LSI LASTEM

Environmental
Monitoring Solutions

IEQ MONITORING STATIONS

Indoor Environmental Quality

- Multi-parametric System for IEQ
- Sphensor system

Theory and Norms

IEQ (Indoor Environmental Quality) concerns the set of parameters that together define the environmental quality, the degree of healthiness and the well-being of people in a confined environment. The factors that define the IEQ are: thermal environment, lighting, acoustics and indoor air quality (IAQ).

The IEQ is the result of both the design solutions (choice of construction materials, architectural solutions and furnishings), and the choice, setting and efficiency of technical systems for heating, cooling and ventilation.

In recent years, attention to the **conditions of indoor spaces** has increased significantly. The population of European urban centers spends on average 95 to 97% of their time indoors. Living and working in healthy and comfortable environments has very important objective consequences, while a low level of IEQ can have a very negative impact on the performance, health and psyche of the occupants.

The management of the IEQ requires a **monitoring strategy**, in order to verify the environmental variables, both in the initial verification phase of the project, and during the use and maintenance of the building.

Achieving ideal IEQ conditions may require high energy consumption, both for artificial lighting and for ventilation, air conditioning and heating. A careful and conscious planning is therefore necessary.

Here are the most recent regulations and guidelines relating to confined spaces based on the topic of indoor quality and energy saving combined with the comfort of the occupants:

UNI ES ISO 16000-1:2006—Indoor air - Part 1: General aspects of sampling strategy : compliance with the requirements in indoor environments is prescribed, described as "environments not subject to the requirements aimed at protecting workers from the effects resulting from exposure to harmful substances". This standard and the others of the 16000 and 16017 series contain indications on the monitoring of the chemical and biological components of the air.

UNI EN ISO 7730:2006 – Ergonomics of the thermal environment: analytical determination and interpretation of thermal well-being through the calculation of indices and criteria of local thermal well-being. Creation of a single parameter able to synthesize the thermohygrometric sensation of the occupants in confined spaces, defined as PMV or Predicted Mean Vote described in this standard.
• *PMV (Predicted Mean Vote):* defines a comfort scale ranging from -3 (sensation of cold) to +3 (sensation of hot), passing through 0 (thermal neutrality).
• *PPD (Predicted Percentage Dissatisfied):* represents in relative terms the incidence of subjects who do not like the environment from a thermal point of view.

Sick building syndrome (SBS) *indicates well-defined symptoms occurring in a large number of modern buildings which tend to be “sealed” with respect to the external climate.*
In the workplace, SBS can cause decreased productivity and worker absences.
Many chemical compounds present in indoor air are known for or suspected of ***causing irritation or stimulation of the sensory system*** *and can give rise to the symptoms commonly present in the SBS. Studies conducted on offices and other public buildings in different countries have revealed a frequency of disturbances among occupants between 15% and 50%.*

WHO (OMS) Guidelines for indoor air quality (2010): guidelines for the protection of public health from risks due to chemicals commonly found in indoor air. The substances considered (benzene, carbon monoxide, formaldehyde, naphthalene, nitrogen dioxide, polycyclic aromatic hydrocarbons, radon, trichlorethylene and tetrachlorethylene), have their sources in confined spaces and are dangerous for health.

EU Directive 2018/844 concerning the energy performance of buildings and energy efficiency: the objective is to pursue "the development of a sustainable, competitive, safe and decarbonised energy system", taking into account that the real estate sector is attributable to the 36% of all CO_2 emissions in the EU. It introduces the obligation to improve the energy performance of new and existing buildings and requires national building renovation strategies to be considered.
The EU directive introduces an "intelligence readiness indicator of buildings", the Smart Readiness Indicator (SRI), which also includes the comfort needs of the occupants.

ISO 17772-1:2017—Energy performance of buildings—Indoor environmental quality—Part 1: Indoor environmental input parameters for the design and assessment of energy performance of buildings: specifies the requirements for the thermal environment, indoor air quality, lighting and acoustics, and how to establish these parameters for building and plant design and for energy performance calculations. It also includes design criteria for local thermal discomfort factors, air currents, radiant temperature asymmetry, vertical differences in air temperature and floor surface temperature. The standard is applicable where the criteria for the indoor environment are established by human occupation and where the production or process does not have a major impact on the indoor environment.
A good design is aimed at the rational use of energy (good/excellent energy performance) as well as obtaining a satisfactory thermal comfort and indoor air quality.
The standard can be used during the design phase and during the verification phase. In the design phase, comfort project parameters are defined to be used as input for system sizing and building design calculations. In the verification phase it is possible to measure the environmental variables to assess whether the categories defined in the design phase are respected.

UNI EN 16798-1:2019— Energy performance of buildings - Ventilation for buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics : implementation of the ISO 17772-1: 2017 standard at UNI EN level.

The importance of assessing the quality of confined spaces has led to greater attention during the design phases, but also during the operation of the building: the monitoring of internal environmental conditions can in fact allow to take virtuous initiatives to improve the IEQ and energy efficiency.

One of the initiatives in this regard is the **LEED (Leadership in Energy and Environmental Design)** certification, born in the U.S.A. thanks to the U.S. Green Building Council, but also adopted throughout Europe. It proposes a voluntary certification of the quality of buildings with an approach oriented towards sustainability and the management of safety and comfort. For indoor environments, LEED has a special section, named LEED IEQ. It is applicable to every phase of the life of a building and is able to decree whether and how much a confined environment is safe for the occupants and at the same time how sustainable it is. LEED IEQ also includes LEED IAQ, which is the specific certification area for assessing indoor air quality.

For a correct assessment of the quality of indoor environments it is necessary to consider all the parameters that are involved in the definition of thermal, light, acoustic and air quality comfort, namely: **air temperature and relative humidity, radiant asymmetry, air, lighting, noise, gas concentration in the air**.

The table shows the parameters required by the standard **ISO 17772-1:2017—Energy performance of buildings—Indoor environmental quality—Part 1: Indoor environmental input parameters for the design and assessment of energy performance of buildings** for the classification of a building with respect to its IEQ grade:

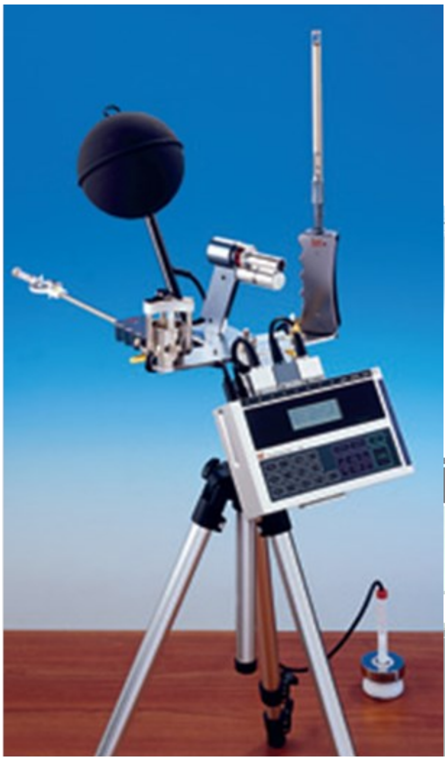
Objective	Method	Needed quantities
Thermal environment		
Check of **general thermal comfort**	PMV-PPD Indexes calculation	Air temperature and RH%, Radiant temperature, Air velocity
Check of **general thermal comfort**	Operative Temperature Index calculation	Air temperature and RH%, Radiant temperature, Mobile average outdoor temperature
Check of **general thermal comfort**	Measurement of the increase in air speed to mitigate high temperatures	Air velocity
Check of **localized air currents**	Dissatisfied from air currents Index calculation	Air velocity, Turbolence index
Check of the **radiant asymmetry** between the walls and between the floor and ceiling	Unsatisfied with radiant asymmetry Index calculation	Net radiation
Check of **vertical temperature gradients**	Dissatisfied with vertical temperature gradient Index calculation	Temperature at 10 cm and 110 cm in height
Check of the **floor temperature** too hot or too cold	Dissatisfied with floor temperatures Index calculation	Floor contact temperature
Check of **air temperature**	Air temperature measurement	Air temperature
Air quality		
Check the ventilation system in order to ensure a certain **air flow** per occupant	Calculation of air flow (l/s per m^2, l/s per occupant)	Air velocity
Dilution of **CO_2 concentration** through air changes	Calculation of air flow and number of air changes to dilute the gas concentration	CO_2 measurement, Air velocity
Illuminance		
Check of the **amount of light** present in the environment	Illuminance measurement	Illuminance
Verification of the **quantity of natural lighting** present inside the building	Daylight factor calculation	Indoor and outdoor illuminance
Noise		
Verification of plant **noise**	dB Level (A) measurement	Equivalent level (L-Aeq)

LSI LASTEM's Solutions

The classification of buildings is carried out with the measurement of environmental variables and data processing according to the criteria defined by the regulations. The values obtained are then verified according to the limits required for the purpose of classification. LSI LASTEM offers systems where many of the defined calculations are already available as "derived quantities" obtained directly in the data logger or with post-processing calculations via software. Other elaborations can be subsequently calculated via software starting from the data reports downloaded from the data logger.

Method	Derived quantity from Data Logger (ELO009-ELR510.1)	Post-processing via Software
PMV-PPD Index		**GIDAS TEA (BSZ313)** (*see MW9006-ITA-06*)
Operative Temperature Index	YES	
Unsatisfied by air currents Index	YES	
Unsatisfied by radiant asymmetry Index	YES	
Unsatisfied by vertical temperature gradient Index	YES	
Unsatisfied by floor temperatures Index	YES	
Air flow (l/s per m^2, l/s per occupant) meas.	YES	
Air flow and number of **air changes**	YES	
Daylight factor	YES	

LSI LASTEM is a historic company in the production of instrumentation for measuring the microclimate. Since 1972, the then LSI Laboratories of Industrial Instrumentation, for the growing market of thermal microclimate for evaluations in the workplace, had put on the market the first equipment for this purpose. Over the years, the range of sensors has been enriched towards the completion of the typical IEQ parameters.



1985: BABUC-A MICROCLIMATE Station

First multi-measurement acquisition system 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 ASTEM had created the first application on PC (Infogen), which in post-processing, calculated the main microclimatic indices.

Globo-thermometric sensor

The average radiant temperature is 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. Indices based on the heat balance require the radiant temperature obtained with the globe thermometer sensor.

Thermo-hygrometric sensor

The temperature is the form assumed by energy exchanged between man and the environment, a fundamental parameter for the definition of heat exchanges by convection and conduction. 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.

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, a low threshold and fast response time, essential in measuring the air speed and Turbulence index.

Floor temperature sensor

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 sensor

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).

Illuminance sensor

To enable visual tasks to be performed efficiently, appropriate lighting must be provided. The criteria must be selected based on the activities carried out to provide comfortable conditions for the occupants.

CO_2 and CO sensors

Pollutants present in indoor environments can derive from the external environment, and penetrate by infiltration, or from sources present inside the buildings. WHO recommends maximum gas thresholds.

VOC sensor

In the indoor air, more than 900 VOCs (Volatile Organic Compounds) have been identified, released by: construction and furniture materials, upholstery, adhesives, detergents, cigarette smoke and the occupants themselves.

Noise sensor

The standards require the measurement of the equivalent continuous level of sound pressure, weighted "A" (L Aeq, nT) to verify the noise emitted by technical systems of building, as well as the sound insulation of its structures.

Multi-parametric System for IEQ

- Portable system that can be easily repositioned in different measurement positions
- Multi-parameter monitoring unit with the ability to connect a large variety of probes for the different aspects of the IEQ: Thermal environments, Light, Sound, Air Quality
- Sensors for measuring thermal comfort (temperature and humidity, radiant temperature, air speed) and local discomfort (floor temperatures, radiant asymmetry, air flows)
- Sensors for the measurement of IAQ (Indoor Air Quality) for the measurement of the main gases present in confined environments (CO_2, VOC, and many others).
- Gidas-TEA software for calculating the PMV-PPD indexes (ISO7730)
- Gidas-Viewer software for statistical reprocessing of acquired data and creation of data tables and graphs

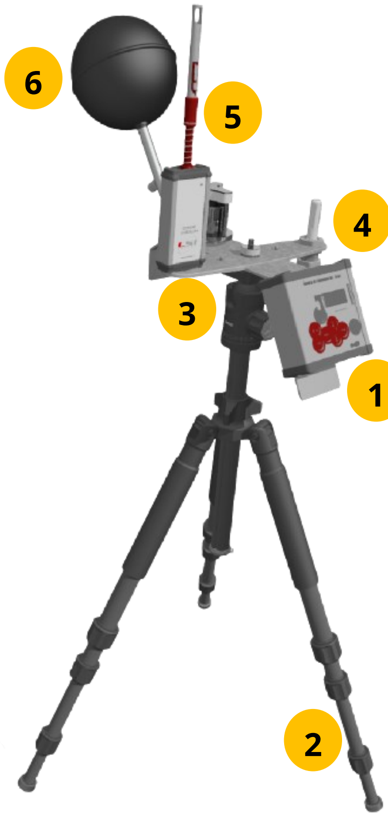
The system consists of an instrumental assembly (data logger and sensors) mounted on a tripod. Depending on the type of site and the related survey on the quality of the internal environment, it is possible to choose different types of sensors.
It is possible to **connect a maximum of 5 different sensors via cable** to the **M-Log data logger**, for this reason, to carry out all the measurements relating to the typical quantities of the IAQ it is necessary to connect the probes to the system at different times.

The monitoring areas that can be achieved concern all the variables indicated by the standards as characterizing the indoor environment, for the measurement of these parameters, different sets of sensors are available:

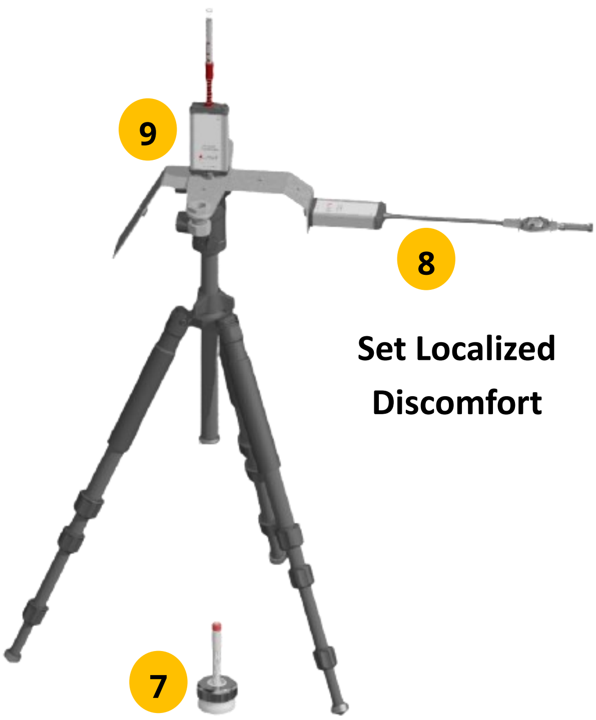
- **Thermal Comfort**: sensors for the calculation of microclimatic indices for the evaluation of the global thermal comfort of the confined environment, such as temperature and relative humidity, radiant temperature, air speed.
- **Localized Discomfort**: sensors for evaluating the variables that affect localized discomfort, such as the temperature gradient, the floor temperature, the air velocity and the radiant asymmetry.
- **Illuminance**: lux meters for evaluating the illuminance and calculating the Daylight Factor.
- **Indoor Air Quality**: sensors for monitoring the gases present in the confined environment, typically CO_2 and VOC. LSI Lastem has additional sensors for other gases (eg CO, SO_2, H_2S, etc.).
- **Noise**: noise level probe for the evaluation of the equivalent continuous level of sound pressure, weighted “A”.

The data logger stores the data by dividing them into "surveys"; The surveys are then downloaded to the PC for statistical processing and post-processing calculation of PMV-PPD indices using Gidas-Viewer and Gidas-TEA programs.
Some indices are calculated directly by the M-Log data logger (see Table on page 6).

Kit 1—Multi-parametric System for IEQ



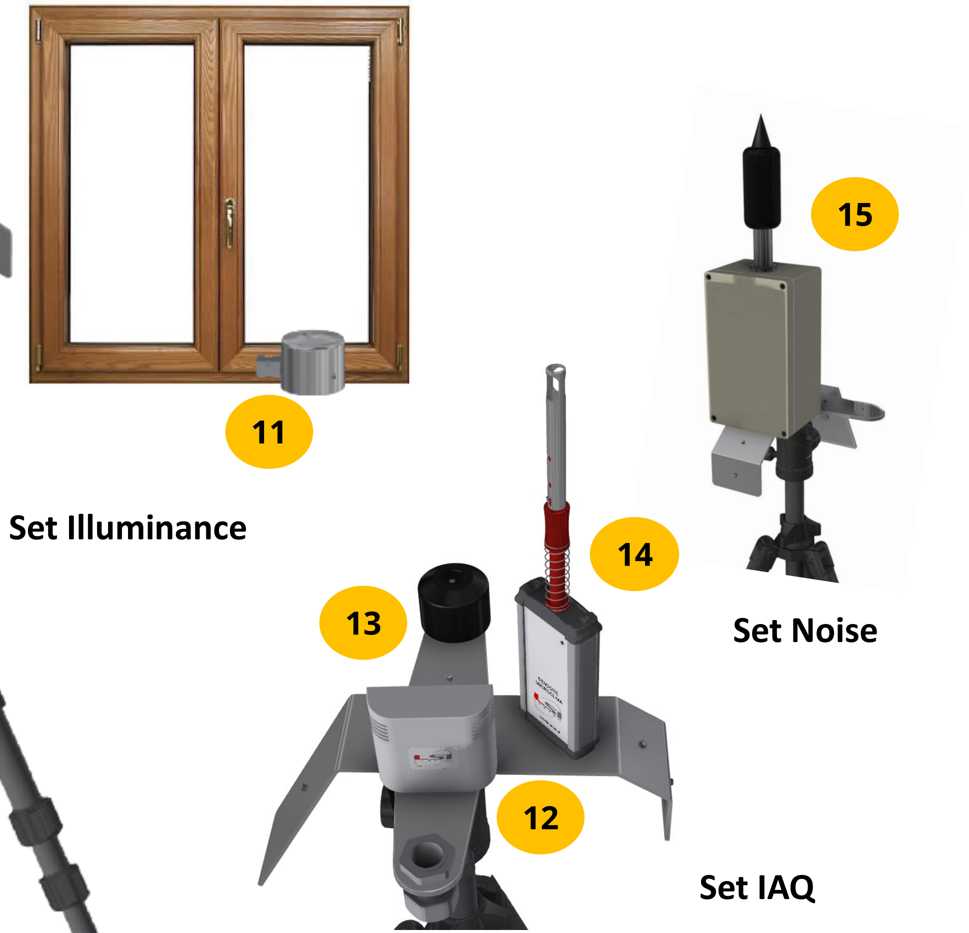
Set Thermal Comfort



Set Localized Discomfort

NOTE	
A	The BSZ313 software is used to calculate the PMV-PPD index (ISO7730)
B	The EST130 sensor, if used for the calculation of the "Dissatisfied with vertical temperature gradient" Index, must be combined with an air temperature sensor placed at about 110 cm in height. For this it is possible to use the air temperature acquired by the ESU403.1 probe already present in the module for the calculation of thermal comfort

Ref. Fig.	PN	Description	Kit1	Ref. Note
		Data Logger		
1	**ELO009**	M-Log/N.5 inputs/8MB/Batt/MiniDIN	1	
	BSC015	Power charger 230Vac->9Vdc/M-RLog/IP54	1	
		Cases for the transport of data loggers and sensors		
	BWA319	Trolley/68x53x28cm/antishock/IP65	1	
	BWA048	Long bag for tripod	1	
		Software		
	BSZ311	SW Gidas Viewer/PC	1	A
		Mounting accessories		
2	**BVA304**	Tripod	1	
3	**BVA320**	Stand for MLog sensors	1	
		Set of sensors and software for thermal comfort (PMV-PPD, Operating Temperature)		
4	**ESU403.1**	Sensor/T+RH%/Pt100+0÷1V/12V/Cable+MiniDin	1	
5	**ESV308**	Sensor/Air speed+Turbolence/Hot-wire/RS232/Cable+DB	1	
6	**EST131**	Sensor/Temp.globo nero/Pt100/Cable+MiniDin	1	
	BSZ313	SW Gidas TEA/Comfort/PC	1	
		Set of sensors for localized thermal discomfort (floor temperature, radiant asymmetry, air currents)		
7	**EST130**	Sensor/Double Temp./Surface+H=10cm/2xPt 100/Cable+MiniDin	1	B
8	**ESR231**	Sensor/Radiant Asymetry/Cable+MiniDIN	1	
9	**ESV308**	Sensor/Air speed+Turbolence/Hot-wire/RS232/Cable+DB	1	



NOTE	
C	The ESR001 probe is useful if the calculation of the daylight factor is required
D	In addition to the probes for the measurement of CO_2 and VOC, LSI LASTEM offers many other probes for the measurement of other gases. See catalogue MW9001-ENG-12.

Ref. Fig.	PN	Description	Kit1	Ref. Note
		Illuminance sensor set (daylight factor calculation)		
10	**ESR000**	Sensor/Lux CIE/0÷5Klux/Cable+MiniDIN	1	
11	**ESR001**	Sensor/Lux CIE/0÷25Klux/Cable+MiniDIN	Optional	C
		Indoor Air Quality and ventilation sensor set		
12	**ESO204**	Sensor/CO2/0÷5000ppm/Cable+MiniDIN	1	D
13	**ESO150**	Sensor/VOC/0÷20ppm/Cable+MiniDIN	1	D
14	**ESV307**	Sensor/Air.Vel/hot wire/RS232/Cable+ DB	1	
		Noise sensor		
15	**PRSLA1000**	Noise sensor	1	
	DEA999	Connection cable for noise sensor to M-Log	1	
	BVA327	Accessory to fix PRSLA1000 to tripode	1	

Sphensor system

- Sphensors: radio multiparameter indoor sensors for IEQ
- Meausrement quality at higher market standards
- Real-time data on INDOOR CUBE cloud platform for analysis and monitoring projects

Sphensors are spherical multi-parameter radio sensors that can form a network; they are designed with a pleasing visual impact, to be harmoniously integrated into their surroundings. The sensors measure various physical and chemical quantities, sending the data via a robust mesh radio network to the Sphensor Gateway and finally being transferred to the INDOOR CUBE cloud platform **(see datasheet MW9001-ENG-14-Sphensor)**.

Contact LSI LASTEM for more information about system configurations and options

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