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# Ergonomics of the thermal environment — Instruments for measuring physical quantities

*Ergonomie des ambiances thermiques — Appareils de mesure des grandeurs physiques*



ISO 7726:1998(E)

# Contents







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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.



International Standard ISO 7726 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment*.



This second edition cancels and replaces the first edition (ISO 7726:1985), of which it constitutes a technical revision.

Annexes A to H of this International Standard are for information only.

## Introduction

This document is one of a series of International Standards intended for use in the study of thermal environments.

This series of International Standards deals in particular with

— the finalization of definitions for the terms to be used in the methods of measurement, testing or interpretation, taking into account standards already in existence or in the process of being drafted;

— the laying down of specifications relating to the methods for measuring the physical quantities which characterize thermal environments;

— the selection of one or more methods for interpreting the parameters;

— the specification of recommended values or limits of exposure for the thermal environments coming within the comfort range and for extreme environments (both hot and cold);



— the specification of methods for measuring the efficiency of devices or processes for personal or collective protection from heat or cold.



Any measuring instrument which achieves the accuracy indicated in this International Standard, or even better improves on, may be used.

The description or listing of certain instruments in the annexes can only signify that they are "recommended", since characteristics of these instruments may vary according to the measuring principle, their construction and the way in which they are used. It is up to users to compare the quality of the instruments available on the market at any given moment and to check that they conform to the specifications contained in this International Standard.

# Ergonomics of the thermal environment — Instruments for measuring physical quantities

## 1 Scope

This International Standard specifies the minimum characteristics of instruments for measuring physical quantities characterizing an environment as well as the methods for measuring the physical quantities of this environment.

It does not aim to define an overall index of comfort or thermal stress but simply to standardize the process of recording information leading to the determination of such indices. Other International Standards give details of the methods making use of the information obtained in accordance with this standard.

This International Standard is used as a reference when establishing

a) specifications for manufacturers and users of instruments for measuring the physical quantities of the environment;

b) a written contract between two parties for the measurement of these quantities.



It applies to the influence of hot, moderate, comfortable or cold environments on people.



## 2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 7730:1994, *Moderate thermal environments — Determination of the PMV and PPD indices and specification of the conditions for thermal comfort*.

## 3 General

### 3.1 Comfort standard and stress standard

The specifications and methods contained in this International Standard have been divided into two classes according to the extent of the thermal annoyance to be assessed.

The type C specifications and methods relate to measurements carried out in moderate environments approaching comfort conditions (comfort standard).

The type S specifications and methods relate to measurements carried out in environments subject to a greater thermal stress or even environments of extreme thermal stress (heat stress standard).

The specifications and methods described for each of these classes have been determined bearing in mind the practical possibilities of *in situ* measurements and the performances of measuring instruments available at present.

## 3.2 Physical quantities characterizing the environment

### 3.2.1 Introduction

The determination of overall indices of comfort or thermal stress requires knowledge of physical quantities connected with the environment. These quantities can be divided into two categories according to their degree of dependence on the environment.

### 3.2.2 Basic physical quantities

Each of the basic physical quantities characterizes one of the factors of the environment independently of the others. They are often used to define the indices of comfort or thermal stress based on the rationalization of the establishment of the thermal balance of a person placed in a given thermal environment. These quantities are as follows:

a) air temperature, expressed in kelvins ($T_a$) or in degrees Celsius ($t_a$);

b) mean radiant temperature expressed in kelvins $\left(\overline{T}_r\right)$, or in degrees Celsius $\left(\bar{t}_r\right)$ plane radiant temperature expressed in kelvins ($T_{pr}$) or in degrees Celsius ($t_{pr}$) direct radiation expressed in watts per square metre;

c) absolute humidity of the air, expressed by partial vapour pressure ($p_a$) in kilopascals;

d) air velocity ($v_a$), expressed in metres per second;

e) surface temperature, expressed in kelvins ($T_s$), or in degrees Celsius ($t_s$).

The connections between these quantities and the various gains and losses of heat in relation to the human body are shown in table 1. Table 1 also gives four other quantities which, because they are usually estimated from data tables rather than measured, are not included in the remainder of this International Standard.



NOTE — The concept of mean radiant temperature allows the study of radiative exchanges between man and his environment. It presupposes that the effects on man of the actual environment which is generally heterogeneous and the virtual environment which is defined as homogeneous are identical. When this hypothesis is not valid, in particular in the case of asymmetric radiation, the radiation exchanges arising from thermally different regions and the extent of their effect on man should also be assessed using the concept of plane radiant temperature.

### 3.2.3 Derived physical quantities

The derived physical quantities characterize a group of factors of the environment, weighted according to the characteristics of the sensors used. They are often used to define an empirical index of comfort or thermal stress without having recourse to a rational method based on estimates of the various forms of heat exchanges between the human body and the thermal environments, and of the resulting thermal balance and physiological strain. Some derived quantities are described in the specific standards as they apply and where measuring requirements are included.

# 4 Measuring instruments

## 4.1 Measured quantities

**4.1.1** The air temperature is the temperature of the air around the human body (see annex A).

**4.1.2** The mean radiant temperature is the uniform temperature of an imaginary enclosure in which radiant heat transfer from the human body is equal to the radiant heat transfer in the actual non-uniform enclosure.

The mean radiant temperature can be measured by instruments which allow the generally heterogeneous radiation from the walls of an actual enclosure to be "integrated" into a mean value (see annex B).

The black globe thermometer is a device frequently used in order to derive an approximate value of the mean radiant temperature from the observed simultaneous values of the globe temperature, $t_g$, and the temperature and the velocity of the air surrounding the globe.

The accuracy of measurement of the mean radiant temperature obtained using this appliance varies considerably according to the type of environment being considered and the accuracy of measurement of the temperatures of the globe and the air and the velocity of the air. The actual measuring accuracy shall be indicated wherever it exceeds the tolerances specified in this International Standard.

The mean radiant temperature is defined in relation to the human body. The spherical shape of the globe thermometer can give a reasonable approximation of the shape of the body in the case of a seated person. An ellipsoid-shaped sensor gives a closer approximation to the human shape both in the upright position and the seated position.

The mean radiant temperature can also be calculated from measured values of the temperature of the surrounding walls and the size of these walls and their position in relation to a person (calculation of geometrical shape factors). (See annex B.)

The mean radiant temperature may also be estimated for the plane radiant temperature in six opposite directions weighted according to the projected area factors for a person. Similarly, it can be estimated from the measurement of the radiant flux from different directions.

Any other measuring device or calculation method which allows the mean radiant temperature to be determined with the accuracy specified in the following subclauses may be used.

**4.1.3** The plane radiant temperature is the uniform temperature of an enclosure where the radiance on one side of a small plane element is the same as in the non-uniform actual environment.

The so-called "net" radiometer is an instrument which is often used to measure this quantity (see annex C). With this it is possible to determine the plane radiant temperature from the net radiation exchanged between the environment and the surface element and the surface temperature of the radiometer.



A radiometer with a sensor consisting of a reflective disc (polished) and an absorbent disc (painted black) can also be used.



The plane radiant temperature can also be calculated from the surface temperatures of the environment and the shape factors between the surfaces and the plane element (see annex C).

The radiant temperature asymmetry is the difference between the plane radiant temperature of the two opposite sides of a small plane element (see definition of the plane radiant temperature).

The concept of radiant temperature asymmetry is used when the mean radiant temperature does not completely describe the radiative environment, for instance when the radiation is coming from opposite parts of the space with appreciable thermal heterogeneities.

The asymmetric radiant field is defined in relation to the position of the plane element used as a reference. It is, however, necessary to specify exactly the position of the latter by means of the direction of the normal to this element.

The radiant temperature asymmetry is measured or calculated from the measured value of the plane radiant temperature in the two opposing directions.

Any other device or method which allows the radiant temperature asymmetry or the plane radiant temperature to be measured or calculated with the same accuracy as indicated below may be used.

**4.1.4** The absolute humidity of the air characterizes any quantity related to the actual amount of water vapour contained in the air as opposed to quantities such as the relative humidity or the saturation level, which gives the amount of water vapour in the air in relation to the maximum amount that it can contain at a given temperature and pressure.

With regard to exchanges by evaporation between a person and the environment, it is the absolute humidity of the air which shall be taken into account. This is often expressed in the form of partial pressure of water vapour.

The partial pressure of water vapour of a mixture of humid air is the pressure which the water vapour contained in this mixture would exert if it alone occupied the volume occupied by the humid air at the same temperature.

The absolute humidity can be determined directly (dew-point instruments, electrolytic instruments) or indirectly by the measurement of several quantities simultaneously (relative humidity and temperature of the air; psychrometric wet temperature and temperature of the air) (see annex D).

The psychrometer is an appliance which is frequently used for measuring humidity. It allows the absolute humidity of the air to be determined from a measured value of the air temperature ($t_a$) and the psychometric wet temperature ($t_w$). The accuracy of measurement is likely to be in accordance with the specifications of this International Standard only if the appliance is well designed and the precautions to be taken during use closely adhered to.

Any device which allows the absolute humidity of the air to be measured with the accuracy indicated in the following subclauses may be used.

**4.1.5** The air velocity is a quantity defined by its magnitude and direction. The quantity to be considered in the case of thermal environments is the speed of the air, i.e. the magnitude of the velocity vector of the flow at the measuring point considered (see annex E).

The air velocity, $v_a$, at any point in a space fluctuates with time and it is recommended that the velocity fluctuations be recorded. An air flow can be described by the mean velocity, $v_a$, which is defined as the average of the velocity over an interval of time (measuring period) and by the standard deviation of the velocity, SD, given by the equation:

$$\mathrm{SD} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(v_{a_i} - v_a\right)^2}$$

where

$v_{a_i}$ is the velocity at the time "$i$" of the measuring period.



The turbulence intensity, TU, of the airflow is defined as the standard deviation divided by the mean velocity and is usually expressed in percent,

$$\mathrm{TU} = \frac{\mathrm{SD}}{v_a} \times 100$$



**4.1.6** Surface temperature is the temperature of a given surface. This is used to evaluate the radiant heat exchange between the human body by means of the mean radiant and/or the plane radiant temperature. It is also used to evaluate the effect of direct contact between the body and a given surface. The surface temperature can be measured by the method given in annex F, including:

— contact thermometer, where the sensor is in direct contact with the surface. The sensor may change the heat flow at the measuring point and then influence the result.

— infrared sensor, where the radiant heat flux from the surface is measured and converted to a temperature. This may be influenced by the emissivity of surface.

## 4.2 Characteristics of measuring instruments

### 4.2.1 Characteristics of instruments for measuring the basic quantities

The measuring ranges, measuring accuracy and 90 % response times of the sensors for each of the basic quantities are summarized in table 2. These characteristics shall be considered to be minimum requirements. According to needs and technical manufacturing possibilities, it is always possible to specify more exact characteristics. Thus, for certain quantities, very precise thermal stress measurements may require the use of appliances with measuring ranges in class S and accuracy of class C.

For the purposes of this International Standard, the time constant of a sensor is considered to be numerically equal to the time taken for the output of the sensor, in response to a step change in the environmental quantity being measured, to reach 63 % of its final change in steady-state value without overshoot. The response time, which is in practice the time after which the quantity being measured (for example: temperature of the thermometer) can be considered to be sufficiently close to the exact figure for the quantity to be measured (for example: temperature of the air), can be calculated from the time constant. A 90 % response time is achieved after a period equal to 2,3 times the time constant. It is necessary to wait, as a minimum, for a time equivalent to the response time before a measurement is taken.

As the time constant and hence the response time of a sensor does not depend solely on the sensor (mass, surface area, presence of a protective shield) but also on the environment, and hence on factors connected with a given measurement (air velocity, radiation, etc.), it is necessary to indicate the conditions under which these values were obtained. The standard environmental conditions are specified in table 3 (classes C and S). They shall be used as a reference except where this contradicts the principle for measuring the quantities under consideration.

In addition, the accuracy of measurement for air temperatures, mean radiant temperature, radiant temperature asymmetry, air velocity and humidity also depends on the effect of other quantities. Consequently, the accuracy specified in table 2 shall be achieved for the environmental conditions specified in the table.

### 4.2.2 Characteristics of integrating types of measuring instruments

Any measuring instrument integrating the measurement of several variables shall have a measuring interval, a response time and an accuracy equal to or better than those of the corresponding individual variables.

## 5 Specifications relating to measuring methods

### 5.1 General

The methods for measuring the physical characteristics of the environment shall take account of the fact that these characteristics vary in location and time.



The thermal environment may vary with the horizontal location, and then account has to be taken of how long a time a person is working at the different locations. The environment may also vary in the vertical direction, as shown in 5.2.



### 5.2 Specifications relating to variations in the physical quantities within the space surrounding the subject

An environment may be considered to be "homogeneous" from the bio-climatical point of view if, at a given moment, air temperature, radiation, air velocity and humidity can be considered to be practically uniform around the subject, i.e. when the deviations between each of these quantities and their mean spatial value calculated as a mean of the locations does not exceed the values obtained by multiplying the required measuring accuracy from table 2 by the corresponding factor $X$ listed in table 4. This condition is frequently met in the case of air temperature, air velocity and humidity, but more rarely in the case of radiation.

When the environment is too heterogeneous, the physical quantities shall be measured at several locations at or around the subject and account taken of the partial results obtained in order to determine the mean value of the quantities to be considered in assessing the comfort or the thermal stress. Previous analyses of the thermal stress of the work places being studied or of work places of a similar type may provide information which is of interest in determining whether certain of the quantities are distributed in a homogeneous way. It is usual in the case of poorly defined rooms or work places to consider only a limited zone of occupancy where the criteria of comfort or thermal stress shall be respected. In case of dispute in the interpretation of data, measurements carried out presuming the environment to be heterogeneous shall be used as a reference.

Table 5 shows the heights to be used for measuring the basic quantities and the weighting coefficients to be used for calculating the mean values for these quantities according to the type of environment considered and the class of measurement specifications.

The heights to be used for the derived quantities shall preferably be chosen in conformity with the information supplied in table 5. Plane radiant temperature, mean radiant temperature and absolute humidity are normally only measured at the centre height. Reference, however, shall be made to the general standard which defines the stress indices or thermal comfort indices and which takes precedence over this International Standard.

The different sensors shall be placed at the heights indicated in table 5 where the person normally carries out his activity. When it is impossible to interrupt the activity in progress, it is necessary to place the sensors in positions such as that the thermal exchanges are more or less identical to those to which the person is exposed (this measurement detail shall be mentioned in the results).

### 5.3 Specifications relating to the variations in the physical quantities with time

The physical quantities in the space surrounding the person can change as a function of time, for the following two reasons:

a) for a given activity, the quantities can vary as a function of external incidents such as those which accompany a manufacturing process in the case of an industrial activity;

b) the quantities can also vary as a result of the movements of the person in different environments (for example, a warm environment close to a machine and a comfortable rest environment).

An environment is said to be stationary in relation to the subject when the physical quantities used to describe the level of exposure are practically independent of the time, i.e. for instance when the fluctuations in these parameters in relation to their mean temporal value do not exceed the values obtained by multiplying the required measuring accuracy from table 2 by the corresponding factor $X$ listed in table 4.

It should be noted that the other quantities used to describe the level of exposure to heat (metabolism, energy efficiency, insulation of clothing) can also depend on time.

When an environment cannot be considered as stationary in relation to the subject, note should be taken of the main variations in its physical quantities as a function of time (this information will be used in other standards in this series in order to determine an overall comfort or thermal stress index). The measuring time and interpretation of the data will depend on which comfort or thermal stress index is being used. This information shall be found by reference to the appropriate standards.

**Table 1 — Main independent quantities involved in the analysis of the thermal balance between man and the thermal environment**

| Elements in the thermal balance | Quantities | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $t_a$ | $\bar{t}_r$ | $v_a$ | $p_a$ | $I_{cl}$ | $R_{cl}$ | $M$ | $W$ |
| | Air temperature | Mean radiant temperature | Air velocity | Absolute humidity of the air (partial pressure of water vapour) | Insulation of clothing | Evaporative resistance of clothing | Metabolism | External work |
| Internal heat production, $M - W$ | | | | | | | x | x |
| Heat transfer by radiation, $R$ | | x | | | x | | | |
| Heat transfer by convection, $C$ 1) | x | | x | | x | | | |
| Heat losses through evaporation: | | | | | | | | |
| — evaporation from the skin, $E$ | | | x | x | | x | | |
| — evaporation by respiration, $E_{res}$ | | | | x | | | x | |
| Convection by respiration $C_{res}$ | x | | | | | | x | |

1) Heat transfer by convection is also influenced by body movements. The resultant air velocity at skin level is called relative air velocity ($v_{ar}$). Heat conduction (surface temperature) has only a limited influence on the total heat balance.

**Table 2 — Characteristics of measuring instruments**

| Quantity | Symbol | Class C (comfort) | | | Class S (thermal stress) | | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Measuring range | Accuracy | Response time (90%) | Measuring range | Accuracy | Response time (90 %) | |
| Air temperature | $t_a$ | 10 °C to 40 °C | Required: ± 0,5 °C<br>Desirable: ± 0,2 °C<br>These levels shall be guaranteed at least for a deviation $\lvert t_r - t_a \rvert$ equal to 10 °C. | The shortest possible. Value to be specified as characteristic of the measuring instrument. | − 40 °C to + 120 °C | Required:<br>− 40 °C to 0 °C: ± (0,5 + 0,01 $\lvert t_a \rvert$) °C<br>> 0 °C to 50 °C: ± 0,5 °C<br>> 50 °C to 120 °C:<br>± [0,5 + 0,04 ($t_a$ − 50)] °C<br>Desirable: $\frac{\text{required accuracy}}{2}$<br>These levels shall be guaranteed at least for a deviation $\lvert t_r - t_a \rvert$ equal to 20 °C. | The shortest possible. Value to be specified as characteristic of the measuring instrument. | The air temperature sensor shall be effectively protected from any effects of the thermal radiation coming from hot or cold walls. An indication of the mean value over a period of 1 min is also desirable. |
| Mean radiant temperature | $\bar{t}_r$ | 10 °C to 40 °C | Required: ± 2 °C<br>Desirable: ± 0,2 °C<br>These levels are difficult or even impossible to achieve in certain cases with the equipment normally available. When they cannot be achieved, indicate the actual measuring precision. | The shortest possible. Value to be specified as characteristic of the measuring instrument. | − 40 °C to + 150 °C | Required:<br>− 40 °C to 0 °C: ± (5 + 0,02 $\lvert t_a \rvert$) °C<br>> 0 °C to 50 °C: ± 5 °C<br>> 50 °C to 150 °C:<br>± [5 + 0,08 ($t_r$ − 50)] °C<br>Desirable:<br>− 40 °C to 0 °C: ± (0,5 + 0,01 $\lvert t_r \rvert$) °C<br>> 0 °C to 50 °C: ± 5 °C<br>> 50 °C to 150 °C:<br>± [0,5 + 0,04 ($t_r$ − 50)] °C | The shortest possible. Value to be specified as characteristic of the measuring instrument. | When the measurement is carried out with a black sphere, the inaccuracy relating to the mean radiant temperature can be as high as ± 5 °C for class C and ± 20 °C for class S according to the environment and the inaccuracy for $v_a$, $t_a$ and $t_g$. |

**Table 2 — Characteristics of measuring instruments** (*continued*)

| Quantity | Symbol | Class C (comfort) | | | Class S (thermal stress) | | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Measuring range | Accuracy | Response time (90%) | Measuring range | Accuracy | Response time (90 %) | |
| Plane radiant temperature | $t_{pr}$ | 0 °C to 50 °C | Required: ± 0,5 °C<br>Desirable: ± 0,2 °C<br>These levels shall be guaranteed at least for a deviation $\lvert t_{pr} - t_a \rvert < 10$ °C | The shortest possible. Value to be specified as characteristic of the measuring instrument. | 0 °C to 200 °C | Required:<br>– 60 °C to 0 °C: ± (1+ 0,1 $\lvert t_{pr} \rvert$) °C<br>0 °C to 50 °C: ± 1 °C<br>50 °C to 200 °C:<br>± [1 + 0,1 ($t_{pr}$ – 50)] °C<br>Desirable: $\frac{\text{required accuracy}}{2}$<br>These levels shall be guaranteed at least for a deviation $\lvert t_{pr} - t_a \rvert < 20$ °C | The shortest possible. Value to be specified as characteristic of the measuring instrument. | |
| Air velocity | $v_a$ | 0,05 m/s to 1 m/s | Required: ± (0,05 + 0,05 $v_a$) m/s<br>Desirable: ± (0,02 + 0,07 $v_a$) m/s<br>These levels shall be guaranteed whatever the direction of flow within a solid angle<br>(:) = 3 π sr | Required: 0,5 s<br>Desirable: 0,2 s | 0,2 m/s to 20 m/s | Required: ± (0,1 + 0,05 $v_a$) m/s<br>Desirable: ± (0,05 + 0,05 $v_a$) m/s<br>These levels shall be guaranteed whatever the direction of flow within a solid angle<br>(:) = 3 π sr | The shortest possible. Value to be specified as characteristic of the measuring instrument.<br>For measuring the degree of turbulence a small response time is needed. | Except in the case of a undirectional air current, the air velocity sensor shall measure the velocity whatever the direction of the air. An indication of the mean value and standard deviation for a period of 3 min is also desirable. |

**Table 2 — Characteristics of measuring instruments** (*concluded*)

| Quantity | Symbol | Class C (comfort) | | | Class S (thermal stress) | | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Measuring range | Accuracy | Response time (90%) | Measuring range | Accuracy | Response time (90 %) | |
| Absolute humidity expressed as partial pressure of water vapour | $p_a$ | 0,5 kPa to 3,0 kPa | ± 0,15 kPa<br>This level shall be guaranteed for a difference $\|t_r - t_a\|$ of at least 10 °C. | The shortest possible. Value to be specified as characteristic of the measuring instrument. | 0,5 kPa to 6,0 kPa | ± 0,15 kPa<br>This level shall be guaranteed for a difference $\|t_r - t_a\|$ of at least 20 °C. | The shortest possible. Value to be specified as characteristic of the measuring instrument. | |
| Surface temperature | $t_s$ | 0 °C to 50 °C | Required: ± 1 °C<br>Desirable: ± 0,5 °C | The shortest possible. Value to be specified as characteristic of the measuring instrument. | – 40 °C to + 120 °C | Required:<br>< – 10 °C: ± [1 + 0,05 (– $t_s$ – 10)]<br>– 10 °C to 50 °C: ± 1 °C<br>> 50 °C: ± [1 + 0,05 ($t_s$ – 50)]<br>Desirable: $\frac{\text{required accuracy}}{2}$ | The shortest possible. Value to be specified as characteristic of the measuring instrument. | |
| Radiation directional | $r_d$ | From – 35 W/m² to + 35 W/m² | ± 5 W/m² | Required: 1,0 s<br>Desirable: 0,5 s | From – 300 to + 100 °C<br>From 100 °C to 1000 °C<br>From 1000 W/m² to 2500 W/m² | ± 5 W/m²<br>± 10 W/m²<br>± 15 W/m² | Required: 1,0 s<br>Desirable: 0,5 s | |

NOTE — At some work places in hot environments (steel, coal, glass industries) there may be a need to measure plane radiant and surface temperatures at higher levels than the range in this table. The manufacturers of instruments are required to state the accuracy for an extended range.

**Table 3 — Standard environmental conditions for the determination of time constants of sensors**

| Measurement of the response time of sensors for \ Quantities of the standard environment | $t_a$ | $\bar{t}_r$ | $p_a$ | $v_a$ |
|---|---|---|---|---|
| Air temperature | | = $t_a$ | Any | < 0,15 m/s |
| Mean radiant temperature | = $t_r$ | | Any | < 0,15 m/s |
| Absolute humidity | = 20 °C | = $t_a$ | | To be specified according to the measuring method |
| Air velocity | = 20 °C | = $t_a$ | Any | |
| Plane radiant temperature | = 20 °C | = $t_a$ | Any | < 0,15 m/s |
| Surface temperature | = 20 °C | = $t_a$ | Any | < 0,15 m/s |

**Table 4 — Criteria for a homogeneous and steady-state environment**



| Quantity | Class C (comfort) Factor $X$ | Class S (thermal stress) Factor $X$ |
|---|---|---|
| Air temperature | 3 | 4 |
| Mean radiant temperature | 2 | 2 |
| Radiant temperature asymmetry | 2 | 3 |
| Mean air velocity | 2 | 3 |
| Vapour pressure | 2 | 3 |

NOTE — Deviation between each individual quantity and their mean value shall be less than that obtained by multiplying the required measuring accuracy (table 2) by the appropriate factor $X$ from this table.

**Table 5 — Measuring heights for the physical quantities of an environment**

| Locations of the sensors | Weighting coefficients for measurements for calculation mean values | | | | Recommended heights (for guidance only) | |
|---|---|---|---|---|---|---|
| | Homogeneous environment | | Heterogeneous environment | | Sitting | Standing |
| | Class C | Class S | Class C | Class S | | |
| Head level | | | 1 | 1 | 1,1 m | 1,7 m |
| Abdomen level | 1 | 1 | 1 | 2 | 0,6 m | 1,1 m |
| | | | | | | |