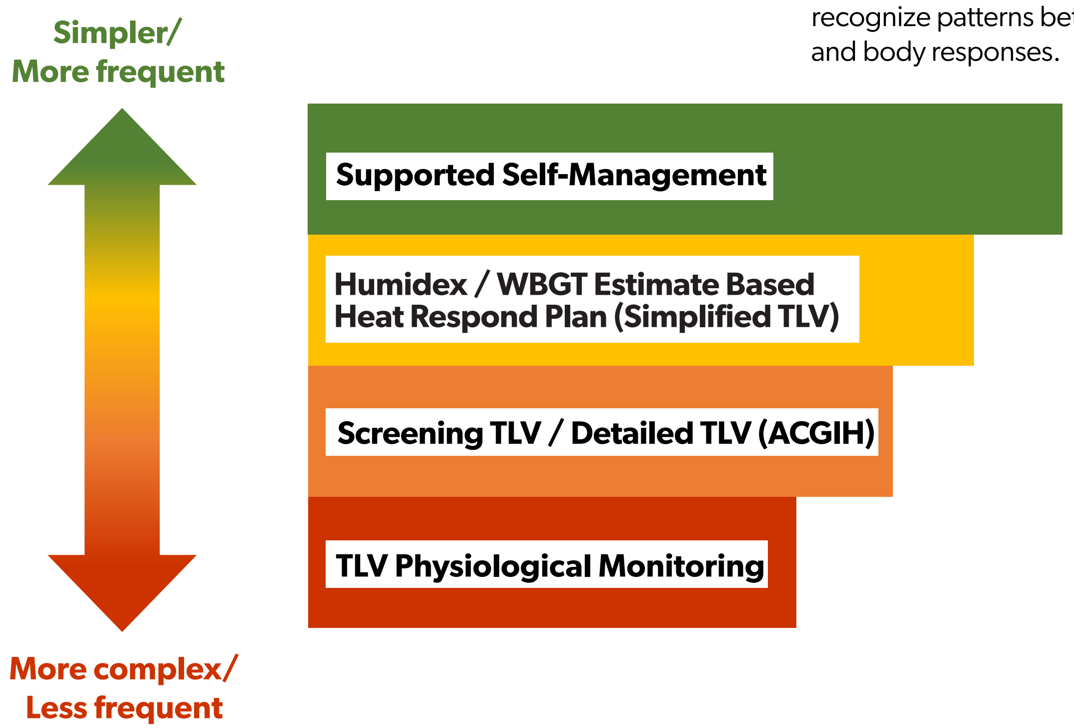
Humidex-based heat response plan a simplified version of the ACGIH TLV guidelines based on direct measurements of temperature and relative humidity. The measurements are converted to Humidex (or WBGT estimates) prescribing preventive actions. **This approach is designed for workplaces without process heat/ humidity sources and regular work clothing** – this approach can evolve into **supported self-management** over time under good management practices with supported self-calibration (being able to predict when preventive actions need to be taken by "listening to their body").

Screening TLV / Detailed TLV (ACGIH)

Using the "official" screening WBGT measurements and appropriate application of work-rest regimens to prevent heat stress (often to settle disputes) – may evolve into **simplified TLV/Humidex** approach over time. **This method is recommended for workplaces with process heat/humidity and added clothing adjustment values.** For complex and unusual exposures there is also the option to follow the technically challenging "TLV Analysis" method outlined in the ACGIH TLV documentation. **A WBGT meter is needed for these methods.**

TLV Physiological Monitoring

may be required to manage exposures above the ACGIH TLV criteria (for tough to manage exposures) – such measures can be correlated with ambient measurements over time and with correlational analysis (pattern detection) evolve into the establishment of "home-made" **screening levels**, or even a **simplified TLV/Humidex** approach. Physiological self-monitoring using smart watches or apps is another "unofficial" approach which should be viewed with caution (accuracy & validity problems). The data from these tools can evolve into **supported self-management** as workers consciously (or even sub-consciously) recognize patterns between measurements and body responses.



CASE STORY

Unexpected Recommendation for Heat Stress Control at the Source

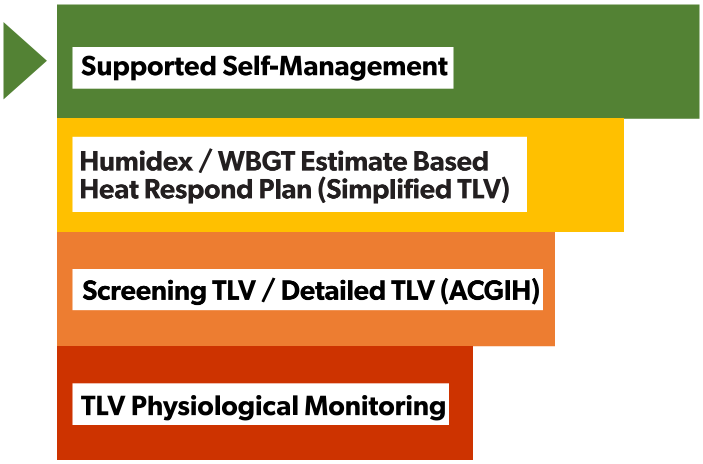
When we were first piloting the Humidex plan in an automotive assembly plant in 2002, we pitched the plan to the company who were looking for an easier way to manage heat stress in their assembly plant. When we presented the plan, we went through the hierarchy of controls with them, and we all chuckled when we perfunctorily discussed the top of the hierarchy, namely "control at the source". The Humidex plan is based on administrative controls.

During the development of the Humidex plan we also were asked about the "business case" for heat stress interventions. However, since the plan was based on reducing work, we assumed that the only "business case" that could be made was a crass cost-benefit analysis of avoiding acute and chronic health effects and deaths – always a difficult business case to make not to mention the moral sensitivity of monetizing ill-health and death.

After the Humidex plan was in place for the first heat stress season, the automotive assembly plant decided to install massive chillers to dehumidify the supply air to the assembly plant buildings (reducing the humidity in the plant would lower the Humidex and keep the line running longer). What amazed us the most about this recommendation was that the idea for the "controls at the source" came from the organization's accountants, not the JHSC. They had calculated the cost of heat-related interruptions to the assembly line and had shown that installing the chillers was a cost-effective control to keep the assembly line running. It was one of the most memorable cases of a true "business case" for a heath & safety intervention coming from accountants, not heath and safety folks.

SUPPORTED SELF-MANAGEMENT

(OPTIMAL SOLUTION)



Supported self-management of heat stress management requires specific prerequisites to ensure workers' well-being under heat stress conditions. Here are the key requirements:

1. A solid **understanding of heat strain symptoms and remedies** is crucial to prevent health risks related to overheating. This knowledge helps individuals identify warning signs and address heat-related issues promptly.
2. **Supervisory support** in the ability to set your own work pace and take necessary breaks is essential for self-management, allowing individuals to recharge, rehydrate, and prevent heat strain.
3. Access to an **ample water supply** for hydration is fundamental for physical performance, and overall well-being.
4. Availability of **other cooling options** like air conditioning, shaded rest areas, and supporting effective self-management practices.

By meeting these key requirements and receiving leadership support, a workplace can implement supported self-management of heat strain.

FIRST THINGS FIRST

Training

Recognizing the early signs and symptoms of heat stress is important in preventing serious health issues. Common indicators include excessive sweating, fatigue, headache, dizziness, muscle cramps, and nausea. It's essential for workers to be able to recognize these symptoms as the result of heat stress and know what to do to counteract them (such as adjusting their work pace, taking frequent breaks in shaded or cooler areas, and staying well hydrated by drinking water regularly).

Empowering workers to self-manage by "listening to their bodies" is a key component of all layers of managing heat stress. This requires an organizational culture that encourages workers to prioritize their health and well-being. Self-management needs to be supported – supervisors need to be able to recognize when a worker may be experiencing heat-related distress and support them by taking necessary precautions.

Evaluating your heat stress training efforts is critical to the point where, some day, it might save someone's life. Adequate training is not just being able to repeat facts, but being able demonstrate that you can use the knowledge you've gained. This is more than passing a quiz. This is being able to describe what heat stress feels like, knowing what it can do and describing how to prevent it. Supervisors/trainers need to be fully confident that the workers they are responsible for have understood the information and are applying it when the need arises.

A worker experiencing the early signs of a heat stroke will begin to be confused and will no longer be able to apply the training they've had. At this point it is absolutely critical that those around them intervene to get them the immediate medical attention they desperately need. If you let them continue without intervening, they may die!

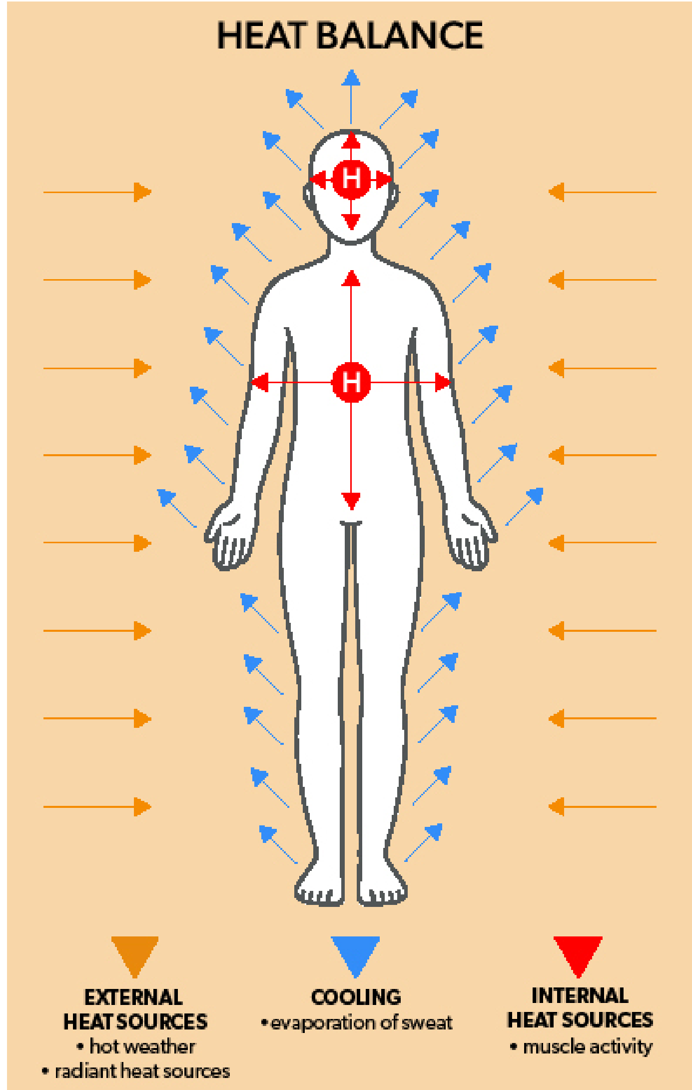
WATCH OUT FOR EACH OTHER!

Exposure Situation

(heat sources and cooling mechanisms)

Unlike other occupational hazards which originate outside the body, heat stress has both **external** and **internal** sources of exposure. Heat stress due to hot weather is something everyone who is not in an air-conditioned workspace will experience. However, for those who have to use their muscles to do their work, there is a second source of heat stress: namely, the heat generated from your muscle activity. When the body converts stored energy (which it gets from food and drinks) into muscle activity (i.e., work), 70% of that energy gets converted into heat. So, the more muscle you use in order to do your work, the greater the internal sources of heat exposure.

Hot weather is one external source, but some workplaces have additional external heat sources. Work processes which involve additional heat and/or humidity sources such as ovens, boilers, dishwashers, steam, handling hot materials like asphalt, etc., can significantly increase the external sources of heat stress. Outdoors, working in direct sunlight or having the sun's heat reflected at you from surfaces such as pavement or concrete can also increase your exposure. These heat stress conditions with additional sources of heat and/or humidity may require more sophisticated heat stress evaluation methods such as the ACGIH Heat Stress TLV methods. The simplified tools in this toolkit may not apply in these more complex exposure situations. For more information, please see the *Heat Stress Awareness Guide*.



TRAINING ESSENTIALS

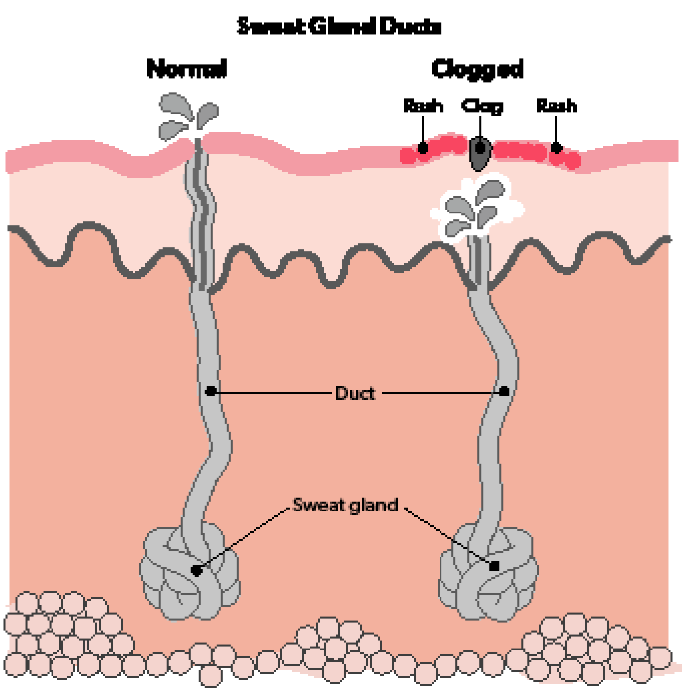
Acute Health Effects

Head Edema

The pooling of fluid in the hands and feet. Often occurs early in the heat stress season prior to any heat adaptations or acclimatization.

Heat Rash

Skin becomes reddened and may itch, feel prickly or hurt. Practice good personal hygiene; keep the skin clean and the pores unclogged, allow skin to dry, wear loose clothing, see doctor if rash persists. Often happens early in heat stress season (first heat wave) when skin is unacclimatized.



Heat Syncope (fainting)

Dizziness, feeling light-headed and perhaps nauseous, then the person may faint. Often happens in combination with other risk factors such as standing/sitting in one position for a long time, after eating, or in combination with other risk factors such as viral infection, or circulatory health conditions.

Heat Cramps

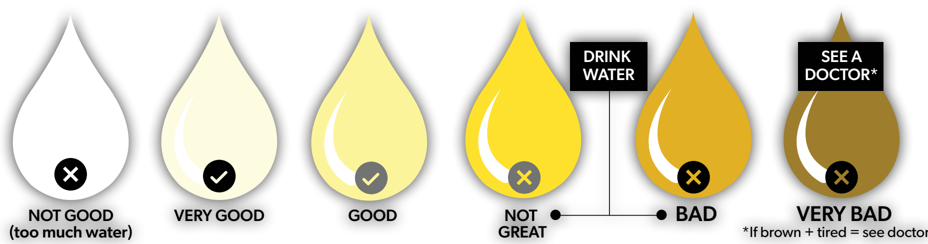
Cramping of either active muscles (arms, legs) or involuntary (usually abdominal) muscles (or both). Generally, a sign of electrolyte imbalance during heavy physical activity. Often happens early in the heat stress season when the body has yet to acclimatize.

Dehydration

Under heat stress conditions workers need to drink about a cup of water every 20 minutes - more than just relying on satisfying your thirst. Stay away from caffeinated, carbonated, diet drinks and alcohol.

CAUTION: There can be consequences of drinking too much water, which is sometimes called water intoxication, or **hyponatremia**. Drinking too much water dilutes electrolytes in the blood, such as sodium. When this happens, your body's water levels rise, and your cells begin to swell. This swelling can cause many health problems, from mild to life-threatening. Symptoms include headache, fatigue, irritability, muscle weakness/cramps. Electrolyte containing beverages should be considered during heavy work activities in the heat. IF you are not dehydrated, or working in conditions causing you to sweat, take caution with electrolyte containing beverages. **Hypernatremia**, or too many electrolytes, in your body can cause muscle twitching, confusion, seizures, and abnormal heart rate. Therefore, having a good fluid balance is important.

Take note of the colour of your urine:



Rhabdomyolysis (often called rhabdo) is a serious medical condition caused by heat exposure (dehydration), physical exertion, and overuse or traumatic injury. It occurs when damaged muscle tissue releases its proteins and electrolytes into the blood. Symptoms include muscle cramps/pain, abnormally dark urine, weakness, and exercise intolerance (it can be diagnosed with medical tests). In the long term it can cause damage to the heart and kidneys.

Heat Exhaustion

Nausea, dizziness, weakness headache, blurred vision, profuse sweating, cold/wet (clammy) grayish skin, unconsciousness, coma and death. Place victim in a prone position in a cool location, administer fluids if the victim is conscious. If unconscious, seek medical care or transport to a medical emergency room.

Heat Stroke

Chills, restlessness, irritability, euphoria, red face and skin, disorientation, hot/dry skin (not always), collapse, unconsciousness, convulsions and death. Immediate, aggressive cooling of the victim's body using wet cloths, immersion into cold water or alcohol wipes. Transport to emergency medical facility ASAP!

A worker heading into a heat stroke will no longer realize what's happening to him/her. It is vital that co-workers be able to recognize what's happening and intervene. Without quick attention, the co-worker may die!

WATCH OUT FOR EACH OTHER!

A person who has experienced heat exhaustion or heat stroke previously will be more sensitive, and less tolerant to the heat. Recurrence of a second heat-stress event is common.

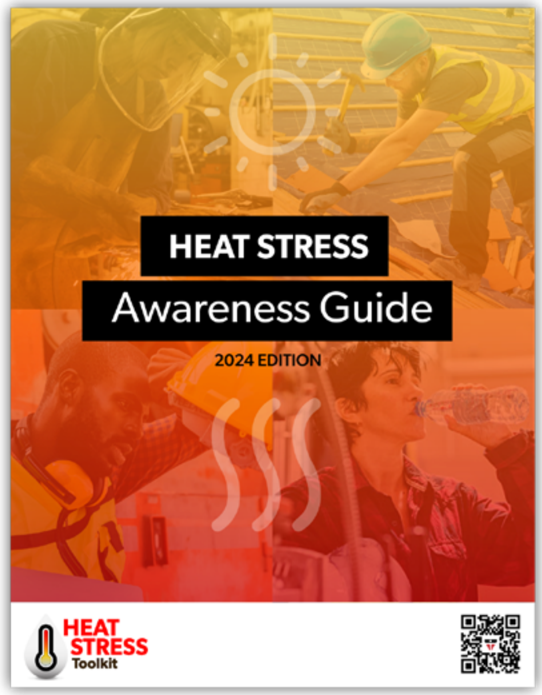
Chronic Health Effect

Chronic exposure to heat strain can result in long term illness affecting the brain, heart, kidneys, liver, and muscles. Also, both the male and female reproductive systems making it harder to conceive. Chronic heat strain can also disturb sleep patterns and affect mental health.

Heat Strain Carry-over

It is important to prioritize giving the body ample time to cool down and recuperate after being exposed to high temperatures. Continuing to subject the body to prolonged periods of heat stress, exceeding 6 hours a day, can lead to a cumulative impact on the body. Without adequate breaks and time away from the heat, the strain experienced from the previous day can accumulate. Instead of allowing the body to adapt to the heat, this build-up of strain may result in causing more harm *(Notley et al., 2018)*. Therefore, it is essential to implement proper measures to ensure the body has sufficient opportunities to recover from heat stress and prevent negative consequences.

According to the ACGIH “the TLV assumes complete recovery from a previous heat stress exposure.” *(ACGIH, 2022)* However the literature suggests that with long term heat exposure (more than 5 hours), the peak of adaptability to heat strain was around 2-3 days, and after 5 days the heat strain carried over from the previous days *(Notley et al., 2018)*.

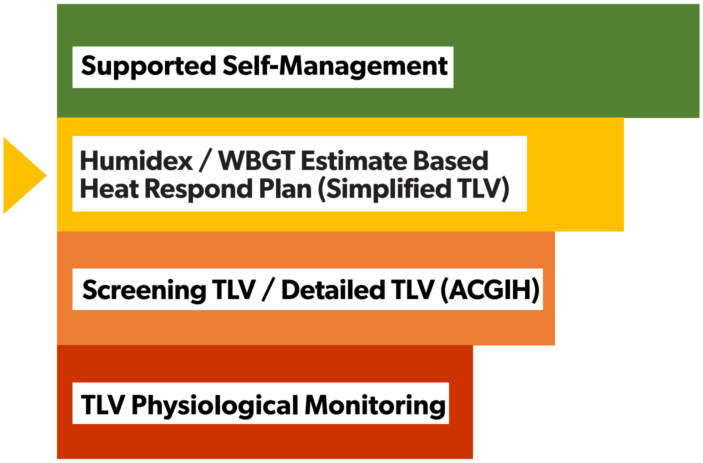


For more information about health effects of heat stress see the

Heat Stress Awareness Guide

“These preliminary findings therefore indicate that the body’s physiological capacity to adapt was perhaps overwhelmed by a thermal “dose” that was too large… Observations highlighted in this communication suggest that the rising number of older workers employed in arduous occupations may experience thermoregulatory impairments that increase their risk of heat-related illness over consecutive workdays.” *(Notley et al., 2018)*

HUMIDEX / WBGT ESTIMATE BASED HEAT RESPONSE PLAN (SIMPLIFIED TLV)



This toolkit is based on a simplification of the ACGIH TLV assuming work classified in the "moderate" physical activity metabolic category for unacclimatized workers. If these assumptions do not fit your workplace, then you should refer to the ACGIH Heat Stress and Strain TLV.

Acclimatization to heat stress is a critical process that allows the body to gradually adapt to higher temperatures and reduce the risk of heat-related illnesses. This physiological adaptation involves a series of changes that occur over a period of time as the body adjusts to heat stress. Initially, exposure to heat triggers responses such as increased sweating, higher heart rate, and redirection of blood flow to the skin to dissipate heat. Through repeated and prolonged heat exposure, the body becomes more efficient at cooling itself and keep electrolytes out of sweat, leading to improved heat tolerance.

It is important to note that the process of acclimatization is gradual and requires time for significant adaptations to occur. The ACGIH provides an objective criteria to estimate whether workers can be considered acclimatized:

"With a recent history of heat stress exposures of at least 2 continuous hours for 5 of the last 7 days, a worker may be considered acclimatized for the purpose of the TLV. Acclimatization declines when activity under heat stress conditions is discontinued. A noticeable loss occurs after 4 days and may be completely lost in 3 weeks. A person may not be fully acclimatized to a sudden or episodic higher level of heat stress." *(ACGIH, 2022)*

Looking at the historical weather data in Ontario it's quite clear that even workers working in direct sunlight (without additional sources of heat), weather conditions are not sufficient to warrant the assumption of acclimatization. Therefore, workers performing "moderate" work (e.g., work with some pushing, lifting) would not be assumed to be acclimatized, unless there is significant radiant heat associated with the work.

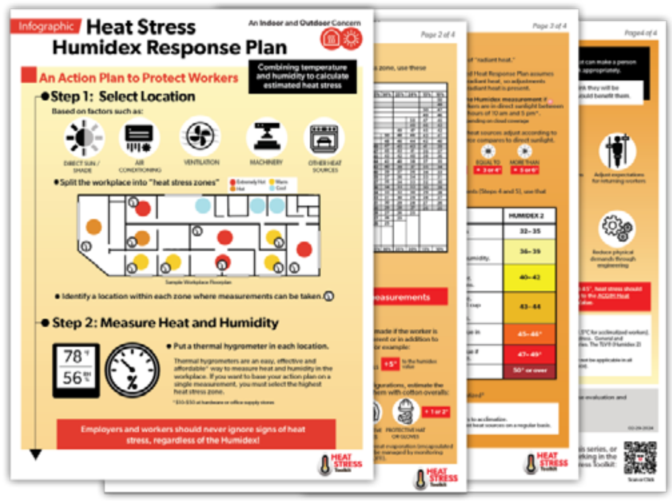
The metabolic categories are based on workers weighing 154 lbs. The table of metabolic rate categories in the TLV®, specifically states in the footnote that "The effect of body weight on the estimated metabolic rate can be accounted for by multiplying the estimated rate by the ratio of actual body weight divided by 70 kg (154 lb)." (ACGIH, 2022). Thus, taking into account this weight adjustment and realizing that some workers maybe somewhat dehydrated, may be older, being female and perhaps have additional risk factors compromising their heat stress response, we feel the "moderate work" metabolic category is a better general assumption than the "light work" metabolic category.

The Humidex plan is a simplified way of protecting workers from heat stress which is based on the 2022 ACGIH Heat Stress TLV® (Threshold Limit Value®) which uses wet bulb globe temperatures (WBGT) to estimate heat strain. The moderate unacclimatized WBGT's were translated into Humidex or WBGT estimate (based on temperature and relative humidity). The following steps must be followed when using the Humidex based heat response plan or WBGT estimate.

Step 1: Training

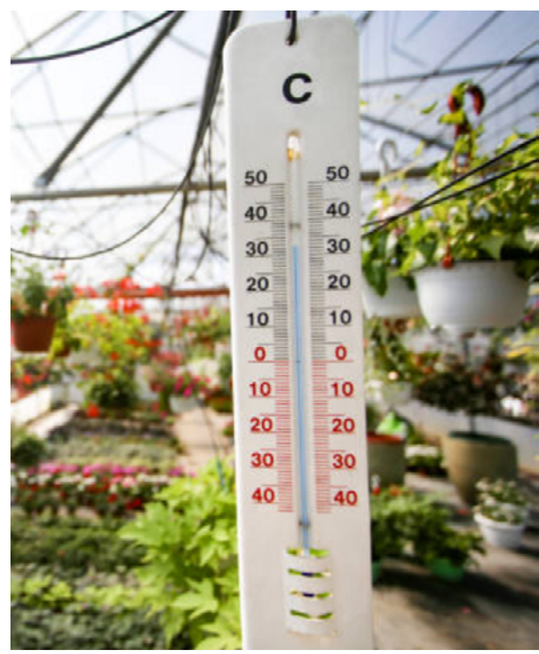
(See Training Essentials above)

The Humidex plan by itself cannot guarantee that workers will not be affected by heat stress. It is important that all workers can recognize the early signs and symptoms of heat stress to prevent more serious heat illnesses. Workers need to adjust their work pace, take frequent breaks in shaded or cooler areas, and stay hydrated by drinking water regularly. Supervisors also need to be able to recognize when a worker is experiencing heat-related symptoms and know what to do to support them. The ideal heat stress response plan would let workers regulate their own pace by "listening to their body" without need for measurements.



Step 2: Select a Measurement Location

The Humidex Heat Stress Response Plan is **based on workplace measurements not weather station or media reports.** Temperatures inside buildings **do not** usually correspond with outdoor temperatures. Therefore, it is important to identify a representative location within the zone where measurements can be taken, within 10m (30 ft) of the exposed worker(s).



Step 3: Measure Workplace Humidex

For workstations where weather conditions are the main source of external heat exposure temperature and relative humidity measurements taken within the work zone are sufficient. Measurements should be taken at least once per hour during heat stress conditions (Humidex approaching 30 or over 23˚C WBGT) and be recorded. A thermal hygrometer a simple way to measure the temperature and relative humidity. For work areas where there is significant process radiant heat and/or humidity sources (steam, circulation of large quantities of water) the preferred measurements are Wet Bulb Globe Temperature (WBGT) measurements taken within 10m (30') of the exposure (the closer to the exposed worker the better).

Humidex Heat Response Plan

Adjusted* Humidex	Action
45+**	only medically supervised work
42 - 44	75% relief
40 - 41	50% relief
38 - 39	25% relief
34 - 37	warning & double water
30-33	alert & water
25-29	water as needed

NEVER IGNORE ANYONE'S SYMPTOMS DESPITE YOUR MEASUREMENTS!

Relative Humidity (in %)

Temp (in °C)	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	Temp (in °C)
49																			50	49
48																			49	48
47																		50	47	47
46																		49	46	46
45																	50	47	45	45
44																	49	46	43	44
43																49	47	45	42	43
42															50	48	46	43	41	42
41															48	46	44	42	40	41
40														49	47	45	43	41	39	40
39													49	47	45	43	41	39	37	39
38												49	47	45	43	42	40	38	36	38
37											49	47	45	44	42	40	38	37	35	37
36									50	49	47	45	44	42	40	39	37	35	34	36
35								50	48	47	45	43	42	40	39	37	36	34	33	35
34							49	48	46	45	43	42	40	39	37	36	34	33	31	34
33					50	48	47	46	44	43	41	40	39	37	36	34	33	32	30	33
32			50	49	48	46	45	44	42	41	40	38	37	36	34	33	32	30	29	32
31	50	49	48	47	45	44	43	42	40	39	38	37	35	34	33	32	30	29	28	31
30	48	47	46	44	43	42	41	40	39	37	36	35	34	33	31	30	29	28	27	30
29	46	45	43	42	41	40	39	38	37	36	35	33	32	31	30	29	28	27	26	29
28	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	28
27	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24		27
26	39	38	37	36	35	34	33	33	32	31	30	29	28	27	26	25	24			26
25	37	36	35	34	33	33	32	31	30	29	28	27	26	26	25	24				25
24	35	34	33	33	32	31	30	29	28	28	27	26	25	24						24
23	33	32	31	31	30	29	28	28	27	26	25	24	24							23
22	31	30	30	29	28	27	27	26	25	25	24									22
21	29	29	28	27	26	26	25	24	24											21
	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	

Relative Humidity (in %)

Limitations: this table is based on work with **little or no radiant heat**, assuming wearing **regular summer clothing**; if your specific working conditions vary from these assumptions, see the steps 1-5 to make adjustments. **For work in direct sunlight add 3-4 units to the Humidex value from the table.**

* "adjusted" means adjusted for additional clothing and radiant heat (see steps 2 & 5)

** above a humidex of 45 use the ACGIH Heat Stress/Strain TLV

WBGT ESTIMATE

T_{air} (in °C)	Relative Humidity (in %)																			T_{air} (in °C)
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	
43																31.0	29.9	28.8	27.7	43
42															31.3	30.3	29.2	28.1	27.1	42
41														31.6	30.6	29.5	28.5	27.5	26.5	41
40														30.8	29.8	28.8	27.8	26.8	25.8	40
39													31.0	30.0	29.1	28.1	27.1	26.2	25.2	39
38												31.1	30.2	29.2	28.3	27.4	26.4	25.5	24.6	38
37											31.2	30.3	29.4	28.5	27.5	26.6	25.7	24.8		37
36										31.2	30.3	29.4	28.5	27.7	26.8	25.9	25.0	24.2		36
35									31.1	30.3	29.4	28.6	27.7	26.9	26.0	25.2	24.3			35
34								31.0	30.2	29.4	28.5	27.7	26.9	26.1	25.3	24.5				34
33						31.6	30.8	30.0	29.2	28.5	27.7	26.9	26.1	25.3	24.5					33
32				31.6	31.2	30.6	29.8	29.1	28.3	27.5	26.8	26.0	25.3	24.5						32
31	31.0	31.0	30.9	30.5	30.1	29.5	28.8	28.1	27.4	26.6	25.9	25.2	24.5							31
30	30.0	30.0	29.8	29.5	29.1	28.5	27.8	27.1	26.4	25.7	25.0	24.4								30
29	29.0	29.0	28.8	28.5	28.1	27.5	26.8	26.2	25.5	24.8	24.2									29
28	28.0	28.0	27.8	27.5	27.0	26.5	25.8	25.2	24.6											28
27	27.0	27.0	26.8	26.4	26.0	25.4	24.8	24.2												27
26	26.0	26.0	25.8	25.4	24.9	24.4														26
25	25.0	25.0	24.8	24.4																25
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	
	Relative Humidity (in %)																			

Limitations: this table is based on work with **little or no radiant heat**, assuming wearing **regular summer clothing**; if your specific working conditions vary from these assumptions, see the steps 1-5 to make adjustments. **For work in direct sunlight add 2°C to the WBGT value from the table**.

Table derived from Bernard and Iheanacho *(2015)*.

Step 4: Adjust for Clothing

There are a number of ways the body can cool itself but under heat stress conditions most of the excess internally generated body heat is removed by the evaporation of sweat. This is why what kind of work clothes you are wearing is so important. Clothing that allows sweat to evaporate will help cool you down, however, clothing that acts as a barrier to evaporating sweat will do the opposite. That's why we need to take into account the type of clothing and personal protective equipment (PPE) you are wearing in heat stress conditions.

The ACGIH TLV has **Clothing Adjustment Values** (CAV's) which are values that need to be added to the measured Humidex or to the estimated WBGT (see table below). Ignoring these adjustment factors can severely under-estimate the exposure workers are experiencing.

- Choose lightweight, loose-fitting, breathable fabrics such as cotton or moisture-wicking materials to allow for better air circulation and sweat evaporation.
- Wear light-colored clothing to help reflect sunlight and reduce heat absorption.
- If clothes do not allow sweat evaporation (encapsulated suits) heat stress should be managed by monitoring vital signs (see ACGIH TLV®).

The derived CAVs are estimates of the ACGIH CAVs for type of PPE not listed in the ACGIH list. They were derived from a study that measured the relative cooling rates of different parts of the body *(Taylor et al., 2014)*.

Step 5: Adjusting for Radiant Heat

For outdoor work in direct sunlight between the hours of 10 am and 5 pm, an adjustment factor must be added. Add 3-4 Humidex units or 2˚C WBGT (pro-rate according to percentage cloud cover and/or shade) to your Humidex/WBGT estimate measurement. If there is cloud cover or partial shade, one can pro-rate these additions by the ratio compared to direct sun exposure (e.g., use 50% of the value if cloud cover is 50%). For indoor radiant heat exposures, use common sense to judge whether the exposure of concern involves more or less radiant heat than direct sunlight and adjust the Humidex measurement by adding the appropriate proportion of the 3-4 Humidex unit (add 2°C to the WBGT estimate from Bernard's temp & RH chart). Keep in mind that this is an estimation of the Humidex. F**or a more accurate measure with radiant heat, use the ACGIH TLV**. If the radiant heat is greater than exposure to direct sunlight use the ACGIH TLV.

Technical Resources/Capabilities

Knowing when its too hot is something so basic that every person can know by listening to their body and, with proper training, be able to recognize the early signs of heat stress. However, trying to determine when it's too hot by using external instruments can get very complicated very quickly.

The ACGIH uses a method called the wet-bulb globe temperature (WBGT) which combines three measures (temperature, relative humidity, and radiant heat) to calculate the heat stress. The monitoring equipment can be very expensive (up to $8000) and takes some training to know how to use appropriately. Furthermore, since the ACGIH WBGT criteria are based on physical activity categories, interpreting the results can be quite complicated (with most users commonly making mistakes). This toolkit does not explain how to use the ACGIH methods – workplaces who wish to use this approach should obtain a copy of the ACGIH Heat Stress and Strain TLV Documentation and follow the procedures outlined in this document.

The simplified tools in this toolkit are based on the assumption that the workplace is able to measure the work zone temperature and relative humidity with reasonable accuracy (an accuracy of at least ±0.5°C and ±5% respectively). Ideally, you should regularly check the accuracy of your instruments against a trustworthy comparison.

Cloth (woven material) Coveralls over underwear	°C WBGT	Humidex
Short Sleeves and Pants of Woven Material	-1.0	-2
Work Clother (Long Sleeve Shirt and Pants)	0.0	0
Cloth (Woven Material) Coveralls Over Underwear	0.0	0
Thin Disposable SMS Polypropylene Coveralls Over Underwear	+0.5	+1
Disposable Polyolefin (Tyvek) Coveralls Over Underwear	+1.0	+2
Adding a Hood (Full Head and Neck Covering; Not Face)	+1.0	+2
Double Layer Woven Clothing (e.g., Coveralls Over Work Clothes)	+3.0	+6
Limited-Use Vapor-Barrier Coveralls with Hood	+11.0	+22

Derived Clothing Adjustment Values	°C WBGT	Humidex
Impervious gloves	+0.2	+0.4
Impervious apron	+0.3	+0.6
Additional protective sleeves	+0.2	+0.4
Leather welding jacket	+1.5	+3.0
Medical mask	+0.05	+0.1
N95 disposable respirator	+0.1	+0.2
Half face piece elastomeric demande respirator	+0.2	+0.4
Ear muffs	+0.1	+0.2
Toque	+0.6	+1.2
Hard hat	+0.2	+0.4
Goggles	+0.1	+0.2
Face shield	+0.1	+0.2
Woven fabric hospital gown	+1.5	+3.0

Adjusted* Humidex	Response	Effective** WBGT (°C)
25 - 29	supply water to workers on an "as needed" basis	⇠ 23.0°C
30 - 33	post Heat Stress Alert notice; encourage workers to drink extra water; start recording hourly temperature and relative humidity	23.1 – 24.0°C
34 - 37	post Heat Stress Warning notice; notify workers that they need to drink extra water; ensure workers are trained to recognize symptoms	24.1 – 25.0°C
38 - 39	work with 15 minutes relief per hour can continue; provide adequate cool (10-15°C) water; at least 1 cup (240 mL) of water every 20 minutes worker with symptoms should seek medical attention	25.1 – 26.0°C
40 - 41	work with 30 minutes relief per hour can continue in addition to the provisions listed previously	26.1 – 27.0°C
42 - 44	if feasible, work with 45 minutes relief per hour can continue in addition to the provisions listed above	27.1 – 29.0°C
45*** or over	only medically supervised work can continue	29.1°C*** or over

*** "adjusted" means adjusted for additional clothing and radiant heat (see steps #4 & #5)**
****at Humidex exposures above 45 (WBGT 29.1˚C), heat stress should be managed as per the ACGIH TLV®**

NEVER IGNORE ANYONE'S SYMPTOMS NO MATTER WHAT THE HUMIDEX!

It should be noted that when you take the accuracy of your instrument into account the total error of the Humidex measurement is ±2° (or ±1.1°C WBGT) and since most categories only span 2° Humidex (or 1°C WBGT), this means that the measurement error could span over 3 categories. For example, if the temperature is 30°C (29.5-30.5°C) and the relative humidity is 60% (55-65%) then the Humidex is 39 (error spanning 37-41) and the WBGT is 26.2°C WBGT (error spanning 25.1-27.3°C WBGT):

This error range is important to take note of since if you're measurements are close to a boundary between one category and another, you could easily be in either category, thus it is important to consider the full range not just the single point estimate.

		RH (in %)		
		55%	60%	65%
Temp (in °C)	31	39	40	42
	30.5	38	39	41
	30	37	39	40
	29.5	37	38	39
	29	36	37	38

Humidex	Action
45+	stop work
42 - 44	75% relief
40 - 41	50% relief
38 - 39	25% relief
34 - 37	warning & double water

CASE STORY

Transition from ACGIH TLV (WBGT) to Humidex

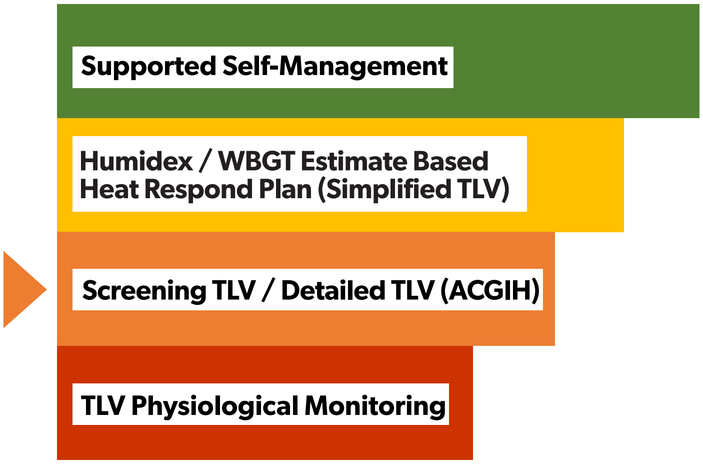
During a very hot summer, an automobile assembly line plant had huge line-ups at the first aid stations when the organization refused to stop the assembly for heat breaks. This was obviously unsustainable, and the union and the company worked together to find a solution. Having only a couple occupational hygiene-trained people available who had access to an (expensive and complicated) instrument that could take WBGT measurements, they quickly realized that during hot weather this was just not practical. Given their extremely large buildings, the handful of trained people with the few instruments they owned, they could only be in so many places at once.

Originally, if workers had a concern about heat stress, they would tell their supervisor and/or their H&S representative, who would then contact the hygiene department to send out a person with the WBGT meter. This worked if there were just a few places where heat was a problem, but during a heat wave, their capacity to respond to concerns was quickly overwhelmed. When we sat down with the union to explore alternatives, we suggested the Humidex plan with inexpensive hygrometers (small electronic machine that measures temperature and humidity) placed throughout the plants with the Humidex table posted on the wall beside hygrometer. At first the union H&S reps were resistant to the idea. "Anyone will be able to read the chart and find out the work/rest recommendations and we'll be hounded by everyone to provide the expected breaks". The hygienist with a WBGT instrument was more "manageable" even if there wasn't enough capacity to meet the demand during hot weather. The union H&S reps feared the new system would lead to shop floor "anarchy". However, once they piloted the system, the H&S reps realized it made their job easier. Workers were able to pressure their supervisors to adhere to the Humidex plan, and the H&S reps were no longer the intermediaries between the workers/supervisors and the occupational hygiene department.

This showed a shift in the balance of power away from the technical expert with the expensive machine being the only one who could tell you whether or not it was time for heat breaks, to everyone being able to determine the need for heat relief and problem solving directly with their supervisors. But, when you think about it, all this technology and expertise associated with WBGT system is really there to tell workers when it's too hot to work (something they already know!).

SCREENING TLV / DETAILED TLV (ACGIH)

ACGIH Screening Criteria Based on WBGTeff



The ACGIH TLV for heat stress and strain is the "gold standard" for the evaluation and assessment of heat stress. If the simpler Humidex based heat response plan does not allow for full characterization of heat stress risk, the ACGIH TLV should be used. **If you decide to use this method consult the ACGIH TLV documentation for heat stress and strain.**

The ACGIH TLV has 4 methods of heat stress assessment. Method 1 is the most commonly used and least complicated method. It consists of a table of TLV and Action Limit (AL) screening criteria based on the effective WBGT (WBGTeff). The screening criteria for heat stress exposure considers:

- the contributions of environment (WBGT),
- metabolic work demands adjusted for weight as light, moderate, heavy, or very heavy, (follow table 1 of the ACGIH TLV)b
- work-rest pattern, (follow table 2 of the ACGIH TLV)
- clothing; (See CAV in the section above)
- level of acclimatization.

CASE STORY

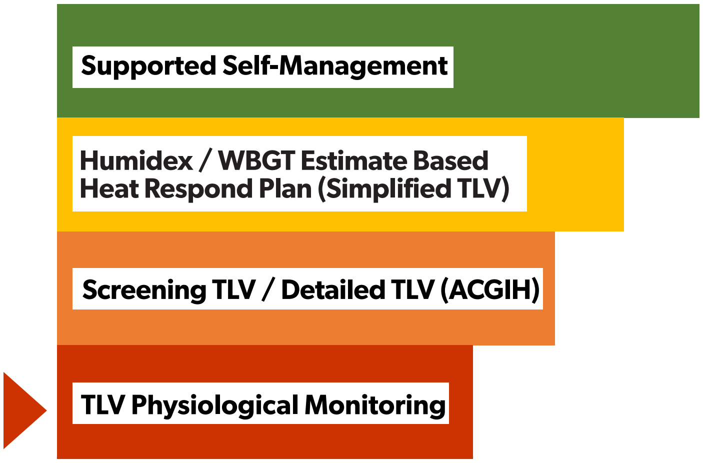
From Humidex to ACGIH TLV (WBGT)

Jamila works in a mid-sized factory producing shaped cardboard containers. The cardboard is shaped when wet and the dried in kilns, so the factory process emits both heat and humidity. At first the plant tried to use the Humidex plan, but heat stress conditions were more complicated than the Humidex plan assumes, so they decided to purchase machines that would measure the wet-bulb globe temperature (WBGT). The employer installed 4 fixed sets of sensors which were programmed to notify supervisors beginning when the conditions in these for areas exceed 20°C WBGT. There are also hand-held measuring units which can be used for following up specific heat stress concerns.

The Health & Safety department liked the simplicity of the Humidex plan so they worked out a correlation between Humidex and WBGT measurements so they could convert the Humidex table into WBGT units. The WBGT measurements take into consideration the radiant heat from the kilns and extra humidity from the wet processes in the plant. Jobs were classified by ergonomic consultants into "light" and "moderate" categories. It was also noted which jobs had access to air-conditioned break rooms for relief and which jobs did not. Engineering controls included ventilation with chillers to control the level of humidity in the plant (for the stability of the cardboard product), ergonomic changes were made to reduce the amount of energy workers have to expend to do their work, and evaporative cooling fans are placed strategically throughout the plant when things get really hot.

As a member of the Joint Health & Safety Committee, on the heat stress days, Jamila is responsible to make sure her fellow workers are doing okay, and are getting enough fluids (usually water but also electrolyte freezies when things get really hot, and she sees people struggling). She also keeps a special eye out for some of her co-workers who she knows have some physical challenges. She's also trained in first aid and knows what to do if someone shows symptoms. She also knows how to take WBGT measurements if a specific concern arises. So far, the system seems to work quite well.

TLV PHYSIOLOGICAL MONITORING



Physiological monitoring for heat stress can be a useful tool to protect the health and safety of individuals working in hot environments especially if engaging in strenuous physical activities. Heat stress occurs when the body is unable to regulate its temperature, leading to symptoms ranging from mild discomfort to life-threatening conditions such as heat stroke. To prevent heat-related illnesses, monitoring tools including wearable technology equipped with heart rate monitors, and thermoregulatory devices can be utilized to track key physiological parameters like body temperature, heart rate, and hydration levels as well as raising awareness for the individual to self-monitor and take breaks when needed.

The integration of these tools can improve a comprehensive heat illness prevention plan, by proactively flagging early signs of heat strain and alerting a need for action to prevent its escalation. Monitoring can identify timely interventions including rest breaks, hydration status, recovery status, and can support self-calibration, particularly in inexperienced workers. Educational programs on heat stress awareness and prevention will enhance the effectiveness of physiological monitoring. In summary, integrating physiological monitoring into heat stress management strategies can be an effective tool in promoting a safe and healthy environment for individuals exposed to high temperatures and should be considered under conditions of high risk, and remote work.

Data collected from monitoring devices used for personal information, belongs to the individual wearing the health monitoring device. The data can be shared with others, such as general practitioners, if the individual chooses to disclose the information, or if the device is being used to monitor a specific health/medical condition. However, personal devices should be differentiated from workplace provided health monitoring devices. Data output from physiological monitoring is considered private medical data, so stringent policies are required in workplaces that implement it related to: circumstances when monitoring is implemented; who has access to the data during monitoring; what the data can be used for; and whether the data is stored.

The technologies for evaluating both physical and psychological health are at various stages of development and are constantly evolving. As new technology and devices are developed, it is important to test the device's ability to assess the intended feature compared to the highest standard of measurement. Some health monitoring devices have been independently tested to determine reliability (produces consistent results) and validity (accurately measures what it was intended to measure). However, there are a large number of devices on the market that have not been properly tested. This is primarily due to the popularity and demand of the devices, causing companies to produce and release devices faster than researchers can test them. However, it should be noted that even though some commercially available devices have been validated, they may not generate the same results in all workplace settings. If you want to use physiological monitors in the workplace, the specific device under consideration should be assessed for its: accuracy; reliability; and practicality for use in the workplace setting.

For a full discussion of physiological monitoring, see the *Heat Stress Physiological Monitoring Guide*.

Appendix A: References

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Appendix B: Definitions

Acclimatization: The body's ability to "get used to" working in hot conditions. Since sweating is the main way the body cools itself, acclimatization actually involves the gradual change in sweat rate (sweat more quickly) and the content of the sweat (less electrolytes are lost when you sweat efficiently). Dehydration can eliminate the benefits of acclimatization. In Ontario, weather conditions seldom reach the levels that allow the body to maintain acclimatization to heat stress conditions. Only if workers are exposed to extra heat/humidity sources (like very hot ovens, steam, molten metal/glass, etc.) would it be possible to be considered acclimatized in Ontario. The ACGIH stipulates that a person can be considered acclimatized after being exposure to heat stress for at least 2 continuous hours, for 5 of the last 7 days.

Action limit (AL): The heat conditions at which healthy, unacclimatized workers can reach thermal equilibrium, under the ACGIH guidelines *(ACGIH, 2022)*.

ACGIH: American Conference of Governmental Industrial Hygienists.

Core body temperature: Is the temperature inside your body (normal core body temperature is 37°C); heat stress programs are designed to keep the body's core temperature below 38°C.

Heat stress: Is the body's exposure to heat. There are two sources of heat stress, one is the heat in the environment, the other is the heat the body generates when it does work (70% of the energy used by the body to function turns into internally generated heat).

Heat strain: Is the effect of heat stress (external and internal) on the body which results in the list of symptoms and health effects described below.

Heat Stress Management Program (HSMP): Written plans that outline workplace policy around managing heat stress including, but not necessarily limited to: training, hygiene practices, monitoring, event documentation, and an emergency response plan. HSMP should include general controls, and job specific controls that are triggered when heat stress exceeds exposure limits, for example those in the TLV or AL *(ACGIH, 2022)*.

Humidex: is a measure created by Environment Canada that considers not just temperature but also the effect of relative humidity. The Humidex provides the temperature that it "feels like" when you take the humidity into account.

Metabolic heat: The heat produced by normal, biochemical processes in the body (e.gs., energy production, hormone activation, digestion). As muscular demand increase during physical activity, metabolic heat production also increases.

Metabolic rate: Is the rate at which the body uses stored energy (digested food) to perform work. For heat stress it is important to realize that when the body uses its energy reserves to do work, 70% of the energy gets changed into heat (our bodies are not very energy efficient work machines).

Radiant heat: is the heat that radiates from hot surfaces and from the sun; radiant heat is an additional factor in heat stress over and above the temperature in the general environment.

Relative humidity: is the amount of moisture in the air at a certain temperature compared to what the air can "hold" at that temperature. The higher the relative humidity the harder it is for sweat to evaporate (and the hotter you feel).

Time Weighted Average (TWA): For heat stress is the weighted average of the different measurements based on an overall time frame of 1 hour calculated as follow: TWA = measurement1 x (minutes at location1/60) + measurement 2 x (minutes at location2/60) + …

Threshold limit value (TLV): The heat conditions at which healthy, well hydrated, acclimatized workers can reach thermal equilibrium under the ACGIH guidelines. For the purpose of the TLV, workers are considered acclimatized if they had recent heat stress exposures of at least two continuous hours, for five of the previous seven days *(ACGIH, 2022)*.

Wet Bulb Globe Temperature (WBGT): is the "official" method of measuring heat stress. WBGT stands for wet bulb globe temperature. The ACGIH has two equations to calculate the WBGT:

WBGT (indoors/shade) = 70% wet bulb temperature + 30% globe temperature

WBGT (outdoors in sun) = 70% wet bulb temperature + 20% globe temperature + 10% dry bulb temp

The ACGIH standard has a table of WBGT criteria which should protect "most" workers who are "healthy and well-hydrated" from experiencing heat stress symptoms or health effects *(ACGIH, 2022)*.

Appendix C: Research and Support

Training & technical support is available from your Health and Safety Association. Workplace-specific information, as well as training and consulting services for illness and injury prevention, are provided by the Health and Safety Associations of Ontario, the Workers Health and Safety Centre, and the Occupational Health Clinics for Ontario Workers. All OHS System Partners are part of the Occupational Illness Prevention Steering Committee that supported this project.

- Centre for Research Expertise in Occupational Disease
- Centre for Research in Occupational Safety and Health
- Infrastructure Health and Safety Association
- Institute for Work and Health
- Occupational Cancers Research Centre
- Occupational Health Clinics for Ontario Workers
- Ontario Ministry of Labour, Immigration, Training and Skills Development
- Public Services Health & Safety Association
- Workers Health & Safety Centre
- Workplace Safety North
- Workplace Safety & Prevention Services
- Workplace Safety and Insurance Board

Other sources of information on heat stress can be found in the list of additional resources from various sources at the bottom of the Heat Stress Toolkit page.

Heat Stress Prevention & Control Program

Version **1.0**

Date: **03.24.2024**

Version History

Version	Approved by	Revision Date	Description of Change	Author
1.0				

	Name	Title	Date
Prepared by			
Approved by			

1. NAME OF PROCEDURE

Heat Stress Prevention & Control Program

2. PURPOSE

The goal of this document is to outline the responsibilities and procedures to protect workers from heat stress and prevent heat-related illnesses.

3. REFERENCES

Compliance with the latest version (currently 2022) of the American Conference of Governmental Industrial Hygienists (ACGIH) Heat Stress and Strain Threshold Limit Value (TLV®) and its Documentation are considered underlying basis for this SOP.

4. DEFINITIONS (Key Terms)

Acclimatization: the body's ability to "get used to" working in hot conditions. Since sweating is the main method the body uses to cool itself, acclimatization actually involves the gradual change in sweat rate (sweat more quickly) and the content of the sweat (less electrolytes are lost when you sweat efficiently). Dehydration can eliminate the benefits of acclimatization. In Ontario, weather conditions seldom reach the levels that allow the body to maintain acclimatization to heat stress conditions. Only if workers are exposed to extra heat/humidity sources (like very hot ovens, steam, molten metal/glass, etc.) would it be possible to be considered acclimatized in Ontario. The ACGIH stipulates that a person can be considered acclimatized after being exposure to heat stress for at least 2 continuous hours, for 5 of the last 7 days.

ACGIH: American Conference of Governmental Industrial Hygienists

Core body temperature: is the temperature inside your body (normal core body temperature is 37°C); heat stress programs are designed to keep the body's core temperature below 38°C.

Heat stress: is the body's exposure to heat. There are two sources of heat stress, one is the heat in the environment, the other is the heat the body generates when it does work (70% of the energy used by the body to function turns into internally generated heat).

Heat strain: is the effect of heat stress (external and internal) on the body which results in the list of symptoms and health effects described below.

Humidex: is a measure created by Environment Canada that considers not just temperature but also the effect of relative humidity. The Humidex provides the temperature that it "feels like" when you take the humidity into account.

Metabolic rate: is the rate at which the body uses stored energy (digested food) to perform work. For heat stress it is important to realize that when the body uses its energy reserves to do work, 70% of the energy gets changed into heat (our bodies are not very energy efficient work machines).

Radiant heat: is the heat that radiates from hot surfaces and from the sun; radiant heat is an additional factor in heat stress over and above the temperature in the general environment.

Relative humidity: is a measure of how much moisture there is in the air. The higher the relative humidity the harder it is for sweat to evaporate (and the hotter you feel).

Time Weighted Average (TWA): is the weighted average of the different measurements based on an overall time frame of 1 hour calculated as follow:

TWA = measurement1* (minutes at location1/60) + measurement2* (minutes at location2/60) + …

Wet Bulb Globe Temperature (WBGT): is the "official" method of measuring heat stress. WBGT stands for wet bulb globe temperature. The ACGIH has two equations to calculate the WBGT:

WBGT (indoors/shade) = 70% wet bulb temperature + 30% globe temperature

WBGT (outdoors in sun) = 70% wet bulb temperature + 20% globe temperature + 10% dry bulb temp

The ACGIH standard has a table of WBGT criteria which should protect "most" workers who are "healthy and well-hydrated" from experiencing heat stress symptoms or health effects.

Health Hazards and Risks

Heat stress symptoms are a set of natural signals telling you that something needs to be done to balance your body's heating and cooling. As your body heats up, it tries to rid itself of excess heat through the evaporation of sweat. If it is unable to cool itself this way, your body temperature will increase. The following are heat stress symptoms and illnesses:

Heat rash: early in the heat stress season before the body can get used to sweating efficiently, rashes can develop on the skin as sweat pores get clogged. The skin becomes reddened and may itch, feel prickly or hurt.

Heat syncope: or fainting also often happens early in the heat stress season but can also happen later on. Usually, it happens when the person is in a static position (sitting, standing in one place) and then suddenly gets up or moves. While the person was stationary, blood pooled in the lower regions of the body and when they moved there is a lack of blood in the head which causes dizziness, feeling light-headed and perhaps nauseous, then the person may faint.

Dehydration: is when the body doesn't have sufficient water to function normally. This can lead to various symptoms including headache, fatigue, etc. Waiting until you feel a thirst is insufficient to keep adequate hydration. The colour of your urine can indicate how hydrated you are (the lighter colour, the better).

Hyponatremia: happens when you drink too much water causing your blood sodium levels to get too low. Symptoms include headache, fatigue, irritability, muscle weakness/cramps.

Heat cramps: happen when the body's muscle reserves get exhausted. The symptoms include cramping of either the muscles you're using to work (e.g., arms, legs) or other muscles like in the stomach region (or both).

Rhabdomyolysis (Rhabdo): is a medical condition that is caused by breakdown of muscle tissue. Symptoms include muscle cramps/pain, abnormally dark urine, weakness and exercise intolerance (it can be diagnosed with medical tests). In the long term it can cause damage to the heart and kidneys.

Heat exhaustion: is a gradual depletion of the body's ability to manage heat stress. Symptoms include nausea, dizziness, weakness headache, blurred vision, and profuse sweating (sweat dripping from the body). If preventive action is not taken, this can progress into heat stroke.

Heat stroke: occurs when the body's temperature management system fails. The core temperature exceeds 40°C, and the body stops sweating (shut down of the heat regulation system). As the body temperature increases the brain overheats and the person may appear confused and act quite outside of normal character. At this point the person can no longer be trusted to manage their condition, you need to intervene and get them to emergency medial care as soon as possible. If not, they could die.

Chronic effects: chronic exposure to heat strain can affect both the male and female reproductive systems making it harder to conceive. Chronic heat strain can also have effects on the heart and kidneys, disturb sleep patterns and affect mental health.

5. RESPONSIBILITIES

Employer: legally the employer is responsible for doing everything reasonable in the circumstances to protect the worker. With respect to heat stress, the Ministry of Labour has interpreted this obligation to mean that the workplace should comply with the requirements of the ACGIH Heat Stress TLV. The Ontario OHS Act also requires employers to consult with workers through the JHSC or worker H&S representatives when protecting workers from workplace hazards. The employer is also responsible to appoint competent supervisors, meaning supervisors who are aware of the hazards in the workplace and know how to control worker exposures to those hazards. The employer needs to establish a heat stress response plan, ensure that it meets the TLV requirements, appoint competent people to administer the plan, and regularly review the performance to ensure that all persons are carrying out their duties under the plan. The employer is also responsible for providing the resources for the controls necessary to manage heat stress in the workplace (e.g., heat barriers, ventilation, ergonomic changes to reduce metabolic heat, adequate water, first aid, emergency plans, etc.) and direct supervisors to use the necessary administrative controls (work/rest regimens) to prevent worker heat strain.

Supervisors: are required by law to be competent, meaning they have the knowledge, training and experience to be able to: organize the work in such a way that workers work in compliance with regulations; ensure that workers use any equipment, protective devices or clothing the employer requires; ensure that workers know about all the workplace health and safety hazards; provide workers with written instructions on measures and procedures to be followed for their own protection; and to take every precaution reasonable in the circumstances to protect workers. Thus, with respect to heat stress, supervisors need to ensure the workers whom they are responsible for, all know the signs and symptoms of heat stress. They also need to ensure they have sufficient access to water to ensure good hydration and support them in maintaining the ability to work without experiencing these symptoms. They need to encourage workers to report their heat stress symptoms or those of others they observe having problems with heat exposure.

Workers: need to be aware of the signs and symptoms of heat stress and know what to do to prevent them. In heat stress conditions, they need to watch out for each other as well since in some heat stress conditions (i.e., heat stroke) the individual experiencing this condition is not able to look after themselves. Workers need to notify their supervisor/health and safety rep if they are experiencing any heat stress symptoms or see others who are not doing well. Workers need to make sure they stay well-hydrated.

6. PROCEDURE

When hot weather arrives or when workplace processes that emit heat and/or humidity expose workers to heat strain, the following procedures will be followed:

1. **Training:** all workers and their supervisors will be provided "verbal and written instructions for pre-job and annual training programs with information about heat stress and strain, heat disorders, mitigation plan, and emergency response plan in a language and format that is understood by workers and supervisors." During episodes of hot weather and/or intense exposures, reminders will be given to exposed workers to reinforce personal and fellow worker symptom monitoring and heat strain prevention practices and procedures. It is important that all workers can recognize the early signs and symptoms of heat stress to prevent more serious heat illnesses. Workers need to adjust their work pace, take frequent breaks in shaded or cooler areas, and stay hydrated by drinking water regularly. Supervisors also need to be able to recognize when a worker is experiencing heat-related symptoms and know what to do to support them.

2. **Threshold Environmental Conditions Triggering Monitoring:** The trigger environmental conditions initiating measurements may be any of the following: (1) if there are reports of heat-related discomfort or other symptoms; (2) judgment based on past experience suggesting heat stress conditions; or (3) the Humidex reaches 30°.

3. **Measurements:** For work areas where there is significant process radiant heat and/or humidity sources (steam, circulation of large quantities of water) the preferred measurements are Wet Bulb Globe Temperature (WBGT) measurements taken within 10m (30') of the exposure (the closer to the exposed worker the better). For workstations where weather conditions are the main source of external heat exposure temperature and relative humidity measurements taken within the work zone are sufficient. Measurements should be taken at least once per hour during heat stress conditions and be recorded.

4. Temperature and relative humidity measurements can be converted either to Humidex using the chart in Appendix 1, or else to Estimated WBGT using the chart in Appendix 2. If the work takes place at distinct locations with differing heat levels, a time weighted average (TWA) over one hour can be calculated. WBGT measurements can be used directly after applying the clothing adjustment values.

5. **Clothing Adjustment Values** are to be added to the measurement according to the table in Appendix 3. These values are to be added to the Humidex, or else to the Estimated WBGT

6. **Work in Direct Sunlight:** for work taking place in direct sunlight add 4° Humidex to the Humidex from Appendix #1; or else, add 2°C WBGT to the Estimated WBGT value from Appendix #2. If there is cloud cover or partial shade, one can pro-rate these additions by the ratio compared to direct sun exposure (e.g., use 50% of the value if cloud cover is 50%).

7. Compare the Adjusted Humidex or the Adjusted Estimated WBGT to the following criteria:

NEVER IGNORE ANYONE'S SYMPTOMS REGARDLESS OF ANY MEASUREMENT!

Adjusted* Humidex	Response	Effective** WBGT (°C)
25 - 29	supply water to workers on an "as needed" basis	⇠ 23.0°C
30 - 33	post Heat Stress Alert notice; encourage workers to drink extra water; start recording hourly temperature and relative humidity	23.1 – 24.0°C
34 - 37	post Heat Stress Warning notice; notify workers that they need to drink extra water; ensure workers are trained to recognize symptoms	24.1 – 25.0°C
38 - 39	work with 15 minutes relief per hour can continue; provide adequate cool (10-15°C) water; at least 1 cup (240 mL) of water every 20 minutes worker with symptoms should seek medical attention	25.1 – 26.0°C
40 - 41	work with 30 minutes relief per hour can continue in addition to the provisions listed previously	26.1 – 27.0°C
42 - 44	if feasible, work with 45 minutes relief per hour can continue in addition to the provisions listed above	27.1 – 29.0°C
45*** or over	only medically supervised work can continue	29.1°C*** or over

* "adjusted" means adjusted for additional clothing and radiant heat **(see steps #4 and #5)**

** "Effective" means adjusted for clothing **(step #4)** if the WBGT includes the globe temp

***at Humidex above 45 (29.0°C WBGT), heat stress to be managed as per the ACGIH TLV®

8. Since there is no medical supervision available, all work shall stop when the adjusted Humidex exceeds 45; or when the adjusted WBGT Estimate exceeds 29.0°C.

7.EQUIPMENT

Temperature and relative humidity can be measured with a thermal hygrometer which has an accuracy of at least ±0.5°C and ±5%. The accuracy of the hygrometer should be checked at least annually against calibrated measures of temperature and relative humidity.

WBGT must be measured with equipment that has an actual wet bulb (using distilled water) and an actual globe and operated according to manufacturer's specification and calibrated annually. The person taking the measurement shall ensure the machine has reached equilibrium with the environment before recording the values.

8. CONTROLS

The Hierarchy of Controls should be considered at all steps along the process:

Elimination/substitution controls

• Dehumidification, air conditions, process changes, etc.

Engineering controls

- Barriers, insulation, ventilation, etc.
- Ergonomic optimizations to reduce metabolic demands

Administrative controls

- Work/rest regimens, rotation, etc.
- Supply of water, first aid, buddy system

Personal Protective Equipment

- Personal cooling equipment

Emergency response

- Internal and external process in response to syncope, heat stroke, unmanageable symptoms

9. RESOURCES

Heat Stress Awareness Guide

Humidex-Based Heat Stress Calculator and Plan

10. DISTRIBUTION

The following persons shall be required to review this SOP on at least an annual basis:

1. All supervisors responsible for workers working under heat stress conditions
2. All JH&SC members and H&S representatives
3. All managers and senior leadership

11. REVISION DESCRIPTIONS

REV ID	DATE	REVISED BY	DESCRIPTION	APPROVED/REVIEWED BY

12. APPENDICES

APPENDIX	TITLE	DESCRIPTION
Annex #1	Humidex chart	
Annex #2	Estimated WBGT chart	Thomas Bernard reference
Annex#3	Clothing Adjustment Values	

13. REVIEW AND APPROVAL SIGNATURES

REV ID	DATE	REVISED BY	DESCRIPTION	APPROVAL SIGNATURE

Annex 1: Humidex Conversion Table

For work in **direct sunlight**, add 4 °C to the Humidex value from the table

Adjusted* Humidex	Action
45+**	only medically supervised work
42 - 44	75% relief
40 - 41	50% relief
38 - 39	25% relief
34 - 37	warning & double water
30-33	alert & water
25-29	water as needed

NEVER IGNORE ANYONE'S SYMPTOMS DESPITE YOUR MEASUREMENTS!

Relative Humidity (in %)

Temp (in °C)	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	Temp (in °C)
49																			50	49
48																			49	48
47																		50	47	47
46																		49	46	46
45																	50	47	45	45
44																	49	46	43	44
43																49	47	45	42	43
42															50	48	46	43	41	42
41															48	46	44	42	40	41
40														49	47	45	43	41	39	40
39													49	47	45	43	41	39	37	39
38												49	47	45	43	42	40	38	36	38
37											49	47	45	44	42	40	38	37	35	37
36									50	49	47	45	44	42	40	39	37	35	34	36
35								50	48	47	45	43	42	40	39	37	36	34	33	35
34							49	48	46	45	43	42	40	39	37	36	34	33	31	34
33					50	48	47	46	44	43	41	40	39	37	36	34	33	32	30	33
32			50	49	48	46	45	44	42	41	40	38	37	36	34	33	32	30	29	32
31	50	49	48	47	45	44	43	42	40	39	38	37	35	34	33	32	30	29	28	31
30	48	47	46	44	43	42	41	40	39	37	36	35	34	33	31	30	29	28	27	30
29	46	45	43	42	41	40	39	38	37	36	35	33	32	31	30	29	28	27	26	29
28	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	28
27	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24		27
26	39	38	37	36	35	34	33	33	32	31	30	29	28	27	26	25	24			26
25	37	36	35	34	33	33	32	31	30	29	28	27	26	26	25	24				25
24	35	34	33	33	32	31	30	29	28	28	27	26	25	24						24
23	33	32	31	31	30	29	28	28	27	26	25	24	24							23
22	31	30	30	29	28	27	27	26	25	25	24									22
21	29	29	28	27	26	26	25	24	24											21
	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	

Relative Humidity (in %)

* "adjusted" means adjusted for additional clothing and radiant heat (see steps 2 & 5)

** above a humidex of 45 use the ACGIH Heat Stress/Strain TLV

Annex 2: Estimated WBGT Conversion Table

T_{air} (in °C)	Relative Humidity (in %)																			T_{air} (in °C)
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	
43																31.0	29.9	28.8	27.7	43
42															31.3	30.3	29.2	28.1	27.1	42
41														31.6	30.6	29.5	28.5	27.5	26.5	41
40														30.8	29.8	28.8	27.8	26.8	25.8	40
39													31.0	30.0	29.1	28.1	27.1	26.2	25.2	39
38												31.1	30.2	29.2	28.3	27.4	26.4	25.5	24.6	38
37											31.2	30.3	29.4	28.5	27.5	26.6	25.7	24.8		37
36										31.2	30.3	29.4	28.5	27.7	26.8	25.9	25.0	24.2		36
35									31.1	30.3	29.4	28.6	27.7	26.9	26.0	25.2	24.3			35
34								31.0	30.2	29.4	28.5	27.7	26.9	26.1	25.3	24.5				34
33						31.6	30.8	30.0	29.2	28.5	27.7	26.9	26.1	25.3	24.5					33
32				31.6	31.2	30.6	29.8	29.1	28.3	27.5	26.8	26.0	25.3	24.5						32
31	31.0	31.0	30.9	30.5	30.1	29.5	28.8	28.1	27.4	26.6	25.9	25.2	24.5							31
30	30.0	30.0	29.8	29.5	29.1	28.5	27.8	27.1	26.4	25.7	25.0	24.4								30
29	29.0	29.0	28.8	28.5	28.1	27.5	26.8	26.2	25.5	24.8	24.2									29
28	28.0	28.0	27.8	27.5	27.0	26.5	25.8	25.2	24.6											28
27	27.0	27.0	26.8	26.4	26.0	25.4	24.8	24.2												27
26	26.0	26.0	25.8	25.4	24.9	24.4														26
25	25.0	25.0	24.8	24.4																25
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	
	Relative Humidity (in %)																			

For work in **direct sunlight** add 2° C to the WBGT value from the table

Annex 3: Clothing Adjustment Values

ACGIH Clothing Adjustment Values	° C WBGT	Humidex
Short sleeves and pants of woven material	-1.0	-2
Work clothes (long sleeve shirt and pants)	0.0	0
Cloth (woven material) coveralls over underwear	0.0	0
Thin disposable SMS polypropylene coveralls over underwear	+0.5	+1
Disposable polyolefin (Tyvek) coveralls over underwear	+1.0	+2
Adding a hood (full head and neck covering; not face)	+1.0	+2
Double layer woven clothing (e.g. coveralls over work clothes)	+3.0	+6
Limited-use vapour barrier coveralls with hood	+11.0	+22

Derived Clothing Adjustment Values	° C WBGT	Humidex
Impervious gloves	+0.2	+0.4
Impervious apron	+0.3	+0.6
Additional protective sleeves	+0.2	+0.4
Leather welding jacket	+1.5	+3.0
Medical mask	+0.05	+0.1
N95 disposable respirator	+0.1	+0.2
Half face piece elastomeric demand respirator	+0.2	+0.4
Ear muffs	+0.1	+0.2
Toque	+0.6	+1.2
Hard hat	+0.2	+0.4
Goggles	+0.1	+0.2
Face shield	+0.1	+0.2
Woven fabric hospital gown	+1.5	+3.0