Managing Physical Hazards

Lecture Title:
Thermal Hazards: Heat Stress, Cold Stress, and Thermal Comfort

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Undergraduate Diploma in
Occupational Health and Safety

Welcome and Objectives

This lecture explores heat illness, cold-related injuries, and environmental monitoring techniques including WBGT and metabolic load assessment.

Students learn preventive strategies (hydration, acclimatisation, work-rest cycles), thermal comfort parameters, and control measures in indoor and outdoor environments.

What do we mean by Thermal hazards?

Thermal hazards refer to any environmental or work-related conditions that expose individuals to excessive heat or cold, causing the body to struggle to maintain a stable internal temperature.

They arise when thermal energy (heat or cold) is transferred between the body and the environment. Can lead to heat stress (e.g., heat exhaustion, heat stroke) or cold stress (e.g., hypothermia, frostbite).

Part A — Welcome, Module Roadmap & Transition from Risk Management

Lecture 1 — Introduction to Physical Hazards & Regulatory Frameworks
Lecture 2 — Measurement & Monitoring Techniques for Physical Hazards
Lecture 3 — Noise & Vibration Hazards: Exposure, Measurement & Control
Lecture 4 — Thermal Hazards: Heat Stress, Cold Stress, and Thermal Comfort
Lecture 5 — Radiation Hazards: Ionising and Non-Ionising
Lecture 6 — Lighting, Visibility, and Workplace Ergonomics
Lecture 7 — Machinery, Mechanical Hazards & Machine Safeguarding
Lecture 8 — Workplace Environment Hazards: Slips, Trips, Falls, and Confined Spaces
Lecture 9 — Integrated Physical Hazard Management & Continuous Improvement
Lecture 10 — Physical Hazard Control Strategies: Engineering, Administrative & PPE

This module focuses on physical agents and their technical, physiological, and legal considerations

What do we mean by Thermal hazards?

The thermal environment is determined by several factors:

1. **Air Temperature**: The ambient temperature in the workplace.
2. **Radiant Heat**: Heat emitted from hot surfaces, machinery, or sunlight.
3. **Air Movement (Velocity)**: How fast air moves around the worker, influencing heat loss through convection.
4. **Humidity**: The amount of moisture in the air, which affects sweat evaporation and cooling.
5. **Clothing Insulation**: The type and amount of clothing worn by workers, which impacts heat retention.
6. **Metabolic Heat**: Heat generated by the body during physical activity

Why It Matters

1. Affects Core Body Function
2. Impairs Cognitive & Physical Performance
3. Raises the Likelihood of Accidents
4. Reduces Productivity & Work Capacity
5. Creates Legal & Compliance Risks

Introduction & Maltese Legal Framework

Setting the Stage

1. Thermal hazards include heat stress, cold stress, and thermal comfort issues.
2. High summer temperatures in Malta increase occupational heat stress risks.
3. Cold stress relevant in Malta in cold storage, warehousing, pharmaceuticals, food industry.
4. Today's session links thermal physiology, risk assessment, and legal obligations in Malta.

Maltese OHS Legal Requirements

Core Maltese Legislation

1. Occupational Health & Safety managed under the Occupational Health and Safety Authority Act (Cap. 646) and supporting subsidiary legislation.
2. Malta follows the EU preventive approach, requiring employers to take necessary measures to safeguard worker safety

Maltese OHS Legal Requirements

Subsidiary Legislation Impacting Thermal Hazards

1. S.L. 646.08: Work place (minimum health and safety requirements) Regulations: Obligates employers to maintain safe workplace temperatures and adequate ventilation.

2. S.L. 646.11: General Provisions for Health and Safety at workplaces Regulations

3. S.L. 646.24: Work Equipment (Minimum Safety and Health Requirements Regulations

S.L. 646.08: Work Place (minimum health and safety requirements) Regulations

(1) It shall be the duty of the employer to maintain in every workplace inside buildings or other structures in which people are employed, a thermal environment which is reasonably practicable and comfortable, having regard to the working methods being used and the physical demands placed on the workers, other than for short periods, in conformity with accepted standards.

(2) The employer shall ensure that no person is employed for regular and prolonged work:

(a) in a thermal environment which is unsuitable for the type of work being carried out, or which may be harmful to health;

(b) where there is in use equipment or material which radiates intense heat or which causes intense cooling of the working environment and which is harmful to health, unless suitable and effective measures are taken to remove unnecessary risk or unless suitableand effective protective equipment or clothing and restfacilities are provided.

(3) The employer shall provide and maintain wherever necessary, fixed or movable screens, deflectors or other suitable devices in order to protect the worker against intense cold or heat.

(4) The employer shall ensure that no person is allowed to use any method of heating or cooling which is to be harmful to human health or which may liberate obnoxious or toxic fumes.

(5) The employer shall ensure that workplaces containing workstations are adequately thermally insulated, taking into consideration the type of undertaking involved and the physical activity of the workers.

(6) The employer shall ensure that the temperature in rest areas, rooms for duty staff, sanitary facilities, canteens and first aid rooms is appropriate to the particular purpose of such areas.

(7) Where windows, skylights and glass partitions are installed, they should allow excessive effects of sunlight in workplaces to beavoided, having regard to the nature of the work and the workplace.

What does the law stay? (1)

1. Providing a safe and healthy workplace.
2. Establishing and maintaining a health and safety program.
3. Ensuring workers are trained or certified, as required.
4. Reporting accidents and cases of occupational disease to the appropriate authority.
5. Providing workers with health and safety information.
6. Providing the workers with appropriate first aid services.
7. Ensuring that personal protective equipment is available and in good condition.
8. Supporting supervisors in their health and safety activities.
9. Evaluating health and safety performance of supervisors

What does the law stay? (2)

10. Instructing workers to follow safe work practices
11. Enforcing health and safety regulations
12. Correcting unsafe acts and unsafe conditions
13. Ensuring that only authorized, adequately trained workers operate equipment
14. Reporting and investigating all accidents/incidents
15. Inspecting own area and taking remedial action to minimize or eliminate hazards
16. Ensuring equipment is properly maintained
17. Promoting safety awareness among workers

What does the law say?

Employer commitment to preventing work related injury/illness in the workplace.

Responsibilities

- Employer: to maintain a safe and healthy work place
- Employee: to work safely following safe work practices
- Supervisor: to ensure that safe and healthy work conditions are maintained in assigned work area.

Maltese OHS Legal Requirements

2025 Administrative Instrument requires:

1. Hydration stations
2. Cooling/shaded rest areas
3. High Sun Protection Factor sunscreen
4. Prohibition of shirtless working
5. Light coloured protective clothing
6. Mandatory risk assessment when temperatures reach 40°C

Administrative Instrument No2 of 2025
https://ohsa.mt/legislation

How to do a Risk Assessment?

1. Determine hazards and evaluate risks
2. Use all relevant available data
3. Determine controls needed to minimise those risks
4. Document the assessment
5. Agree it with your supervisor
6. Use those control measures

The risk assessment should include

1. All stages of work cycles and the range of temperature and humidity under which the tasks are performed
2. The range of clothing worn during tasks
3. Major changes in physical activity level
4. Occasional tasks such as cleaning and maintenance of hot equipment and cold areas, and renewal of hot or cold insulation.
5. Where assessment shows that the workers could be at risk from heat stress.
6. employers should, if practicable, eliminate the need for work in hot conditions or if elimination is not practicable, take measures to reduce the thermal load from the environment.

Also….

7. If the residual risk of heat stress remains even after all the control measures have been taken place, workers should be adequately supervised, so that they can be withdrawn from the hot conditions if heat stress symptoms occur.

Also….

8. If the assessment shows that the workers could be at risk from exposure to cold, the employers should, if practicable, eliminate the need for work in cold conditions (ex: by rescheduling work to be performed during warmer weather, or by moving the work from outdoors to indoors, or separating the cold parts of a process from the workers, as far as practicable)

9. If elimination of such work is impracticable, employers should introduce other control measures to reduce risk from cold conditions.

Protection for COLD weather

- Employers should provide:

❖Facilities for warming hands

❖Tools with insulated handles

❖Measures to ensure that the bare hand does not touch surfaces below -7 deg C

❖Measures to ensure that the bare skin does not touch liquids below 4 deg C

❖Appropriate measures to be taken in the event of insulating clothing getting wet

❖Face and eye protection as appropriate for outdoor work and working in snow. (e.g safety goggles against the glare)

Training for workers and supervisors

1. To recognise symptoms that could lead to heat stress or hypothermia and the steps to be taken to prevent onset or emergencies
2. In the use of rescue and first-aid measures
3. To recognise importance of drinking sufficient quantities of liquid and the dietary requirements providing intake of salt and potassium and other elements that are depleted due to sweating.

What do you think it is thermal environment?

The term “thermal” describes a person’s state of mind in terms of whether they feel TOO HOT or TOO COLD

Which are those “environmental factors” that influence your “thermal comfort”?

1. Conditions around us that affect how hot or cold we feel
2. Combination of air temperature, humidity, air movement, and radiant heat
3. Influences worker comfort, performance, and safety
4. Key part of managing heat stress and cold stress in the workplace
5. Varies with clothing, workload, and individual factors

What is Thermal Comfort?

1. Thermal comfort is the condition of mind in which a person feels neither too hot nor too cold — basically, you feel comfortable with the surrounding thermal environment.
2. Thermal Comfort IS NOT measured by room temperature, BUT by the number of employees complaining of thermal discomfort.
3. Thermal comfort is subjective and depends on how people feel in the environment, not just the physical measurement of air temperature

What is Thermal Comfort?

Thermal Comfort Fundamentals

1. Air Temp.
2. Radiant Temp.
3. Air Velocity
4. Humidity
5. Clothing insulation (CLO value)
6. Metabolic heat (MET value)

What is Thermal Comfort?

Thermal Comfort Indices

1. **WBGT (Wet Bulb Globe Temperature):**
    - Used for heat stress assessment.
    - Drives work–rest cycles.

3. **Heat Index**, Humidex (simpler environmental indicators).

Thermal Environment Measurement (WBGT)

Instruments

WBGT meters (indoor/outdoor with solar load)

Infrared thermometers (surface temperature)

Key Concepts

1. Natural wet bulb, dry bulb, globe temperature
2. Calculation of WBGT indoors/outdoors
3. Limitations: clothing correction factors, low airflow conditions

Wet Bulb Globe Temperature

1. WBGT) is an index used in Health, Safety, and Environment (HSE) to assess heat stress risk in workplaces, especially where workers are exposed to hot environments.

2. What WBGT Measures?

WBGT combines several environmental factors that affect heat stress:

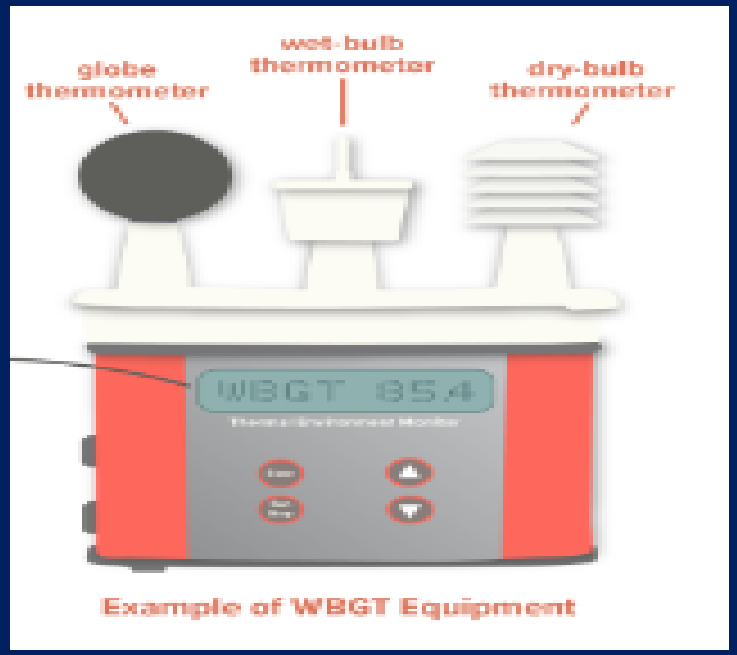
- Air temperature (dry bulb)
- Humidity (via wet bulb temperature)
- Radiant heat (via globe temperature)
- Air movement

It gives a single value that reflects the combined thermal load on the human body

Wet Bulb Globe Temperature

Typical WBGT Thresholds

1. < 25°C → Low risk
2. 25–28°C → Moderate risk
3. > 28°C → High risk (controls needed)
4. 31–33°C → Very High
5. > 33°C → Extreme



Wet Bulb Globe Temperatures (WBGT) meters

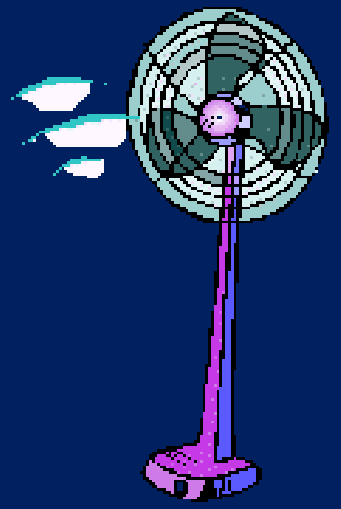
Infrared thermometers

Generation of body heat

- There are two main ways in which our bodies produce heat:

1. Metabolic Heat: the body generates heat through the digestion of food, work and exercise.
2. Environmental Heat: body absorbs heat from the surrounding environment, whether it is the hot sun or a hot room.

The body's cooling system



- **There are three methods in which our bodies can be cooled.**

1. **Convection** - is the transfer of heat through the circulation of air.
2. **Evaporation** - process which occurs when a liquid changes into a vapor.
3. **Radiation** - heat is naturally emitted from the body surface.

Conditions affecting the cooling system

1. Acclimation - the biological process through which our bodies adapt to the environment: basically getting used to the heat.
2. Air Temperature - heat flows from warmer objects to cooler objects.
3. Air Movement - moving air speeds the evaporation process.
4. Humidity - the amount of water vapor in the air affects the rate of evaporation.
5. Clothing - the type of clothing affects the amount of heat our bodies absorb and retain.

Heat Stress

Heat Stress Physiology

1. Body heat balance = metabolic heat + environment.
2. Key stressors: air temp, radiant heat, humidity, metabolic work rate.
3. Cooling mechanisms: sweating, vasodilation, evaporation.
4. Failure of these mechanisms → heat disorder progression.

Heat illnesses

Heat Illnesses

1. Heat rash (blocked sweat ducts).
2. Heat cramps (electrolyte imbalance).
3. Heat exhaustion (heavy sweating, dizziness, nausea).
4. Heat stroke: medical emergency; high core temp; confusion; loss of consciousness.

Heat Illness Progression Table

Stage	Signs	Urgency
Heat rash / cramps	Sweating, muscle spasms	Low
Heat Exhaustion	Dizziness, nausea, heavy sweat	Medium
Heat Stroke	Confusion, Collapse, No Sweating	Emergency

Heat (Fainting), Heatstroke, Heat Exhaustion

Heat Stress
Risk Factors

1. High ambient temperatures (≥35°C).
2. High humidity reduces evaporative cooling.
3. Intense workloads + heavy PPE.
4. Poor hydration, poor acclimatisation.
5. Individual sensitivity.

Heat Stress
Engineering Controls

1. Air conditioning / evaporative cooling systems.
2. Local ventilation and extraction.
3. Radiant heat barriers and reflective shielding.
4. Insulation of hot surfaces.
5. Reduce heat load at source (equipment upgrades, insulation).

Heat Stress
Administrative Control

1. Work–rest cycles based on WBGT.
2. Job rotation during peak heat.
3. Hydration policies (timed drinking).
4. Acclimatisation programmes (5–14 days).
5. Schedule heavy work during cooler hours.

Heat Stress

PPE for Heat Exposure

1. Cooling vests.
2. Breathable clothing.
3. Light-coloured protective garments

Cold Stress

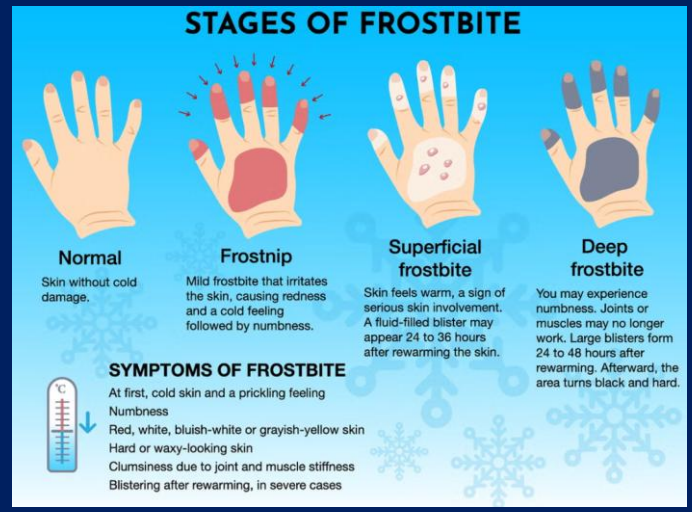
Cold Stress Environments

1. Freezer rooms / cold storage.
2. Food processing and distribution.
3. Pharmaceutical warehouses.
4. Outdoor winter work (rare in Malta but still possible at night/early morning).

Cold Stress

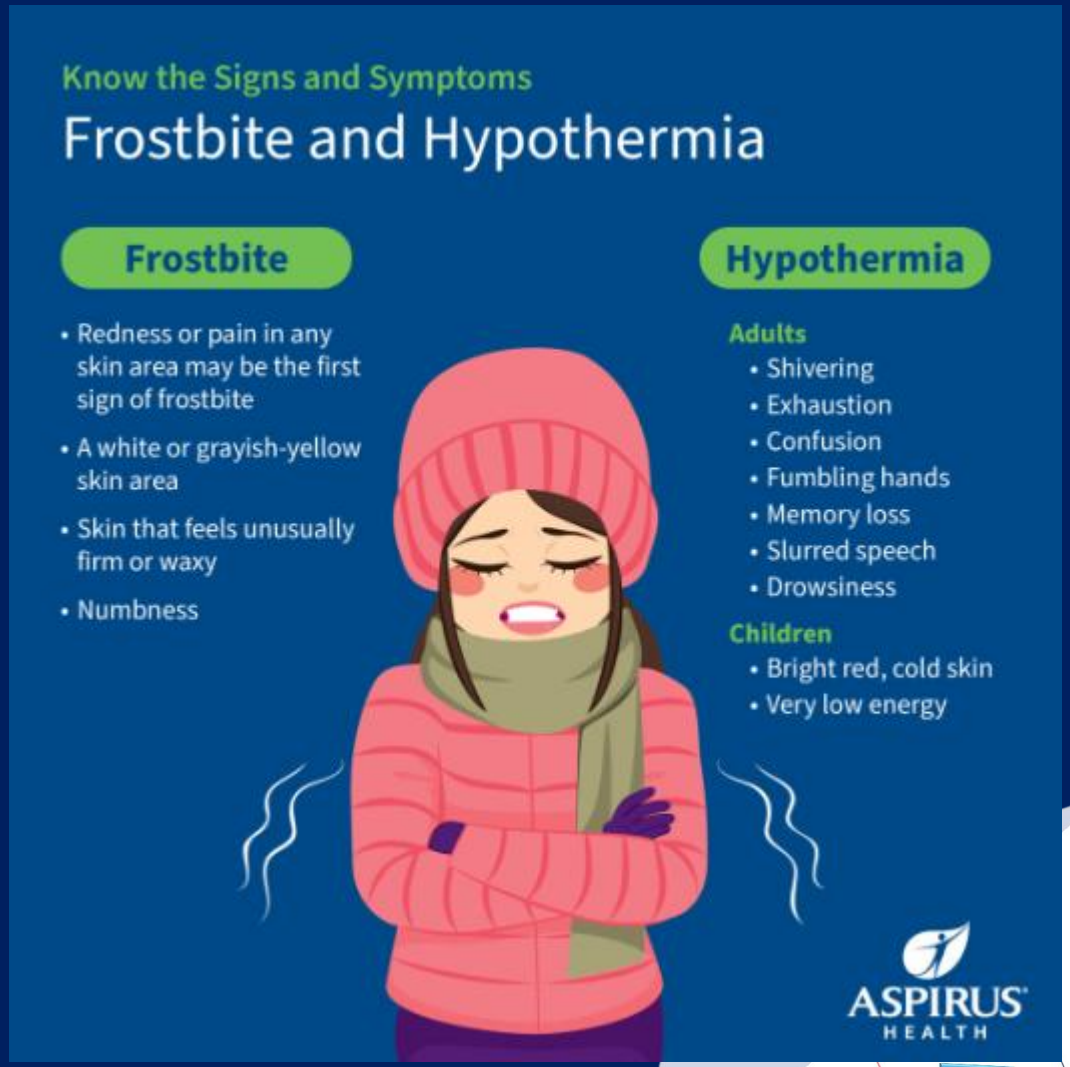
Cold-Related Health Effects

1. Frostnip: early reversible cold damage.
2. Frostbite: tissue freezing.
3. Hypothermia: drop in core temperature.
4. Loss of dexterity & slowed reaction time.
5. Risk of human error and accidents.



Warning Signs of Hypothermia
?
Confusion
Shivering

Difficulty Speaking
zzz...
Sleepiness
Stiff Muscles


Know the Signs and Symptoms
Frostbite and Hypothermia
Frostbite
• Redness or pain in any skin area may be the first sign of frostbite
• A white or grayish-yellow skin area
• Skin that feels unusually firm or waxy
• Numbness
Hypothermia
Adults
• Shivering
• Exhaustion
• Confusion
• Fumbling hands
• Memory loss
• Slurred speech
• Drowsiness
Children
• Bright red, cold skin
• Very low energy
ASPIRUS HEALTH

Cold Stress Progression

Stage	Signs	Urgency
Mild	Shivering, tingling	Low
Moderate	Clumsy movements, confusion	Medium
Severe	No shivering, collapse	Emergency

Cold Stress

Controls for Cold Stress

Engineering:

1. Heated rest stations.
2. Radiant heaters or warm-air blowers.
3. Insulated floors or platforms.

Administrative:

1. Exposure time limits.
2. Work–warm-up scheduling.
3. Cold stress awareness training.

PPE:

1. Thermal gloves, boots, layered clothing, head insulation

Instrumentation for Cold Env?

The equipment used is typically a set of instruments, not one device, and includes:

1. Thermometer (air temperature)
2. Anemometer (wind speed)
3. Hygrometer (humidity)
4. Globe thermometer or radiometer (radiant heat)

- These measurements are then used to calculate IREQ, which tells you how much clothing insulation is needed to maintain thermal balance.

So, the method is called IREQ assessment (ISO 11079)

IREQ = The amount of clothing insulation (in clo units) required to maintain thermal equilibrium under given environmental and activity conditions.

Assessment Steps

1. Measure environmental parameters (temperature, wind speed, humidity).
2. Estimate metabolic rate based on activity.
3. Calculate IREQ using ISO 11079 formulas or software tools.
4. Compare IREQ with actual clothing insulation (measured in clo).

If clothing insulation Clo < IREQ → cold stress risk.

Case Scenario

HEAT CASE 1

Roofer Dies from Heat Stroke (OSHA Case Study)

What happened

A 42-year-old roofer, only three days into a new job, worked in moderate heat (30°C). He complained of feeling hot and sick, climbed off the roof, and sat alone in direct sun. Minutes later, coworkers found him unresponsive with heat stroke. He later died in hospital.

Root causes

1. No acclimatisation plan for new workers
2. Worker left alone after reporting symptoms
3. Lack of structured rest breaks
4. Exposure underestimated because temperatures were not “extreme”

Heat - Case Studies | Occupational Safety and Health Administration

HEAT CASE 1

Roofer Dies from Heat Stroke (OSHA Case Study)

Key learnings

1. Acclimatise all new workers for 1–2 weeks
2. Never leave a symptomatic worker alone — immediate first aid is critical
3. Moderate temperatures can still kill when workload + humidity + PPE contribute
4. Have heat-response procedures and trained supervisors on site

HEAT CASE 2

Bakery Worker Fatality, Indoor Heat Source (2020 OSHA Investigation)

A newly hired bakery worker (only 2 days on the job) worked near industrial ovens operating at 288°C. Indoor heat index reached 41°C. He acted disoriented, repeatedly left the line, and was sweating heavily. After collapsing outside the building, emergency responders found his core temperature at 109°F. He died of heat-related hyperthermia.

Root causes

1. No heat-illness prevention training
2. Fans were removed that day due to COVID measures
3. Worker not acclimatized
4. High radiant heat + clothing (two smocks) increased heat load

Case Study - Heat Related Hazards - CMI

HEAT CASE 2

Bakery Worker Fatality, Indoor Heat Source (2020 OSHA Investigation)

Key learnings

1. Indoor heat sources (ovens, furnaces) can be deadlier than outdoor heat
2. Acclimatisation is essential, even for “simple” production jobs
3. Removing ventilation or fans without alternatives raises risk sharply
4. Supervisors must recognise erratic behaviour as an emergency signal
5. A workplace must have heat index/WBGT monitoring, especially near hot processes

Cold Case 1

Hypothermia in Workers Exposed to Cold Environments

A warehouse worker in a refrigerated storage area (~–1°C) worked a long shift with damp clothing due to condensation. After several hours, coworkers noticed the worker moving slowly, stumbling, and speaking unclearly. He was shivering initially, but eventually stopped shivering — a sign of moderate to severe hypothermia. He collapsed and required emergency medical assistance.

Root causes

1. Extended exposure to cold without adequate breaks
2. Wearing damp clothing (major accelerator of heat loss)
3. Task required continued manual handling with minimal movement breaks
4. No monitoring for cold-stress symptoms
5. Inadequate training on early hypothermia signs (e.g., confusion, loss of coordination)

Cold-related Illnesses in Workers | Cold Stress | CDC

Cold Case 1

Hypothermia in Workers Exposed to Cold Environments

Key learnings

1. Hypothermia can occur above freezing (even up to 10°C), especially when wet
2. Loss of coordination or slurred speech must trigger immediate removal from cold area
3. Warm-up breaks must be scheduled, not optional
4. Clothing must stay dry and layered, with waterproof outer garments
5. Cold-stress training must emphasise:

   Shivering stops = medical emergency

   Need for quick shelter, insulation, warm fluids, and emergency assistance

Cold Case 2

Worker in Cold Storage Develops Hypothermia During Extended Exposure

A worker in a refrigerated warehouse was assigned to repack goods in a cold room for several consecutive hours. The ambient temperature in such facilities is typically maintained below 0–4°C, and because of condensation in the work area, the worker's gloves and outer clothing gradually became damp.

Over the shift:

1. The worker initially experienced shivering, slowed movements, and fatigue.
2. Coworkers later noticed loss of coordination, stumbling, and disorientation — textbook signs of moderate hypothermia.
3. Eventually, the worker stopped shivering, became confused, and collapsed.

cpglover_1224.pdf

Cold Case 2

Worker in Cold Storage Develops Hypothermia During Extended Exposure

Root causes

1. Extended continuous exposure in a refrigerated environment
2. Wet/damp clothing, which increases conductive heat loss
3. Inadequate break schedule — no structured warm-up period
4. Insufficient training on early cold-stress symptoms such as shivering, confusion, and slowed speech
5. Lack of monitoring by supervisors despite clearly observable behavioural changes
6. No clothing-insulation (CLO) assessment to ensure adequate thermal protection

Cold Case 2

Worker in Cold Storage Develops Hypothermia During Extended Exposure

Key learnings

1. Hypothermia can occur above freezing temperatures
2. Shivering stopping is a severe warning sign
3. Damp clothing is a major hazard
4. Cold-stress risk increases when tasks require fine motor skills
5. Warm-up breaks must be scheduled (not optional)
6. Supervisors need cold-stress symptom training

Key Takeaways from the Four Case Scenarios

1. Acclimatisation is Critical — New Workers Are at Highest Risk
2. Moderate Temperatures Can Still Kill — Don’t Rely on “It’s Not That Hot”
3. Indoor Heat Sources Are Just as Dangerous as Outdoor Heat
4. Early Symptoms Were Ignored — Leading to Collapse and Fatality
5. Workers Must Never Be Left Alone After Reporting Symptoms
6. Clothing & PPE Can Increase Heat Load
7. Cold Stress Can Occur Above Freezing — Especially When Clothing Gets Wet
8. Shivering Stopping = Severe Hypothermia = Medical Emergency
9. Supervisory Awareness and Monitoring Were Insufficient
10. All Incidents Involved a Breakdown in the Hierarchy of Controls

International Standards Supporting Thermal Hazard Management

Heat Stress

ISO 7243 — WBGT Index

ISO 7933 — PHS (Predicted Heat Strain)

ACGIH TLVs for Heat Stress

ISO 9886 — Evaluation of thermal strain

Cold Stress

ISO 11079 — IREQ (Required Clothing Insulation)

ISO 15743 — Cold risk assessment

ISO 7243

Heat stress assessment using WBGT

Why it's essential

1. It is simple, fast, and widely accepted for heat hazard assessment.
2. Uses the Wet Bulb Globe Temperature (WBGT) index, which is the most common regulatory tool worldwide for determining when heat exposure becomes dangerous.
3. Ideal for real-world workplaces: foundries, kitchens, construction sites, outdoor work, warehouses.

ISO 7243

Heat stress assessment using WBGT

When it is most useful

1. For screening whether a heat hazard exists.
2. When you need a quick, defensible numerical threshold to trigger controls.
3. When performing compliance audits or inspections.

ISO 7243
Overview Methodology

Step1: Measure the 3 Required Environmental Temperatures

ISO 7243 requires specific instruments to collect:

- **Natural wet-bulb temperature (Tnw)**

– Represents the combined effect of humidity + air movement.

- **Black globe temperature (Tg)**

– Represents radiant heat load.

- **Air (dry) temperature (Ta)**

– Represents ambient air temperature.

These values are measured at head, torso, or working height depending on job posture.

ISO 7243
Overview Methodology

Step2: Calculate the WBGT Index

Different formulas are used depending on whether the work is indoors/outdoors with no solar load or outdoors with solar load.

1. Indoors / No Sun:
- WBGT = 0.7·Tnw + 0.3·Tg
2. Outdoors / Solar Load:
- WBGT = 0.7·Tnw + 0.2·Tg + 0.1·Ta

The weighting shows that humidity (Tnw) has the biggest contribution to heat stress.

ISO 7243
Overview Methodology

Step3: Determine the Metabolic Rate of the Work

Work intensity is categorized as:

1. Light
2. Moderate
3. Heavy
4. Very heavy

Each category correlates with expected metabolic heat production.

ISO 7243
Overview Methodology

Step4: Compare WBGT to Exposure Limits

Each metabolic rate has a maximum allowable WBGT value.

If the measured WBGT exceeds the recommended limit

→ Heat stress hazard exists→ Control measures (rest cycles, hydration, ventilation, PPE adjustments, job rotation) must be applied.

ISO 7243
Overview Methodology

Step5: Adjustments for Clothing

Some clothing increases heat stress.

ISO 7243 provides clothing correction factors (Clo values).

You add a correction value to the WBGT when clothing reduces heat dissipation.

ISO 7243
Overview Methodology

Summary of ISO 7243 Method

1. Measure Tnw, Tg, Ta
2. Calculate WBGT
3. Determine metabolic rate
4. Compare WBGT to ISO Exposure Limits
5. Apply clothing corrections
6. Decide on controls (work/rest cycles, engineering controls

ISO 11079
Cold stress assessment using IREQ

Why it's essential

1. It is the primary international standard for assessing risk in cold environments.
2. Uses the IREQ model (Required Clothing Insulation), which determines:
   - how long a worker can safely remain in a cold environment,
   - what clothing protection is required,
   - when cold exposure becomes hazardous.

ISO 11079 is a methodology standard, not a measurement protoco

ISO 11079

Cold stress assessment using IREQ

When it is most useful

1. Outdoor winter work (ports, construction, agriculture).
2. Cold storage, walk-in freezers, food logistics.
3. Any environment below ~10°C where cold stress is possible.

ISO 11079
Overview Methodology

Step1: Collect Key Environmental and Work Parameters

ISO 11079 requires measurement or estimation of:

Air temperature (Ta)

Mean radiant temperature (Tr)

Air velocity (Va)

Humidity (usually minor effect in cold)

Metabolic rate (M)

Clothing insulation (Clo)

ISO 11079
Overview Methodology

Step2: Calculate the IREQ Value

IREQ = Required Clothing Insulation to maintain the body's thermal balance.

Two versions exist:

IREQ-neutral → no cooling of the body

IREQ-minimal → small, acceptable cooling (more realistic for work)

If actual clothing insulation < IREQ, cold stress will occur.

ISO 11079
Overview Methodology

Step3: Determine Exposure Time

ISO 11079 provides Maximum Exposure Duration (DLE) when IREQ is not met.

Workers can only remain in that cold environment for a safe duration.

DLE depends on:

- Wind speed (increases cooling)
- Metabolic rate
- Clothing insulation

ISO 11079
Overview Methodology

Step4: Evaluate Risk Categories

Based on IREQ vs actual insulation:

1. No risk: CLO ≥ IREQ
2. Low/Moderate risk: IREQ ≤ CLO < IREQ
3. High risk: CLO < IREQ

ISO 11079
Overview Methodology

Step5: Determine Control Measure

Based on the above, controls may include:

1. Additional clothing layers
2. Heated PPE (gloves, boots)
3. Warming shelters
4. Shortened exposure time
5. Work-rest schedules
6. Limits on handling cold metal tools

ISO 11079
Overview Methodology

Summary of ISO 11079 Method

1. Measure environmental conditions
2. Determine metabolic rate
3. Assess clothing insulation
4. Calculate IREQ (minimal/neutral)
5. Compare actual clothing to IREQ
6. Determine safe exposure duration (DLE)
7. Apply clothing/work-rest controls

Standard	Purpose	Core Method	Output
ISO 7243	Heat stress	Measure Tnw, Tg, Ta: Calculate WBGT, Compare to limits	Heat hazard screening (e.g., “safe/not safe”)
ISO 11079	Cold stress	Assess environment, metabolic rate, clothing , Calculate IREQ , Determine exposure duration	Clothing requirements + max safe exposure time

1. What is the most dangerous type of heat illness?
2. Can heat stress occur even if the air temperature is below 30°C?
3. What is the main cooling mechanism of the human body?
4. What does WBGT stand for?
5. Name one factor that WBGT takes into account that simple air temperature does not.
6. Why is heat stress a major issue in Malta during summer?
7. What new Maltese rule activates when ambient temperature reaches 40°C?

8. Why is working shirtless prohibited under Malta's 2025 heat stress regulation?
9. What is acclimatisation?
10. Which is typically more dangerous: high heat with low humidity or high heat with high humidity?
11. What is a simple sign that a worker is moving from heat exhaustion toward heat stroke?
12. What is the first step in treating someone showing early heat exhaustion?
13. Can cold stress occur in Malta?
14. Name one early symptom of hypothermia.
15. What is "thermal comfort"?

Summary of key parameters

CLO VS IREQ – What They Actually Mean

1. **Clo** (clothing insulation) is a unit of measurement that quantifies how much **thermal insulation** clothing provides to the human body.
2. **Clo** is NOT a rating printed on clothes like SNR for hearing protection, and it's NOT a product certification.
3. Clo is a **measured or calculated values** used in thermal comfort and heat-stress assessments.
4. **Clo** is **measured** in a Laboratory Measurement Using a Thermal Manikin OR
5. **Clo** is **calculated** using the following equation**: CLO=R / 0.155**
   (R: here is thermal resistance of the clothing)
6. *Hence **MORE CLo = warmer Clothing; LESS CLo = Cooler clothing***

CLO VS IREQ – What They Actually Mean

1. **IREQ** Stands for **Required Clothing Insulation**
2. **IREQ** is not what the worker is wearing **BUT** it is the **calculated amount of insulation** needed to maintain thermal balance given the cold environment.
3. IREQ is derived mathematically — not measured experimentally
4. Using IREQ Calculator – parameters inputted as per slide 73
5. ISO 11079:2007 – Ergonomics of the thermal environment — **Determination and interpretation of cold stress (IREQ)**

1. Thermal Comfort

Thermal comfort is the condition of mind in which a person feels satisfied with the surrounding thermal conditions—neither too hot nor too cold. It depends on:

Environmental factors (temperature, humidity, radiant heat, air movement) and Personal factors (clothing insulation, activity level)

2. Thermal Environment

The thermal environment refers to the combination of environmental factors that affect the body's ability to gain or lose heat. These include:

Air temperature, Radiant temperature, Humidity, Air movement (air velocity)

Personal factors like clothing and metabolic rate (which influence how the environment affects a person).

In occupational health and safety, the thermal environment is assessed to ensur that conditions do not cause heat stress, cold stress, or discomfort.

3. Thermal Insulation

Thermal insulation is the property of a material or clothing system that reduces the transfer of heat between the body and the environment. In workplace safety and ergonomics:

It is often expressed in clo units. Higher insulation values help retain body heat in cold environments; lower values allow heat dissipation in warm conditions.

4. Metabolic Rate

Metabolic rate is the rate at which the human body produces energy (heat) as a result of biochemical processes that convert food and oxygen into usable energy.

In occupational health and ergonomics, metabolic rate is important because it affects how much heat a person generates, which in turn influences thermal comfort and heat/cold stress.

Or better the heat your body produces based on workload.

5. WGBT

WBGT is an index used to assess heat stress in outdoor or indoor environments.

A WBGT meter outputs Tnwb, Tg, Ta, and the WBGT heat-stress index, which is the key va
used to evaluate safe working conditions in hot environments.

6. Practical WBGT Limit Values

Workload	Safe WBGT Range (°C)	Source
Light	28–31°C	ACGIH, NIOSH, OSHA
Moderate	25–28°C	ACGIH, NIOSH
Heavy	23–26°C	ACGIH, NIOSH
Very heavy	20–23.5°C	ACGIH

ACGIH: American Conference of Governmental Industrial Hygienists
NIOSH: National Institute for Occupational Safety and Health
OSHA: Occupational Safety and Health Administration

7. CLO Reference values

Category	Description	Typical CLO Value
Naked person	No clothing	0.0 Clo
Light summer outfit	T-shirt + shorts	≈ 0.2 - 0.3 Clo
Typical business suit	Long-sleeve shirt + trousers + jacket	≈ 1.0 Clo
Winter clothing	Sweater + trousers + winter coat	≈ 1.5 – 2.0 Clo
Arctic / insulated gear	Multi-layer insulated suit or expedition clothing	≈ 2.7 – 4.0 Clo

8. **What ISO 7243**: is a screening method used to evaluate heat stress on workers by using the WBGT index as the primary measurement tool. It provides a structured approach to determine whether environmental conditions could pose a heat-stress risk during work.

9. **ISO 11079:** provides the scientific method and strategy for evaluating cold stress experienced by people working in cold environments. It defines:
   - How to assess cold exposure
   - How to determine the Required Clothing Insulation (IREQ) to maintain thermal balance
   - How to evaluate local cooling effects (e.g., hands, face, extremities)

Next: Lecture 5: Radiation Hazards: Ionising and Non-Ionising

The session covers ionising (X-rays, gamma, particle radiation) and non-ionising radiation (UV, IR, EMF, lasers). Students learn exposure effects, ALARA principles, shielding techniques, monitoring devices, PPE, and regulatory obligations. Applications in medicine, manufacturing, welding, and communications are reviewed.