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Ergonomics of the thermal environment — Instruments for measuring physical quantities

Ergonomie des ambiances thermiques — Appareils de mesure des grandeurs physiques

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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.