LSI LASTEM Environmental Monitoring Solutions

MICROCLIMATE STATION

Indoor Comfort, Thermal Stress and related quantities

- Portable system for Indoor Comfort, Thermal Stress and related quantities

The term Microclimate expresses a series of thermo-hygrometric parameters that characterize the air in confined places and which are responsible for the thermal sensation of individuals. They are: temperature, relative humidity, average radiant temperature and air velocity. From a thermal point of view, the rooms are divided into **severe** and **moderate environments**. In the latter, the goal is to achieve the best thermal comfort, a situation that affects work performance and the pleasantness of the living environment; in severe environments, both hot and cold, the goal is to protect the occupants from dangerous thermal situations that can expose them to heat stroke (hot environments) or hypothermic conditions (cold environments); in these cases, therefore, the microclimatic analyses are aimed at assessing the distance between the current situation and the potentially dangerous one. The assessment of the individual's thermal sensation is performed through the calculation and related analysis of microclimatic indexes. The objective of an index is to summarize a complex situation, where a series of variables (thermo-hygrometric quantities and quantities relating to the subjects: metabolic activity, degree of clothing and mechanical performance) interact with each other, by obtaining a synthetic number that is objective and comparable. Different indexes apply to different types of thermal environments. The indexes used can vary, but when the goal is to preserve the health of the occupants in the workplace, it is necessary to use indexes approved by the various national regulations. These are the main indexes regulated by ISO:

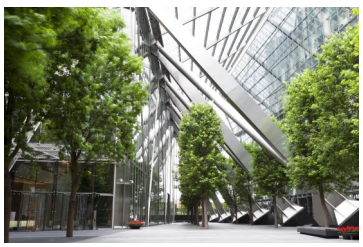
Index	Norm	Title	Description
ISO normed indexes for moderate environments			
Predicted Mean Vote (PMV)	ISO7730 (2018) ASHRAE 55 standard	Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indexes and local thermal comfort criteria	Evaluates the individual's state of well-being through a numerical value on a scale of -3 (sensation of cold) to +3 (sensation of hot), with zero representing thermal well-being
Percentage of Person Dissatisfied (PPD)	ISO7730 (2018)		Indicates the percentage of people not satisfied with the thermal environment
ISO normed indexes for hot environments			
WBGT	ISO7243 (2017)	Ergonomics of the thermal environment — Assessment of heat stress using the WBGT (wet bulb globe temperature) index	It provides a value to be compared to the limits given by the standard for metabolism classes of the subjects under observation. These limits differ when applied to acclimatized and unacclimated individuals
PHS	ISO 7933	Predicted Heat Strain	It is based on an interactive algorithm that analyses instant by instant the heat exchanges of an individual moving between work / rest environments, providing the estimate of the maximum exposure time in the work environment and the recovery time within the resting environment based on fluid loss and core body temperature
ISO normed indexes for cold environments			
IREQ	ISO 11079 (2007)	Ergonomics of the thermal environment — Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects	Provides the thermal insulation value of the clothing required in order to maintain acceptable organic conditions during exposure and the duration of exposure when such clothing is not usable

There is a sub-category of indexes used to evaluate localized discomfort present where heat exchanges are localized in specific surface areas of the human body. In these situations, the analysis of the “global” indexes alone may not highlight situations of hardship due to these localized situations.
These indexes are always described in the ISO7730 (2018) standard:

Index	Norm	Title	Description
Discomfort from draught	ISO7730 (2018) Chap.6 Localized Thermal Discomfort	Percentage of Dissatisfied with Draught (DR)	The index provides the percentage of dissatisfied with draught. According to the temperature, the speed of the air and its degree of turbulence at the point; there may be localized discomfort especially when the current of air hits the back and neck
Vertical difference in air temperature	ISO7730 (2018) Chap.6 Localized Thermal Discomfort	Percentage of dissatisfied as a function of the vertical difference in air temperature between head and ankles (PD)	The index provides the percentage of dissatisfied with the vertical temperature gradient, i.e. the difference in air temperature between the head-neck areas (h = 1.10 m for a seated person) and ankles (h = 0.10 m)
Floor temperature discomfort	ISO7730 (2018) Chap.6 Localized Thermal Discomfort	Percentage of dissatisfied as a function of the floor temperature	The floor temperature can be warmer or colder than that of the air. If the floor is too hot or too cold, the occupants are subjected to a feeling of discomfort due to the thermal sensation of their feet
Radiant asymmetry	ISO7730 (2018) Chap.6 Localized Thermal Discomfort	Percentages of Dissatisfied with radiant temperature asymmetry	People are particularly sensitive to radiant asymmetry due to warm ceilings or cold walls. The index provides the percentual of dissatisfied according to the asymmetry of the radiant temperature caused by a warm ceiling, a cold wall, a cold ceiling or a warm wall

The evaluation of the thermal environment traditionally is aimed at **work environments** in order to preserve the health of workers. For this reason, the "Microclimate" is one of the physical risks contemplated in the Italian legislation in the Consolidated Safety Act (Legislative Decree 81 of 9 April 2008 and subsequent amendments). The thermo-hygrometric conditions of the work environments affect the performance of the worker in moderate ones and on his health in severe ones.

In recent years, the evaluation of the microclimate and in particular of thermal comfort, has been used as one of the elements to define the **energy efficiency** of buildings. Optimizing energy consumption according to the thermohygrometric comfort produced by the thermo-technical system and the architectural elements. The study of microclimatic parameters helps to regulate systems, such as air conditioning and heating systems, to minimize energy expenditure.



Lately, in order to mitigate the effects of the climate and create **urban environments** that are as sustainable and liveable as possible, the assessment of the microclimate is also evolving for outdoor environments. The concept of **smart city** also includes the possibility of measuring outdoor microclimatic parameters and evaluating interventions aimed at mitigating phenomena, such as heat waves, in certain areas.

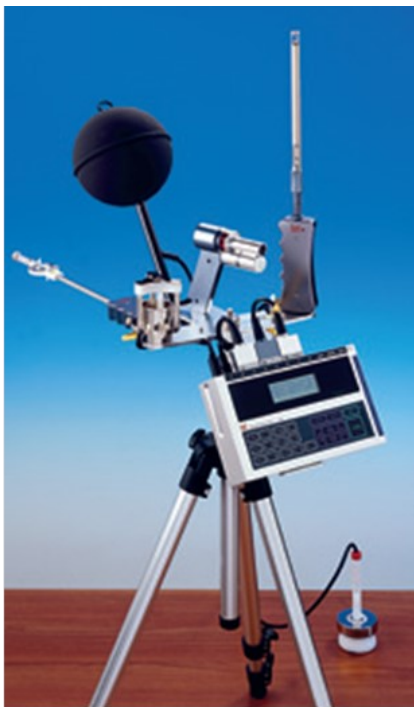
For measures aimed at assessing the health of occupants in the workplace, the measurement instrumentation for the analysis of thermal environments must meet the requirements of an ISO standard. In this case, ISO7726-2002: *Ergonomics of the thermal environment - Instruments for measuring physical quantities*. This standard divides the instrumentation into two classes: class C (used for Comfort measurements) and class S (used for Thermal Stress measurements).
Within the limits of application possibilities, LSI LASTEM supplies sensors that comply with the standard.

Grandezza	Class C		Classe S		Sensor	LSI LASTEM	
	Accuracy	Range	Accuracy	Range	Model	Accuracy	Range
Air temp.	Desirable ±0.2°C	10...40°C	±0.5°C	0...50°C	**ESU403**	±0.1°C	-50...100°C
Mean radiant temp.	Desirable ±0.2°C	10...40°C	±5°C	0...50°C	**EST131**	±0.15°C	-30...70°C
Air velocity	Required ±(0.05+0.05 va) m/s	0.05...1 m/s	Required ±(0.1+0.05 va) m/s	0.2...20 m/s	**ESV306**	0.1...0.5 m/s = ± 0.083 m/s 0.5...1 m/s = ± (0.05+0.05 va) m/s >1 m/s= ± (0.1+0.05 va) m/s	0.01...20 m/s
Surface temp.	Desirable ±0.5°C	0...50°C	Required ±0.5°C	-10...50°C	**EST124**	±0.15°C	-50...70°C
Directional radiation	±5 W/m^2	-35...35 W/m^2	±5 W/m^2		**ESR231**	5%	-1500...1500 W/m^2
Abs. humidity (partial vapor press.)	±0.15 kPa	0.5...3 kPa	±0.15 kPa	0.5...6 kPa	**ESU403**	±1% @ 5...95% RH	0...100% RH

LSI LASTEM is a historic company in the production of instrumentation for measuring the microclimate. Since 1972, the then LSI Laboratories of Industrial Instrumentation, due to the growing market of thermal microclimate for evaluations in the workplace, had put on the market the first equipment for this purpose.

1979: ANADATA Control Unit MICROCLIMA

First portable microprocessor instrument for the calculation of main microclimate indexes and their printing on integrated thermal printer.



1985: BABUC-A Control Unit MICROCLIMA

First multi-measurement acquisition with self-recognition of connected sensors. Babuc could memorize the data from the connected sensors and was connected to the PC to download the measurements. LSI LASTEM had created the first PC application (Infogen), which in post-processing, calculated the main microclimatic indexes.

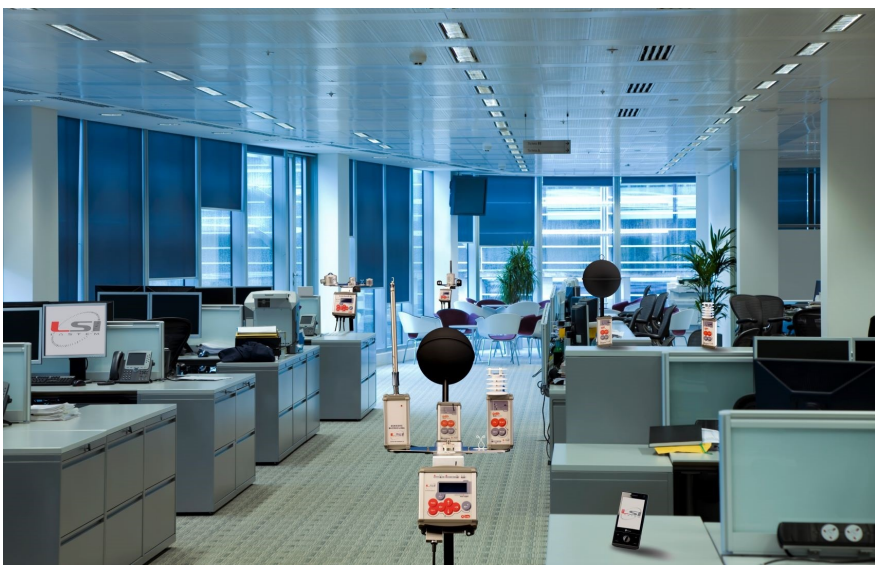
Portable system for Indoor Comfort, Thermal Stress and related quantities

- Only a few minutes for the assembly of the control unit before starting the measurements
- Calculation of indexes for moderate (PMV-PPD), hot (WBGT, PHS) and cold (IREQ) environments by means of a PC program
- Direct calculation, without the need for a PC program, of the WBGT and OT indexes, Unsatisfied with draughts, floor temperature and radiant asymmetries
- Possibility of acquiring other quantities for the analysis of the IEQ (Indoor Environmental Quality) such as Air Quality sensors and lighting sensors to obtain an integrated measurement system

The system consists of an instrumental assembly (data logger and sensors) mounted on a tripod. Depending on the type of environment and the related microclimatic survey (moderate, hot and cold environments and localized discomfort) it is possible to choose different types of sensors. Some indexes (WBGT, Operating Temperature and localized Discomfort indexes) are calculated directly by the data logger (M-Log), others are calculated in post-processing by means of the Gidas TEA (Thermal Environments Application) software on PC. The TEA program is divided into three modules: Moderate, Warm and Cold environments.

The measurements are usually performed near the workstation of the subject under investigation, the measurements have a variable duration, ideally concomitant with the duration of the work cycle, but, where this is not possible, they must be carried out during situations of "Maximum recurrent discomfort", Or with the worst thermo-hygrometric situations among those that occur recurrently. For example as regards the heat, during the central hours of the summer months, in the case of cold discomfort in the early morning of the winter months.

The control unit stores the data by dividing them into "measurements"; The surveys are then downloaded to the PC for the post-processing calculation of the microclimatic indexes and related measurement reports



Globothermometric sensor

The average radiant temperature is the parameter responsible for the heat exchanges by radiation between the individual and the environment and is involved in the definition of the term "R" in the thermal balance formula. All indexes based on the thermal balance (in addition to the WBGT) require the measurement of the radiant temperature obtained with the black globe.

Thermo-hygrometer sensor

Temperature is the form assumed by the exchanged energy between man and the environment, it is the fundamental parameter for the definition of heat exchanges by convection and conduction in the thermal balance. The amount of water contained in the air is of fundamental importance for well-being, as it is linked to the transfer of heat through the skin (convection).

Air speed sensor

The air speed influences the heat exchange by convection and is a common cause of localized discomfort described by the "Draught Rate" (DR) index. The hot wire sensor ensures the omni-directionality of the measurement, in addition to the low threshold and fast response time essential in measuring the air speed and Turbulence index in confined environments.

Humid temperature sensor with natural ventilation

The humid temperature sensor with natural ventilation is only necessary for the calculation of the WBGT index, as described in the ISO7243 standard.

Floor temperature

For the discomfort due to the high floor temperature *tf* (eg due to underfloor heating) or too low, it is possible to estimate the percentage of dissatisfied, under the condition (5 °C < *tf* <35 ° C).

Radiant asymmetry

For the discomfort due to a radiant asymmetry it is possible to estimate the percentage of dissatisfied by different situations: warm ceiling, warm wall, cold ceiling, cold wall (eg glass walls).

GIDAS TEA—Comfort Module

Calculation of indexes:

- PMV predicted mean vote (ISO7730)
- PPD % unsatisfied (ISO7730)
- DR % unsatisfied for draughts (ISO7730)
- OT Operative Temperature

GIDAS TEA—Cold Module

Calculation of indexes (ISO11079) :

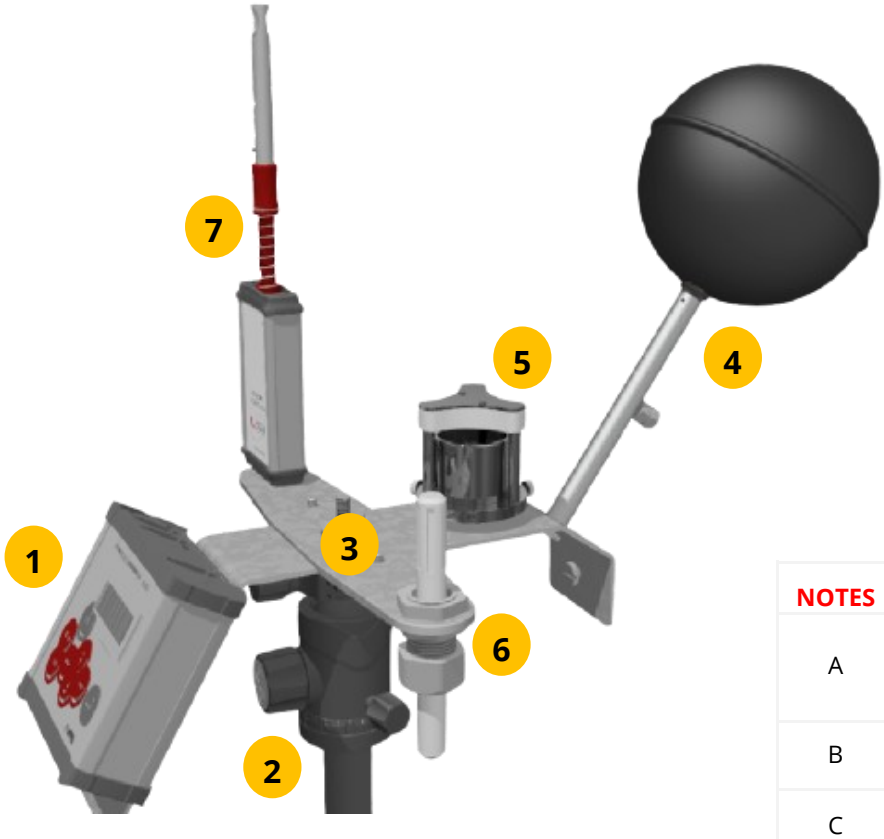
- IREQ Thermal insulation required
- IclReq Thermal insulation required by clothing
- Dlim Maximum duration of exposure and Drec recovery time
- TWC WindChill temperature

GIDAS TEA—Hot Module

Calculation of hot thermal stress indexes, useful where there may be a risk of heat stroke:

- WBGT Indoor/Outdoor (ISO7243:2018)
- PHS Predicted Heat Strain (ISO7933:2004)

Portable Microclimatic Control Unit Kit



NOTES	
A	Select this module for PMV-PPD, DR, OT, radiant asymmetry indexes Temperatu-re dissatisfaction index
B	Select this module for TWC, IREQ in-dexes
C	Select this module for WBGT and PHS indexes

Ref. Fig.	PN	Description	Kit1	Ref. Notes
		M-Log Data Logger		
1	**ELO009**	M-Log/N.5 inputs/8MB/Batt/MiniDIN	1	
	BSC015	Power charger 230Vac->9Vdc/M-RLog/IP54	1	
		Carrying case for data logger and sensors		
	BWA319	Trolley/68x53x28cm/antishock/IP65	1	
	BWA048	Long bag for tripod	1	
		Software		
	BSZ311	SW Gidas Viewer/PC	1	
	BSZ313	SW Gidas TEA/Comfort/PC	1	A
	BSZ315	SW Gidas TEA/Cold/PC	1	B
	BSZ317	SW Gidas TEA/Hot/PC	1	C
		Mounting accessories		
2	**BVA304**	Tripod	1	
3	**BVA305**	Stand for sensor and data logger on tripod	1	
		Globe temperature sensor		
4	**EST131**	Sensor/Temp.globo nero/Pt100/Cable+MiniDin	1	
		Natural ventilated wet temperature sensor (for WBGT index)		
5	**ESU121**	Sensor/Wet Bulb temp./Cable+MiniDin	1	
		Thermo-hygrometer sensor		
6	**ESU403.1**	Sensor/T+RH%/Pt100+0...1V/12V/Cable+MiniDin	1	
		Air Speed sensor		
7	**ESV107**	Sensor/Air speed/Hot-wire/mV/Cable+ MiniDin		

Ref. Fig.	PN	Description	Kit1	Ref. Notes
		Sensors for local Thermal Comfort Criteria		
		Radiant asymetry sensor (for radiant asymmetry index)		
8	**ESR231**	Sensor/Radiant Asymetry/Cable+MiniDIN	Optional	
		Air Speed sensor (for TU and DR index)		
9	**ESV306**	Sensor/Air speed+Turbolence/Hot-wire/RS232/Cable+DB	Optional	
		Floor temperature sensor (for % disatisfy by Floor temperature index)		
10	**EST130**	Sensor/Double Temp./Surface+H=10cm/2xPt 100/Cable+MiniDin	Optional	

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