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Ergonomics of the physical environment — Application of International Standards to people with special requirements

Ergonomie de l'environnement physique — Application des Normes internationales aux personnes ayant des exigences particulières

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 28803 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment*.

Introduction

This is one of a series of International Standards concerned with the ergonomics of the physical environment. This International Standard complements others in the series concerned with specific components of the environment, such as thermal environments, acoustics, lighting or air quality, building upon them to allow an assessment of human response to the total environment. This International Standard is particularly concerned with extending the scopes of other International Standards — see 5.2.2, 5.3.2 to 5.3.5, 5.4.2, 5.5, 6.2 to 6.6, 7.3 and 9.2 — so that they can be applied to as wide a range of people as possible. The background information it provides on the responses and needs of groups of persons with special requirements will contribute to accessible environmental designs that will complement other activities in the field of ergonomics.

This International Standard includes a description of the range and variety of responses and adaptations to physical environments of people with special requirements, and the consequences for measuring and evaluating those environments. It considers the application of indices and methods for people with special requirements where health and safety, comfort and well-being are considerations. It provides a description of the nature of the particular characteristics of people with special requirements in the context of their responses to environments (e.g. restricted sensation, reduced perception or ability to respond). It is not a database of characteristics of people with special requirements, but uses data from ISO/TR 22411 to provide methods and criteria that will in turn provide accessible environments.

Ergonomics of the physical environment — Application of International Standards to people with special requirements

1 Scope

This International Standard describes how International Standards concerned with the ergonomics of the physical environment can be applied for people with special requirements, who would otherwise be considered to be beyond the scope of those standards. It has been produced according to the principles of accessible design provided in ISO/IEC Guide 71 and using the data provided in ISO/TR 22411.

It is not restricted to any specific environment but provides the general principles that allow assessment and evaluation, and can contribute to the development of standards concerned with specific environments. It is applicable to built environments as well as to other indoor, vehicle and outdoor environments. Nor is it restricted to specific environmental components; it includes assessment of acoustic environments, thermal environments, lighting, air quality and other environmental factors that could be considered to influence the health, comfort and performance of people with special requirements in an environment.

It is applicable to all occupants of such environments who can be considered to have special requirements.

NOTE This will depend upon context and can, for example, include babies, infants, men or women, people with disabilities, older or ill people. A person could have a special requirement in one type of environment but not in another.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13731, *Ergonomics of the thermal environment — Vocabulary and symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13731 and the following apply.

3.1
accessible design
design focussed on principles of extending standard design to people with some type of performance limitation to maximize the number of potential customers who can readily use a product, building or service which may be achieved by

— designing products, services and environments that are readily usable by most users without any modification,

— making products or services adaptable to different users (adapting user interfaces), and

— having standardized interfaces to be compatible with special products for persons with disabilities

NOTE 1 Terms such as design for all, barrier-free design, inclusive design and transgenerational design are used similarly but in different contexts.

NOTE 2 Accessible design is a subset of universal design where products and environments are usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.

[ISO/IEC Guide 71:2001, definition 3.2]

3.2
assistive technology
technology that is used to increase, maintain or improve functional capabilities of individuals with disabilities

3.3
assistive device
piece of equipment, product system, hardware, software or service that is used to increase, maintain or improve functional capabilities of individuals with disabilities

3.4
user
person who interacts with the product, service or environment

3.5
alternative format
different realization or presentation which may make products and services accessible by the use of another modality or sensory ability

3.6
impairment
limitation in body function or structure, such as a significant deviation or loss of capability, which can be temporary (for example, due to injury) or permanent (slight or severe and can fluctuate over time)

EXAMPLE Deterioration due to aging.

3.7
standard

document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context

NOTE Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

[ISO/IEC Guide 2:2004, definition 3.2]

3.8
international standard
standard that is adopted by an international standardizing/standards organization and made available to the public

[ISO/IEC Guide 2:2004, definition 3.2.1.1]

3.9
International Standard
international standard where the International Standards organization is ISO or IEC

3.10
adaptive opportunity
opportunity for a person to alter the environment to which he or she is exposed by behavioural (move away, adjust posture, adjust clothing, etc.) or other means (open window, close door, adjust environmental controls etc.)

4 General factors requiring consideration when designing or evaluating environments for people with special requirements

People with special requirements are people who generally fall outside the scope of most International Standards. Standards for environmental design and assessment are often valid only for people with specific characteristics who are frequently referred to as “normal” or “typical”. Environmental design for a wider

population can require different conditions from those given in a standard, in order to provide comfort or avoid unacceptable stress on the body.

NOTE Existing thermal International Standards cover a range of conditions, types of people and so on, which are identified in the scope of those documents, thereby providing information for people who fall outside the scope and who should be treated as people with special requirements.

One reason for standards to have a restricted scope in terms of user population, is that knowledge is incomplete for people who might have special requirements in environmental design. These people often include children, people with disabilities and older people. Although knowledge about such populations is incomplete, advice can still be provided to ensure accessible design of environments.

Clauses 5 to 9 describe the assessment of the thermal, acoustic, visual, lighting, air quality and other environments. For each environmental component, guidance is provided on how to apply the relevant International Standards for people with special requirements.

General considerations include factors which affect a person's response to the particular environmental component. For example, body size and shape or the ability to move around can be important. The relevant International Standards are then considered in terms of these general considerations. For example, if someone with a spinal injury cannot sweat below the lesion, then a heat stress standard based upon sweat rate will require appropriate modification. General advice can then be provided in terms of modifications to the relevant International Standard in order to make it more valid for a wider range of people.

A characteristic of people who are not "normal" or "typical" is the wide variation in response across the population; often, individual characteristics would have to be considered. In such cases, or where unacceptable strain or threat to health are involved, then medical advice needs to be sought. In such cases, the information provided in Clauses 5 to 9 should be brought to the attention of the medical advisor.

One particular consideration is the degree to which a person can modify exposure to environments by behavioural measures. People with special requirements could have restricted behavioural opportunities (to move around, change clothing, control the environment, etc.) and this will be important for all environmental components.

5 Considerations related to design and evaluation of the thermal environment

5.1 Factors requiring special consideration for design and evaluation

The following factors shall be considered when assessing the thermal environment.

a) **Sensory impairment and paralysis**

Some physical disabilities and methods of treatment (e.g. drugs) affect thermal sensation and requirements for thermal comfort and health. Examples of drugs that can affect body temperature regulation are beta blockers, diuretics, laxatives, anticholinergics, antihistamines, neuroleptics, methydopa, MAO inhibitors, tricyclic antidepressants, serotoninergic agonists, phenothiazines and vasoconstrictors.

Additional issues include methods for collecting valid and reliable data on the responses of people with special requirements, e.g. pregnant women, older people or babies.

b) **Difference in the shape of the body**

The loss or atrophying of a limb makes the application of the Dubois' surface area formula difficult and prone to error. Consequently, it will have some influence on the concept of mean skin temperature. Infants and babies will have somewhat different body proportions compared to average adults. This influences the projected surface area available for heat exchange from different parts of the body and hence the impact of thermal radiation, convection and evaporation.

c) **Impairment of sweat secretion**

It is not uncommon for more than 80 % of the sweat-secreting skin area to be impaired in quadriplegic persons (high-level spinal cord injured persons) and some other paralytic diseases. This will affect the

interpretation of thermal environment indices for hot environments, especially rational ones in which a "normal" level of sweating is assumed and the concept of *wettedness* plays an important role.

d) **Impairment of vasomotor control**

Impairment of peripheral vasomotor control, often found in such groups as the aged, spinal-cord injured or persons taking vasodilator drugs, affects adaptability to both cold and hot environments and often requires special consideration when considering thermal conditions.

e) **Differences in metabolic rate**

People with physical disabilities who use technical aids such as wheelchairs often have low metabolic rates due to their sedentary activity level. Conversely, others (such as those suffering athetosic cerebral palsy) require greater energy to perform tasks and hence have a higher metabolic rate due to the greater effort involved. Older persons are often less active and have a lower metabolic rate than average adults but there are large individual differences.

f) **Influence of thermal stress on other physiological functions**

Cerebral apoplexy and cardiovascular attacks are often evoked by thermal stress in (cold) winters and unusually hot summers. Sweat secretion can cause some cutaneous chronic diseases such as epidermolysis bullosa hereditaria. Cold environments may cause frequent urination. Strain is greater after exhaustive work, night work, "jet lag", etc.

5.2 Moderate thermal environments and people with special requirements

5.2.1 General considerations

Thermal conditions that are "normally" considered as moderate and providing thermal comfort, may not be moderate or acceptable to people with disabilities. People with paralysis due to injury to the spinal cord, for example, may report thermal sensation even on the paralyzed part of the body, which will also affect overall body sensation and comfort. Peripheral vasomotor disorders will affect heat exchange with the environment and studies have reported deterioration of thermal sensation and slow thermoregulatory responses in older people.

To evaluate whether an environment is acceptable or not, in addition to taking sensation votes, some simple physiological measurement (of oral temperature, using a clinical thermometer, heart rate, etc.) can be necessary on a regular basis. When at work, most people with special requirements are likely to be in what are, for the average healthy person, moderate thermal environments.

5.2.2 ISO 7730, *Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*

The PMV (predicted mean vote) and PPD (predicted percentage of dissatisfied) indices were statistically derived from a theoretical comfort equation and experimental data obtained from a large number of subjects, mainly healthy young adults, although some older persons were considered. The method given in ISO 7730 could require modification for adequate prediction of the thermal sensation or dissatisfaction of people with disabilities and older people with thermoregulatory impairments. The method given is not intended for predicting the thermal sensation of persons, but rather to predict which thermal conditions (temperature, humidity, air velocity, clothing, activity) are acceptable or preferred. Both laboratory and field studies suggest that the PMV/PPD indices may adequately predict mean thermal responses for the majority of people with disabilities; however, they also show a wide variation in responses, demonstrating that consideration of individual requirements is necessary.

The PMV comfort equation seems to be useful for evaluating moderate thermal environments, i.e. the effect of the thermal environment on various persons with and without special requirements.

One problem with the structure of the comfort equation is the physiological background of the comfortable evaporative heat loss related to activity level. Further examination is necessary to determine if the equation for comfortable evaporation is appropriate for people with disabilities with impaired nervous control of sweating.

When estimating the mean radiant temperature, differences in body shape can be taken into account, but this is only of importance in environments with large directional differences in radiant temperature.

Persons with physical disabilities (e.g. spinal cord injury) often have vasoconstriction disorder and impaired sweating. This means their thermoregulation system does not compensate well if the ambient temperature deviates from the neutral temperature. Therefore, it is important for people with disabilities that the ambient temperature be close to the neutral temperature. Most studies show that the preferred neutral ambient temperature is the same as for people without disabilities and so the method in ISO 7730 can be used. People with physical disabilities often also have lower activity levels. They may not easily be able to change their activity or clothing level. Furthermore, the insulation of a wheelchair (0,1 to 0,2 clo) must be taken into account.

Under the same clothing and activity conditions, older persons may prefer the same neutral temperature as younger people. Nevertheless, many older people have a lower activity level (spending more hours of each day seated) than younger persons with a corresponding elevation in the neutral temperature. Due to lack of vasoconstriction and decreased thermal sensation, ambient temperatures on the cool side of thermal neutrality should be avoided. The designer should select an acceptable temperature range corresponding to $0 < \text{PMV} < +0{,}5$.

Many of the above factors will be taken into account in the PMV/PPD method, as they affect estimates of the six basic parameters (inputs to the method). Additional modification is often required, however, especially when deviating from thermal neutrality and where individual characteristics are important.

5.3 Hot environments and people with special requirements

5.3.1 General considerations

Except in tropical countries, normally only a limited number of people with special requirements will work in hot environments. But they may be exposed to severe conditions in their home, during outdoor activities, sport activities or traveling. ISO 12894 provides a list of contraindications that would make people particularly vulnerable to exposure to heat and hence require special consideration. See also Table 1.

5.3.2 ISO 7243, *Hot environments — Estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature)*

ISO 7243 was developed for estimating heat stress during work in hot environments based on the WBGT-index.

Reference values should naturally be re-established to allow for a maximum rectal temperature but taking into consideration the physiological tolerance and reactions of the persons with special requirements concerned.

The WBGT-index may underestimate the effects of heat stress on persons with disorders of sweat secretion because of their reduced ability to cool themselves by evaporation of sweat.

The effects of age on responses to heat stress are varied and directly relate to fitness. Fit, healthy and thin older people will have similar tolerance levels when compared to younger people. However, older people are often not as fit as younger people and reduced limits for unacceptable heat stress will be required.

5.3.3 ISO 7933, *Ergonomics of the thermal environment — Analytical determination and interpretation of heat stress using calculation of the predicted heat strain*

The required sweat rate may be used as an index for hot environments for people with special requirements but it will require careful modification and application. Impairments of sweat secretion must be considered when applying ISO 7933 to older adults and people with disabilities and comparing estimated and measured values for sweat rate.

For several types of the disabled, such as spinal-cord-injured persons whose sweat-secreting skin areas are reduced, the formula for calculating the maximum evaporation rate should be modified to take account of the reduced surface area for sweating. For example, for a spinal cord injury in the mid-spine region, the maximum capacity to cool by sweating should be halved.