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Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 6:
Guidance on the work environment

Exigences ergonomiques pour travail de bureau avec terminaux à écrans de visualisation (TEV) —

Partie 6: Guide général relatif à l'environnement de travail

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International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

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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 3.

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 9241-6 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Sub-Committee SC 4, *Ergonomics of human-system interaction*, Working Group WG 3, *Control, workplace and environmental requirements*.

ISO 9241 consists of the following parts, under the general title *Ergonomic requirements for office work with visual display terminals (VDTs)*:

— *Part 1: General introduction*

— *Part 2: Guidance on task requirements*

— *Part 3: Visual display requirements*

— *Part 4: Keyboard requirements*

— *Part 5: Workstation layout and postural requirements*

— *Part 6: Guidance on the work environment*

— *Part 7: Requirements for display with reflections*

— *Part 8: Requirements for displayed colours*

— *Part 9: Requirements for non-keyboard input devices*

— *Part 10: Dialogue principles*

— *Part 11: Guidance on usability*

— *Part 12: Presentation of information*

— *Part 13: User guidance*

— *Part 14: Menu dialogues*

— *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

— *Part 17: Form filling dialogues*

Annexes A to D of this part of ISO 9241 are for information only.

Introduction

This part of ISO 9241 applies to work systems as defined in ISO 6385 with visual display terminals (VDTs) as described in ISO 9241-1. Office work with VDTs can be performed in various environments. These environments can influence both the comfort and performance of the user. In addition, the work environment can be influenced by specific characteristics of the VDTs and related equipment (for example, printers, computers).

This part of ISO 9241 has been prepared to give guidance on the determination of environmental conditions which enhance user comfort and performance. Enhancing the interaction between users and environments often requires a well-balanced trade-off. For this reason, this part of ISO 9241 provides guiding principles as generic goals, basic aspects for each item (for example, lighting, noise) and gives guidance on developing integrated solutions under given circumstances (for example, methods of controlling the acoustic environment for a given task and a given environment).

Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 6:
Guidance on the work environment

1 Scope

This part of ISO 9241 provides guidance on basic principles for the ergonomic design of the work environment and the workstation, taking into account lighting, effects of noise and mechanical vibrations, electrical and magnetic fields and static electricity, thermal environment, space organization and workplace layout.

This part of ISO 9241 is applicable to the work environment and workstation in those work systems where a visual display terminal (VDT) is used for office work.

However, this part of ISO 9241 does not specify the technical characteristics of the equipment needed to satisfy those equipment-related guidelines associated with the work environment.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 9241. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 9241 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1996-1, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures.*

ISO 2631-1, *Evaluation of human exposure to whole-body vibration — Part 1: General requirements.*

ISO 2631-2, *Evaluation of human exposure to whole-body vibration — Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz).*

ISO 5349, *Mechanical vibration — Guidelines for the measurement and the assessment of human exposures to hand-transmitted vibration.*

ISO 6385, *Ergonomic principles in the design of work systems.*

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

ISO 8995:1989, *Principles of visual ergonomics — The lighting of indoor work systems.*

ISO 9241-3:1992, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 3: Visual display requirements*.

ISO 9241-7, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 7: Requirements for display with reflections*.

ISO 9612, *Acoustics — Guidelines for the measurement and assessment of exposure to noise in a working environment*.

ISO 11690-1:1996, *Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 1: Noise control strategies*.

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test*.

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 8, Power frequency magnetic field immunity test.*

3 Terms and definitions

For the purposes of this part of ISO 9241, the terms and definitions given in ISO 6385, ISO 1996-1, ISO 11690-1 and the following apply.

3.1
adaptation, visual
process by which the state of the visual system is modified by previous and present exposure to stimuli that may have various luminances, spectral distributions and angular subtenses

[IEC 60050(845):1987, IEC 845-02-07]

3.2
clothing insulation
resistance of a clothing ensemble to dry heat loss from the body (convection, radiation, conduction)

NOTE Adapted from ISO 9920:1995.

3.3
colour rendering
effect of an illuminant on the colour appearance of objects by conscious or subconscious comparison with the appearance under a reference illuminant

[IEC 60050(845):1987, IEC 845-02-59]

3.4
colour rendering index R_a
mean of the CIE 1974 special colour rendering indices for a specified set of eight test colour samples

[IEC 60050(845):1987, IEC 845-02-63]

3.5
colour temperature
the temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus

[IEC 60050(845):1987, IEC 845-03-49]

3.6
draught rating
percentage of people predicted to be bothered with draught

[ISO 7730:1994]

3.7
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

[IEC 60050(845):1987, IEC 845-02-49]

3.8
general lighting
substantially uniform lighting of an area without provision for special local requirements

[IEC 60050(845):1987, IEC 845-09-06]

NOTE General lighting can be thought of as the lighting of a room to achieve approximately the same visual conditions at all places in the room.

3.9
glare
condition of vision in which there is discomfort or a reduction in the ability to see details or objects, caused by an unsuitable distribution or range of luminance, or to extreme contrasts

[IEC 60050(845):1987, IEC 845-02-52]

3.10
glare by reflection
glare produced by reflections, particularly when reflected images appear in the same or nearly the same direction as the object viewed

[IEC 60050(845):1987, IEC 845-02-54]

3.11
illuminance
(at a point of a surface), the quotient of the luminous flux ($d\Phi_V$) incident on an element of the surface containing the point, by the area (dA) of that element

[IEC 60050(845):1987, IEC 845-01-38]

3.12
lighting, localized
lighting designed to illuminate an area with a higher illuminance at certain specified positions, for instance those at which work is carried out

[IEC 60050(845):1987, IEC 845-09-08]

3.13
luminance balance
ratio between the luminances of the displayed image and its adjacent surround, or sequentially viewed surfaces

NOTE Adapted from the definition of “luminance” given in IEC 60050(845):1987, IEC 845-01-35.

3.14
mean radiant temperature
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

[ISO 7726:1998]

3.15
operative temperature
uniform temperature of a radiantly black enclosure in which an occupant would exchange the same amount of heat by radiation plus convection as in the natural non-uniform environment

NOTE Adapted from ISO 7726:1998.

3.16
predicted mean vote
PMV
index that predicts the mean value of the votes of a large group of persons on a 7-point thermal sensation scale

[ISO 7730:1994]

3.17
predicted percentage of dissatisfied
PPD
index that predicts the mean value of the thermal votes of a large group of people exposed to the same environment as a quantitative prediction of the number of thermally dissatisfied people

NOTE Adapted from ISO 7730:1994.

3.18
radiant temperature asymmetry
difference between the plane radiant temperature of the two opposite sides of a small plane element

[ISO 7726:1998]

3.19
rating level
LAR
equivalent continuous A-weighted sound pressure level during a specified time interval plus adjustment for tonal character and impulsiveness

NOTE Adjustment for tonal character DL_T = 0,5 dB according to subjective assessments. Impulsiveness is specified only if $DL_I = L_{IAeq} - L_{Aeq} > 2$ dB, both according to ISO 11690-1.

3.20
relative humidity
ratio between the partial pressure of water vapour in humid air and the water vapour saturation pressure at the same temperature and the same total pressure

[ISO 7726:1998]

3.21
reverberation
continuation of a sound in an enclosed space after the source has stopped; a result of reflections from the boundary surfaces of the room

3.22
turbulence intensity
ratio of the standard deviation of the local air velocity to the local mean air velocity

[ISO 7730:1994]

3.23
workplace
arrangement of workstations allocated to one person to complete a work task

[ISO 9241-5:1998]

3.24
workstation
assembly comprising display equipment with or without a central processing unit, which may be provided with a keyboard and/or input device and/or software determining the operator/machine-interface, optional accessories, peripherals and the immediate work environment

[ISO 9241-5:1998]

4 General guiding principles

Improving the ergonomic properties of the design of workstation, work equipment and work environment, will help to improve user performance, reduce errors and discomfort, and will help to improve their overall well-being.

Environmental design should incorporate adequate control by the individuals over their environmental conditions.

The interference of environmental factors with the relevant characteristics of the equipment should be kept as low as possible. The unwanted influence of the equipment on the work environment should also be minimized.

NOTE "Interference" in this sense means that the function of a given device is impaired by the influence of a specific environmental factor.

The characteristics of the work equipment and the work environment are considered under the following headings:

— natural and artificial lighting;

— sound and noise;

— mechanical vibrations;

— electromagnetic fields and static electricity;

— thermal environment;

— space organization and workplace layout.

NOTE This part of ISO 9241 does not address any potential health effects associated with electromagnetic radiation emissions from equipment and environment.

5 Guidance on natural and artificial lighting

5.1 General

Visual tasks associated with work with most visual displays differ primarily in three ways from the visual tasks related to traditional office work.

— The main visual object, the visual display unit, is in a vertically oriented position.

— The main visual object can be environment dependent (for example, because of reflections, loss of contrast and colour information caused by ambient light) to a high degree.

— The elevated line-of-sight increases the importance of the consideration of the characteristics of the visual environment.

5.2 Basic aspects

5.2.1 Visual tasks

In regard to the type of office work performed with a visual display terminal, a basic distinction should be made between two types of visual tasks:

a) assimilation of data presented on the display screen (for example, reading texts, viewing graphs, observing processes or perceiving and distinguishing symbols on the VDT screen);

b) assimilation of data presented on passive media (for example, reading texts or viewing graphs on paper or perceiving and distinguishing symbols on the VDT keyboard).

These different types of visual tasks, each considered on its own, indicate that the lighting should fulfil various user requirements. The lighting system should have sufficient flexibility to match the needs of users of display screens and passive media.

Correct lighting will not compensate for situations where a user's vision is not adequate or has not been adequately corrected for the task.

5.2.2 Basic design goals

A good lighting installation should be designed to fulfil its intended functions and should be compatible with the work environment. Relevant factors include the following:

- favourable distribution of the luminance and contrasts in the workroom;
- the illuminance in the horizontal and vertical planes;
- the ratio between the illuminance in the two planes.

In addition, it is important to consider that

- the lighting of many work environments is produced by a combination of natural and artificial light;
- windows perform a dual function that involves
  - visual contact with the outside, and
  - creating an adequate and acceptable level of luminance(s) on the inside;
- the quality criteria for artificial lighting are specified in the introduction of ISO 8995:1989 and include the following aims of visual ergonomics:
  - “to optimize the perception of visual information used during the course of work;
  - to maintain an appropriate level of performance;
  - to guarantee maximum safety;
  - to provide acceptable visual comfort.”
- the resulting quality can be affected by the presence of uncontrolled daylight.

In many situations, the installation of workstations and work equipment can be varied, based on the needs of work organization or users. Well designed lighting systems take into account frequent changes in workstation layout, equipment and work space layout.

5.3 Luminance distribution in the work space

The luminance distribution in the field of vision should be selected so that

- visual conditions are enhanced,
- glare is avoided,
- perception of relevant task objects is ensured,
- modelling of three-dimensional objects, for example faces, is enhanced,
- a well-balanced luminance distribution is achieved,
- visual communication is improved, and
- safety at work is not impaired.

For acceptable visual conditions, as well as for psycho-physical reasons, a balanced luminance distribution in the field of vision is beneficial.

Further information on lighting is given in annex A, together with a guide to selecting the type of lighting (see A.8).

5.4 Glare control

Glare should be avoided by suitable design and installation of the work equipment and the work environment.

In this connection, a distinction is made between

— direct glare,

— glare by reflection.

Direct glare refers to glare (see ISO 8995) from luminaires and other light-emitting surfaces (lamps, illuminated ceilings, sky, obstructions like adjacent buildings with reflecting glass surfaces). Glare can be caused by excessive, simultaneous local or successive differences in luminance in the field of vision. It relates both to large space-confining surfaces and to objects in the immediate and wider surroundings. The degree of impairment depends on the apparent size, luminance and position of the source of interference in the field of vision and on the state of adaptation of the viewer.

Glare by reflection is glare caused by reflected light (see ISO 8995). It can be caused by specular reflections resulting in a distinct image of the original object or by diffuse reflections resulting in high luminances. Glare by reflection can affect both task performance and comfort. Task performance can be affected if the reflected image of a visual object obscures the task on the display or on other visual objects. In addition, the contrast ratio of images can be lowered to an extent that readability or visibility is impaired. Comfort can be affected directly by luminance imbalance caused by the reflected image or indirectly by impairing visual functions.

To avoid glare by reflection, displays with a reflection-control treatment appropriate for the task and environment intended should be used (see ISO 9241-7). ISO 9241-7 specifies three classes of VDTs. Class I is considered suitable for general office use whereas Class II is suitable for most, but not all, office environments. Class III monitors require a specially controlled luminous environment for use. To achieve acceptable visual conditions, either the visual environment should be controlled according to the category of the display used or the appropriate category for the display should be selected considering the visual environment.

Methods for the restriction of glare are discussed in A.3. As a result of different characteristics of the work equipment or work environment, the appropriate method for a particular workstation can be different.

The selected methods for glare control should ensure that a comfortable posture can be maintained. This means that the glare control method should not impose any postural restrictions on the user. With respect to windows, adequate measures should be taken to control glare from windows. Such measures should be selected to allow user control and to maintain visual contact with the outside.

For avoiding or restricting glare by reflection on a VDT, different methods can be applied. The adequate combination should be selected with respect to the needs of the particular user and circumstances at the particular workstation (see annex A). These methods can be used in isolation or in combination with each other.

When applying the methods for avoiding glare by reflection, it should be remembered that an appropriate match between the VDT and the environment is not the product of a single factor, and that the methods given in Figure A.2 represent different approaches. Different types of display (for example, cathode ray tubes (CRTs) with curved surfaces or flat panel displays) may require different measures to achieve the same level of visual comfort. In general, positive polarity displays with adequate additional reflection control measures should be used as a preferred solution.

Glare control by artificial lighting (luminaire design, correct positioning of luminaires) should be taken into account when planning the work space. Shielding the glare source from the display position by movable partitions or similar techniques is a measure that should be applied if other lighting-related measures are not applicable in a given situation.

Glare control by correct location of the display and/or the workstation can be realized by applying one or more of the possibilities described in A.3.

Where multiple displays are used, a combination of the measures described in this part of ISO 9241 may be needed.

6 Guidance on sound and noise

6.1 Basic aspects

The purpose of the details given in this clause is to provide guidance on improving workstations and workrooms acoustically for activities on visual display terminals.

Unlike those acoustic events which serve the specific purpose of transmitting information (for example, verbal communication and warning signals), the term noise is used for acoustic events which disturb, are undesired or have an adverse effect. Undesired effects of noise can be classified as follows:

- impaired hearing;
- undesired reactions of the central and autonomic nervous system;
- hindrance of verbal and other communication;
- reduced performance and cognitive functioning;
- annoyance.

The annoyance and undesired effects of noise at the workplace should be assessed by the rating level (L_{AR}) (see ISO 9612). Furthermore, the information content of the noise and nature of the work should be taken into account when assessing noise.

Undesirable effects of noise, such as reduced performance, annoyance and reactions of the nervous system, are more likely the more difficult and complex the task performed. These effects manifest themselves as a drop in performance in memory processes, i.e. prompt recall, retention and acquisition of information when continuous attentiveness and concentration are required, and in complex processing techniques. Information-containing sounds (including speech, machine sounds with a distinctive time sequence) can also impair the performance at low noise levels. Human speech as an undesired sound can interfere with acoustic communication, as well as the mental capabilities associated with short-term memory. Noise, in particular information-containing sound, result in disturbances to the attention and impairment of verbal communication. This is true for both face-to-face and mediated communication.

NOTE For offices with multiple workplaces, it is not necessary to remove all sound from extraneous sources in a work environment, because in an environment which is "too quiet" even low-level sound from nearby conversation and equipment can be distracting.

Building services and office architecture can cause noise by different mechanisms. With regard to the building services, there is the noise from air supply through grills and dampers, ductwork transmitted fan noise and cross-talk between areas through ductwork. With regard to the architecture, there is noise break-through between partitions and cross-talk through ceiling and floor voids between areas.

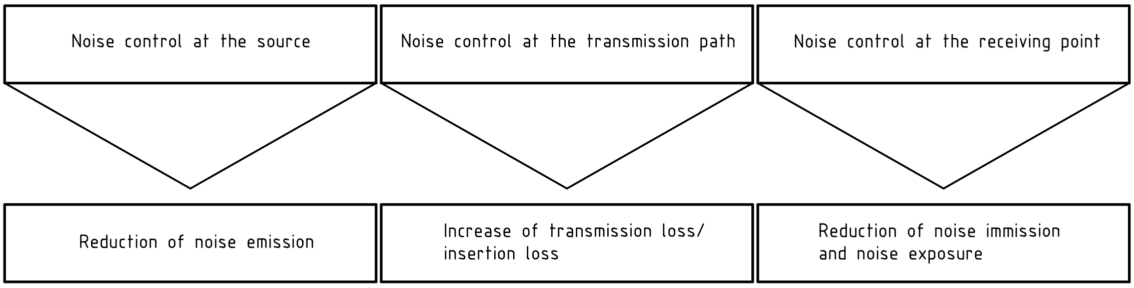
6.2 Reduction of noise effects

In order to avoid undesirable effects of noise, the rating level L_{AR} at the workplace should be low enough to perform the intended tasks. Noise exposure in workplaces [35 dB(A) to 55 dB(A)] which should not be exceeded for specific tasks is given in ISO 11690-1. In order to achieve this, the noise emission from work equipment should be low enough not to interfere with the performance of the task. However, these general measures may not be applicable in certain environments, for example, where a number of people need to use a telephone. Therefore, in such cases single factors (for example, noise from external sources) should be identified and appropriate noise-control measures considered with regard for relevant user needs (for example, improving verbal communication, reducing unwanted communication and annoyance). Basic aspects of noise control are displayed in Figure 1.

The relationship between different control measures and the specific goals for their introduction is shown in Figure B.1.

When replacing or purchasing equipment and machinery for workrooms, relevant data given in equipment specifications for the noise emission from these equipment and machines should be taken into account. Furthermore, the workrooms should be acoustically designed so that the rating level is acceptable for the intended task. The selection of the appropriate control measures depends upon the task to be performed and the characteristics of the noise. Noise control strategies and measures are described in ISO 11690-1 and ISO 11690-2.

Further information, including methods for measuring and evaluating sound and noise are discussed in annex B.



NOTE Derived from Figure 1 of ISO 11690-2:1996.

Figure 1 — Basic aspects of noise control

7 Guidance on mechanical vibrations

7.1 Basic aspects

Mechanical vibrations (defined in ISO 2041) are periodically occurring changes in physical location. They can influence or impair the user, the function of working devices or parts of them. These effects have generally been well researched (see annex C).

Examples of vibration in the work environment relating to office work include air-conditioning systems, impact printers and the proximity of the workstation to industrial activities that are liable to cause vibrations.

7.2 Reduction of effects of mechanical vibrations

7.2.1 General

7.2.1.1 Types of effect

This subclause provides guidance for limiting the presence of vibrations at the workplace and in workrooms. Mechanical vibrations at certain levels acting on the users or their working devices can adversely influence health and safety at work. Moreover, they can impair the user well-being and her/his perception of the information displayed and the use of controls, for example keyboards. This impairment can take the following form:

a) effect on the user;

b) effect on the legibility of optical devices;

c) effect on the use of operating elements.

7.2.1.2 Effects of mechanical vibrations on the user

When mechanical vibrations act on the user's body (for example, feet, buttocks, hands, head), a nuisance, work hindrance, drop in performance and damage to health can occur depending on the evaluated vibration intensity (see ISO 2631-1, ISO 5349). For the perception of optical displays, vibrations in the range 2 Hz and the resonance range of the eyeball (16 Hz to 32 Hz) are generally of importance. Certain forms of vibration result in a decrease in visual acuity of up to 20 %. At a vibrational stress in the vertical or lateral axis of the body, considerable increases in the perception times (up to 50 fold) can be expected.

7.2.1.3 Effects of mechanical vibrations on the legibility of optical devices

The effect of vibrations on time-constant displays (for example, printed symbols) impairs perception differently from the perception of time-variable displays (for example CRTs). In general, the legibility or visibility of time-constant displays suffer from vibration less strongly than time-variable displays do. Line-oriented text is more prone to degradation than grey scale images on the same device [see Çakir and Çakir (1988)[21]]. The impact of vibrations on the legibility also depends on the VDT display characteristics (for example, the refresh rate of the screen). With simultaneous vibratory excitation of body and optical displays, the impacts can be amplified.

7.2.1.4 Effects of mechanical vibrations on the use of operating elements

The effect of vibrations on controls and input devices (for example, keyboard, mouse, etc.), can result in loss of performance (speed and accuracy).

7.2.2 Avoidance of vibration effects

The development and propagation of mechanical vibrations should, where possible, be avoided entirely or be reduced at the source. The selection of low-vibration equipment and work processes is the best means of achieving this. There is a large number of measures that can be taken to further reduce vibration at the point of excitation and the transmission paths. These should be adapted to the individual requirement. If vibration-damping systems are not properly coordinated, an increase in vibration can result.

NOTE For basic information on vibration reduction, reference should be made to ISO 2017 and ISO 10846 and also EN 1299 (examples are given in VDI 2062 sheet 2 and VDI 3831)

If the vibration cannot be adequately reduced at the point of excitation, measures to reduce vibration should be employed on the transmission paths. Where necessary, affected items at the workstation or even entire working areas should be isolated from the sources of vibration excitation. Attention should be paid to this when planning and setting up workplaces, since it is then that the necessary measures can be carried out most effectively and economically.

In the case of work environments in which vibration stress cannot be fully avoided, measures should be taken to ensure that the legibility of displays and usability of operating elements, for example controls, are not impaired.

8 Guidance on electromagnetic fields and static electricity

8.1 Basic aspects

In this clause, possible influences of static electric and magnetic fields, extra-low-frequency (ELF) magnetic fields and electromagnetic fields on the image quality of visual displays, especially of CRT displays are discussed, for example:

— static (terrestrial) magnetic fields influence CRT uniformity;

— static magnetic fields of all origins influence convergence on colour-CRT displays;

— ELF magnetic fields from the electrical power distribution system or from nearby sources including nearby CRTs can influence CRT jitter (for maximal spatial instability, see 5.24 of ISO 9241-3:1992).

In this part of ISO 9241, only some effects of electric and magnetic fields are described (for example jitter) that can influence the assimilation of information from visual displays.

Electric and magnetic fields can impair the quality of optical displays and the transmission of signals from parts of the work equipment.

The influence of electromagnetic fields on the optical displays can show up in the form of distortion (Moiré effect) or jitter.

Static electricity originating from the screen can reduce the legibility of the display by dust collection. Static discharges caused by the friction of carpets, clothing or furniture textiles (especially in winter when relative humidity is low) can cause annoyance and interferences with the equipment.

While potential sources should be specified for the lowest possible electromagnetic emission considered by applicable product and environmental safety standards, it is important to also take into consideration the possible cumulative effects resulting from the interaction of several potential local sources. Such local sources (for example emissions from power transmission lines, train or tram routes in the vicinity, internal emissions from machinery, power supply) and their interactions cannot be fully anticipated by the designers of a VDT. Therefore, the effects of such local sources should be evaluated in the particular environment, if necessary.

8.2 Avoiding adverse influences from the environment

The quality of the optical display should not be unacceptably impaired by the influences of electric and magnetic fields external to the display. An unacceptable impairment can be regarded as the exceeding of the maximum values specified in ISO 9241-3 for locus-dependent distortion of the images or character shapes, time-dependent fluctuation in character location and time- or locus-dependent distortions as well as colour distortions.

Unacceptable impairments can be caused either by other equipment at the workplace or by external fields with origins outside the workplace. In order to avoid possible impairments of the first kind, the installation guidance of the manufacturer should be followed. Managing display distortion caused by interfering external fields can be accomplished in two ways:

— shielding, screening, altering, relocating or removing the source;

— shielding or screening the device.

Because of the variety of combinations of equipment characteristics (screening, other installations in the room) and the characteristics of the interference fields (field-strength vectors, frequencies, homogeneity of the fields, etc.), suitable measures cannot be stated directly.

The following measures can prevent or reduce the effects of external static and dynamic fields:

— physical screening of the source

— physical separation, relocation or re-orientation of the source

— screening or adaptation of the affected display.

The immunity of visual display units to external line-frequency magnetic fields is different for different display technologies. CRT-displays possess different immunity levels depending on their technical design. Most CRT-displays meet ISO 9241-3 in ambient magnetic fields up to 0,02 A/m. In many office areas, the strength of the magnetic fields can exceed this value and, thus, can cause jitter problems. Where such problems are detected, a reorientation of the specific display unit can be sufficient to treat the problem.

In the case of undesirable interactions of a specific display with a given environment, it should be determined whether the following engineering measures have been introduced in the design of the display under consideration.

a) Dynamic

— Circuit-engineering measures or metallic screening of the housing (for example, vapour deposition on the inner sides of the housing, coating with conductive lacquer and fault-free contacting).

— Screening of the deflection coils by highly permeable materials.

— Field damping by inverse eddy-current induction.

Standard EMC testing requirements (see IEC 61000-4-8) specify testing and measurement techniques for external line-frequency magnetic fields.

b) Static

Use of equipment withstanding electrostatic discharges according to IEC 61000-4-2.

NOTE Other EMC requirements may need to be considered.

— Demagnetization of the display.

— Antistatic treatment of the display surface.

The following environmental measures can be helpful in the case of problems with existing equipment:

- antistatic room furnishings (floor coverings, furniture);
- increasing humidity (see 9.2.5).

9 Guidance on thermal environment

9.1 Basic aspects

The thermal conditions at the workstations directly influence the comfort and performance of the users. The introduction of VDTs into the workspace leads to additional heat load and changes air movements. The purpose of 9.2 is to describe the relevant thermal parameters and to describe how to adapt these parameters to human needs in order to provide an acceptable thermal environment which prevents possible adverse effects to comfort and health. (See annex D.)

The relevant parameters which affect the occupants of work spaces are the following:

- Personal parameters:
  - thermal insulation of clothing;
  - activity level.
- Environmental parameters:
  - air temperature;
  - mean radiant temperature;
  - air velocity;
  - humidity.

Thermal comfort can be reduced by

- unwanted local cooling,
- radiant asymmetry from cold and hot surfaces,
- draught (air velocity),
- a vertical air temperature difference between head and feet that is too high, and
- floor surface temperatures that are too high or too low.

Local heat build-up caused by thermal radiation or warm air, either from sources in the equipment or climatic effects (for example solar gain) should be avoided by suitable control of thermal conditions combined with careful disposition of heat load from equipment and other electrical heat sources in the work space.

A model that describes the relation among relevant parameters for thermal comfort and provides a measure of the combined influence of these parameters on the general thermal sensation (PMV-index, PPD-index) is presented in ISO 7730. Detailed information on activity levels can be found in ISO 8996. For thermal insulation of clothing, detailed information is given in ISO 9920.

9.2 Relevant parameters for thermal comfort

9.2.1 Activity and clothing

Because of individual differences, it is not possible to provide a thermal environment which will satisfy everyone even if all persons wear the same clothing and perform the same activity. It is therefore important that the individual should be able to achieve some control on her or his heat balance by adjusting some of the parameters of the thermal environment or personal parameters.

9.2.2 Temperatures

The acceptable operative temperature, i.e. the parameter used to describe the combined influence of air temperature and velocity and of mean radiant temperature, depends mainly on the activity level and clothing of the person. In addition, thermal comfort depends on the radiant temperature asymmetry, i.e. the difference of the radiant temperatures of the surrounding surfaces.

At VDT workstations within office areas, the operative temperature may be assumed to be the simple mean of the air temperature and the mean radiant temperature at a certain point. In buildings with well insulated windows and walls, the air temperature and the mean radiant temperature may be assumed to be equal if there are no local heat sources from equipment and lighting.

An unacceptable radiant temperature asymmetry can be caused by large cold or warm vertical surfaces (for example, badly insulated windows in winter, direct sunshine through windows in summer) or warm or cold horizontal surfaces (for example, heated or cooled ceilings). Humans are most sensitive to warm ceilings and cold vertical surfaces. In buildings with small windows or well insulated windows and walls, the radiant temperature asymmetry is normally not a problem.

In workrooms with VDTs, vertical temperature differences can become too high because of one or more of the following factors:

— non-uniform vertical air temperature distribution caused by the heating or cooling or ventilating system;

— non-uniform vertical air temperature distribution caused by the heat dissipation of the equipment;

— cold air flow along cold surfaces towards the floor.

9.2.3 Air velocity

The air velocity affects the general thermal sensation. In most cases, it can also cause a draught sensation. The sensation of draught is influenced by the mean air velocity as well as by the fluctuations of the air velocity (turbulence) and air temperature. Air velocity can be caused by the air-conditioning or ventilation system and by cold surfaces (air flow towards the floor).

The design of air conditioning or ventilating systems, if needed, should consider that humans working in normal clothing are most sensitive to draughts around the ankle and neck region.

9.2.4 Floor surface temperature

Floor temperatures deviating from the air temperature (too high or too low) can cause thermal discomfort, especially if direct contact is possible. The floor surface temperature is, however, of minor importance under the condition that users of VDT workstations wear some kind of footwear.

9.2.5 Humidity

Thermal discomfort is also influenced by the humidity of the air with the effect of an increased humidity corresponding to that of a higher operative temperature. However, for sedentary work under temperatures in the moderate range (i.e. 20 °C to 26 °C) the influence of the humidity is quite modest. Thus, an increase of 10 % of the relative humidity corresponds to less than 0,3 K in operative temperature.

If the humidity is too low, there is a risk of dryness of the mucous membranes. In addition, persons wearing contact lenses can experience eye discomfort.

For air quality reasons, it may be necessary to limit the humidity: if the humidity is too high there is a risk of condensation on cold surfaces and of mould growth.

10 Guidance on space organization and workplace layout

Clauses 5, 6, 7, 8 and 9 of this part of ISO 9241 each deal with one major aspect of environmental requirements as part of ergonomic requirements for office work with VDTs. Space organization and workplace layout have an important influence on good performance for each aspect. For instance, sound and noise performance depends on the appropriate zoning of potential noise sources, whether they are people or office and building systems and equipment, in relation to the level of acoustic performance required for specific tasks and anticipated user populations. Similarly, natural and artificial lighting performance depends on how workstations and VDTs within workstations can be arranged in relation to potential glare from natural light.

In addition, workplace problems are often multifaceted. Thus, they require integrated solutions where a number of aspects and their possible interactions are considered, rather than partial solutions for single aspects (for example, selecting the workstation location for glare control on the visual display unit only). In any specific office context, the environmental considerations of clauses 5, 6, 7, 8 and 9 should be dealt with simultaneously to develop an integrated solution with acceptable trade-offs between different aspects.

The measures to be taken at particular workstations or work spaces should be combined to achieve basic goals of ergonomically designed work systems as described in ISO 6385. Major categories of criteria which should be considered are shown in Figure 2. Space organization and workplace layouts should take into account all the criteria of Figure 2.

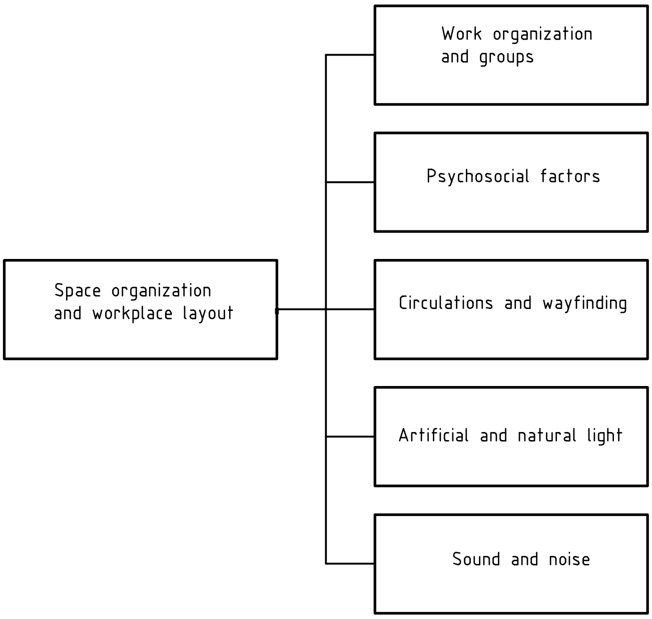


Figure 2 — Space organization and workplace layout; major categories of criteria

Annex A
(informative)

Lighting

A.1 Illuminance

Illuminance represents a physical quantity of light, the density of the luminous flux incident on a surface. It is the quotient of the luminous flux incident on a surface by the area of that surface (for the definition see 3.11).

The illuminance required in a work environment can be provided by daylight or artificial light. In general use in standardization, illuminance relates to the horizontal working plane unless another reference plane is specified in which the main visual objects are located. Typical illuminance ranges related to a specific task, activity or room area are given by standards (see CIE-publication 29.2 and informative annex B of ISO 8995:1989).

Apart from the horizontal illuminance, considerable importance should be given to vertical illuminance, especially when the impression of depth is important. In general, the impression of depth can be enhanced by a high proportion of vertical illuminance. Alternatively, the character-to-background contrast ratio, C, on a VDT display can be reduced.

NOTE Apart from character size, the contrast ratio C is the most important visual factor for good legibility. Good practice shows that the character-to-background contrast on the display should not fall below a minimum of 1 : 3 and 3 : 1, respectively (see ISO 9241-3).

A.2 Luminance balance

Particular attention should be paid to luminance balance at workstations with visual display terminals, especially if in the case of negative contrast. The reason is that the inclination of the line of sight downwards is less than at conventional office workstations because of the arrangement of the displays. Large differences in luminance in the field of vision have a disturbing effect, for example between

— luminaires and ceiling,

— ceiling and walls / windows,

— display and furnishings,

— display and window, and

— exterior sources (for example, dark buildings against a bright sky, snow).

A.3 Restricting glare

A.3.1 Direct glare from daylight

Direct glare from daylight can typically be caused by a direct view of the sun or clouds and by their reflections on adjacent buildings. Protection against glare from the sun or surfaces exposed to the sun should be provided if necessary. Moveable devices such as curtains, rollerblinds, venetian blinds, vertical blinds or awnings or daylight control systems are suitable for this purpose.

Skylights should be screened so as to ensure that they cause no disturbing glare at the workstation.

Window treatments used to limit glare should neither influence the colour climate of the workstation nor the visual appearance of the outside world.

Control devices such as curtains, blinds, shades, etc. should be capable of being controlled by the persons affected. The luminance of curtains or of other vertically aligned devices under direct exposure to sun can exceed that of the brightest lamps used for office work. Thus, during certain periods of the day, they can cause more glare than artificial lighting. Therefore, the transmittance of these devices should be so low that they provide adequate protection against glare and can cause no disturbance by direct or reflected glare (typically less than 0,3). The luminance of the device viewed from inside the room should be of the same magnitude as the room-confining surfaces if the device or parts of it can cause visible reflections on the display.

The introduction of screening will reduce the availability of daylight as well as its distribution.

Installation of workstations in which the line of vision is continuously directed at surfaces with high luminance (view of the sky, building obstruction) should be avoided.

NOTE When glare-control measures are adopted on the inside of the window, attention should be paid to the heat balance in the room.

A.3.2 Direct glare from artificial lighting

Direct glare from artificial lighting can be caused by luminaires or illuminated room surfaces with high luminance. Decisive factors as regards to the glare effect are their luminance, the luminance of the immediate surroundings, their position in the field of vision, their spatial dimension and the state of adaptation.

For luminaires which light downwards, glare-restricting measures should be carried out if necessary.

NOTE Glare-restricting methods applied in different countries are described in national standards.

For lines of vision which vary from the horizontal upwards (for example, in the banking sector at customer-service desks), extra precautions to further reduce glare should be taken (see Figure A.1).

Figure A.1 — Situation under which specific measures for glare guarding are needed

Luminaires for individual workstation lighting should not cause glare at the individual workstation or adjoining workstations.

A.3.3 Glare by reflection

A.3.3.1 General ergonomic considerations

For ergonomic reasons, the complete system consisting of lighting, workplace and visual display should be enhanced. The aim should be a reduction in glare by reflection

a) on the visual display, and

b) on the other working media.

Glare by reflection can occur in vertical, horizontal and intermediate planes. It can impair visual perception and/or cause discomfort. Disturbing glare caused by reflection on working surfaces and work equipment (for example, visual displays, printed documents, keyboards) should be prevented by suitable design and positioning of the work equipment and the lighting (see Figure A.2).

When selecting a suitable measure, it is necessary to ensure that the orientation of work equipment can be easily modified according to task requirements and that visual contact with the outside is impaired as little as possible (this is not the case, for example, if curtains are needed throughout the entire day to avoid excessive glare). Furthermore, the users should be given as much freedom as possible to organize their workspace and allocate all visual representations needed for their tasks (various electronic or printed visual displays, other equipment) without being restrained by glare by reflection.

A.3.3.2 Selecting appropriate measures

The finish of desk surfaces and the surfaces of work equipment, including documents, should be kept matt as far as possible. In order to avoid glare by reflection on work equipment of which the degree of gloss cannot be influenced, or only to a limited extent, it may be necessary to adopt one or more of the following measures (see Figure A.2):

— changing the direction of light incidence by suitable alignment and installation of the work equipment at the workstations, or suitable arrangement of the luminaires;

— use of suitable luminaires;

— reorientation of the workstation;

— altering the ratio of vertical illuminance to horizontal illuminance.

When selecting a suitable measure, a distinction is made between three classes of information media:

— electronic visual displays and other optical displays with a vertical or almost vertical alignment,

— electronic visual displays and other optical displays with a horizontal or almost horizontal alignment,

— work equipment with curved surfaces or surface elements (keycaps, configurations of several visual displays, etc.).

A.3.3.3 Considering monitor classes

For visual displays, ISO 9241-7 establishes three categories of VDTs, based on the lighting environments that are appropriate for their use. To achieve acceptable visual conditions, either

a) the visual environment should be controlled based on the category of the display used, or

b) the category of the display should be selected based on the nature of the visual environment.

NOTE Where there are relatively few Class III screens in an area, it is likely to be more efficient to carefully locate the screens or modify the environment around them rather than to light the whole room for their benefit.

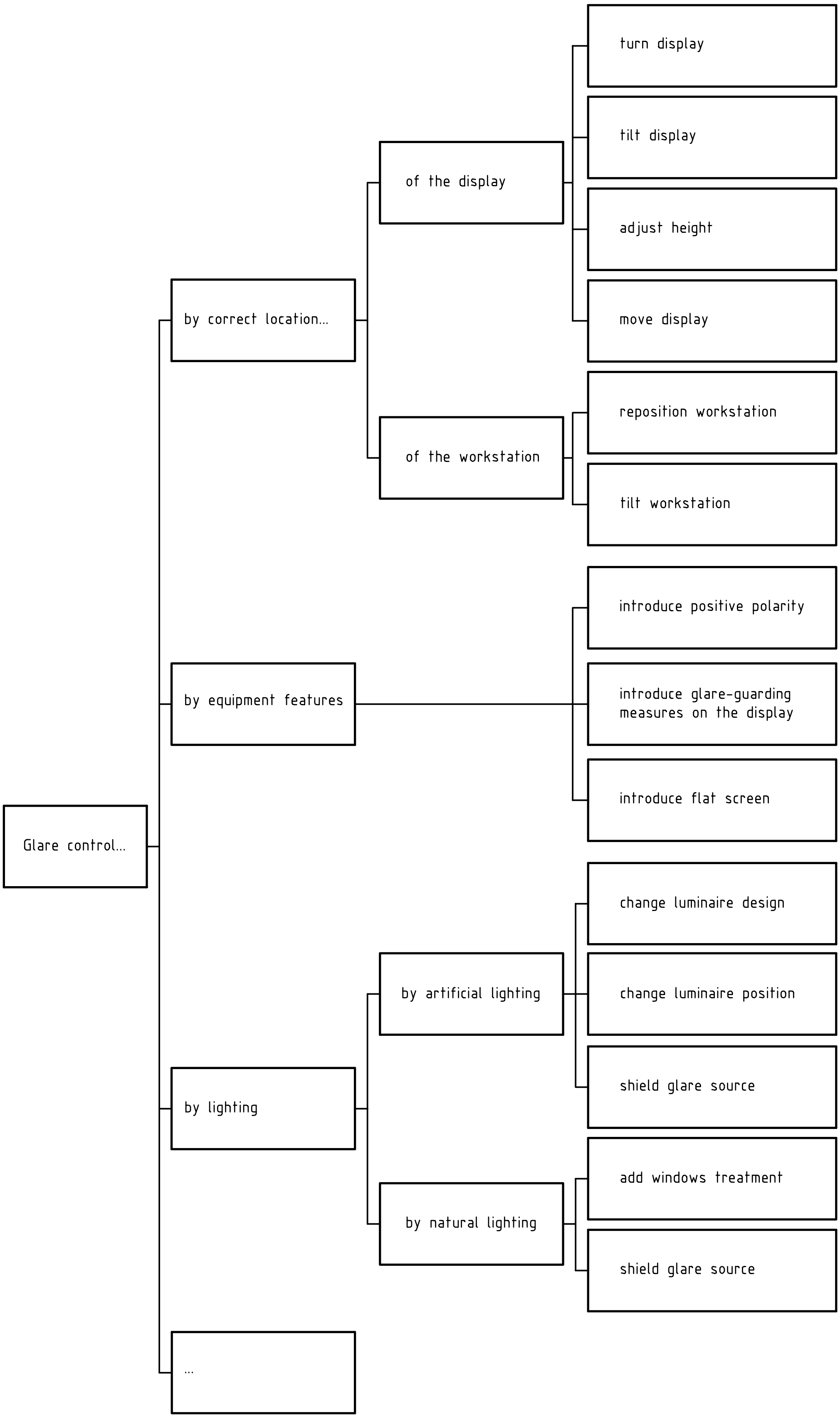


Figure A.2 — Methods for avoiding glare by reflection

The monitor classes are established by using the following test conditions (see ISO 9241-7 for test methods):

Class I $L_{A(REF,EXT)} = 200\ cd/m^2$ and $L_{A(REF,SML)} = 2\ 000\ cd/m^2$

Class II $L_{A(REF,EXT)} = 200\ cd/m^2$ or $L_{A(REF,SML)} = 2\ 000\ cd/m^2$

Class III $L_{A(REF,EXT)} = 125\ cd/m^2$ and $L_{A(REF,SML)} = 200\ cd/m^2$

To achieve acceptable visual conditions, the luminance of luminaires or room surfaces (for example, windows and other openings, skylights, transparent or translucent walls, brightly coloured fixtures, walls) that can be seen reflected in the screen by the user of the screen should be limited to an average luminance of

— $\leqslant 1\ 000\ cd/m^2$ for Class I and Class II displays,

— $\leqslant 200\ cd/m^2$ for Class III displays.

A.3.3.4 Considering luminances

For reasons of practicality, it is recommended that average luminances be measured instead of peak luminances, even if measuring the latter would be more sensible.

It is therefore important that the luminance peaks diverge as little as possible from the average values.

Where the displays are mounted near to horizontal, the above limitations will still apply but the ceiling and luminaires mounted on the ceiling should receive particular attention.

NOTE 1 When dark symbols are represented on a brighter background, the reflection of bright surfaces is found to have a less disturbing effect and differences in luminance between the display, document and keyboard are smaller. As a rule, therefore, preference should be given to this form of representation.

NOTE 2 It is appropriate to carry out a reflection-reducing measure if the disturbing effect of reflection is appreciably lowered, while the character definition and background luminance, for example, are not noticeably reduced and the impairment not increased.

A.3.3.5 Considering form and alignment of surfaces

Disturbances caused by glare, by reflection on horizontally aligned surfaces, can be avoided by

— suitable allocation of work equipment and its surfaces,

— indirect lighting or a combination of direct and indirect lighting, and

— uniform luminance distribution of the reflected surfaces which avoid luminance patterns on the reflected image.

Glare by reflection can be caused by specular reflections on curved surface elements of the equipment (for example, keycaps) or by equipment with more than one reflecting surface element (for example, control panels containing controls with a glossy finish and various visual displays). In such cases, combinations of the above-mentioned measures may be needed to avoid glare by reflection. Since the control of glare by lighting, for example changing the luminaire design or the influx of daylight, is always accompanied by some disadvantages for the visual environment, such measures should be taken into account if other measures, for example suitable allocation of work equipment, do not yield satisfactory results.

If office tasks are performed in work spaces designed either to accommodate other types of work (for example, in manufacturing areas, sales departments) or impose restrictions with regard to certain effective measures for glare control, for example when hygienic requirements play an overriding role, and the surfaces of equipment have to be smooth rather than matt, the freedom from glare should be achieved by suitable combinations of measures as displayed in Figure A.2.

A.4 Directionality of light incidence

In order to make faces, objects or surface structures easily recognizable, the lighting should achieve an adequate modelling effect for which a certain degree of directionality of the light incidence is needed. The modelling effect is induced by shadows on the illuminated object.

If the lighting is too diffuse, there is a lack of shadow, which can feel disagreeable and should therefore be avoided. On the other hand, lighting that is too directional (the diffuse part of the illumination is too low compared with the direct part) can result in unacceptable shadows that are too deep and display hard edges.

An acceptable lighting installation produces a balanced ratio of direct and diffuse illumination. Thus induces an adequate modelling effect.

A.5 Use of colour

The colour arrangement of the workroom and the colour rendering of the lamps or their spectral distribution of light can influence the recognition of coloured information, promote the ability to concentrate, prevent deterioration in performance, reduce errors and relax stress situations. In addition, they can assist in accident prevention by correct rendering of safety and signal colours.

The colour arrangement of the workroom should, within the limits specified by the recommended reflection factors, be determined freely and with regard for the natural and artificial lighting. Walls should be brighter than the floor and the ceiling brighter than the walls.

The lamps, luminaires and colours of the room surfaces should be selected so that signal and safety colours can be recognized. (For more information on colours, see ISO 6385.)

For large surfaces and as the background colour, pale colours with low saturation (pastel shades) should be chosen. The colour arrangement for smaller objects should employ more highly saturated tints.

When the work performed is of a monotonous nature, objects with more lively, stimulating colours should be introduced into the environment.

A.6 Colour rendering and correlated colour temperature

The choice of colour rendering and correlated colour temperature depends on the luminous sources, the lighting level, the colour of the room and the furnishings as well as on task requirements and subjective feeling.

In order to achieve appropriate colours, the use of lamps with colour-rendering indices R_a over 80 is preferred.

The choice of spectral colour and the level of colour rendition should ensure that safety and signal colours, as well as colour-coded objects or diagrams (for example, on control panels or safety signs) can be recognized as such.

A.7 Perception of flicker

In order to avoid the perception of flicker from artificial lighting, it should be operated well above the critical frequency of flicker. Perception of flicker from artificial lighting can be reduced or eliminated by the use of, for example,

— a lead lag,

— a three-phase circuit,

— higher frequency lamp ballasts.

Since recent research has shown that lighting installations operated above the critical flicker frequency can cause problems for persons sensitive to fluctuations of light, the use of high frequency lamp ballasts should be preferred (see Wilkins et al, 1988).

A.8 Selecting the type of lighting

A.8.1 Basic aspects

The selection of the type of lighting should be made considering clauses A.1 to A.7 and the following basic aspects:

— use of daylight or a combination of artificial light and daylight during daytime;

— use of purely artificial lighting, when and where daylight is not available or when the visual task requires it (such as in clean rooms);

— needs arising from the visual tasks and general lighting;

— characteristics of the room, for example physical dimensions, flexibility to control light required by the task.

Allowing for the quality criteria of lighting engineering and economic aspects, the selection can be done in the form of direct or indirect lighting, or a combination of the two.

The application of quality criteria to lighting engineering is described in A.8.2.1 to A.8.2.4.

A.8.2 General lighting

The function of general lighting is to illuminate the entire room to good effect, taking account of the need for good contrast, balanced luminance ratios, good colour rendering and other factors while restricting direct and reflected glare (see 5.1.2 of ISO 8995:1989 and clause 5).

Illuminance levels corresponding to the visual tasks to be performed in a given room or room zone should be provided at each workstation by either the general lighting, if at a suitable level, or by localized lighting supplementing the general lighting. In this case, the lighting for the task should not provide more than twice the level provided by the general lighting.

Good visual conditions should be provided throughout the room as well as at each individual workstation.

NOTE A room zone is regarded as being that area of a room in which a similar type of activity is performed at several workstations.

A.8.2.1 Direct lighting

The light and luminance distribution of luminaires is the major factor which should be taken into consideration to achieve visual comfort. Luminaires which direct the light towards the working plane (direct radiation) achieve best visual conditions (minimizing reflected and direct glare) when workstations are located alongside the luminaires.

Direct lighting may not be appropriate if relevant visual objects have glossy surfaces.

A.8.2.2 Direct-indirect lighting

Direct-indirect lighting allows more independence for the workstation arrangement from the lighting installation, as the relative luminance of the direct part of the lighting is reduced by the lit ceiling above. Workstations can be arranged with minor limitations in size and location if this type of luminaire can be applied.

A proportion of the light from the luminaire is directed towards the ceiling. For a well-balanced luminance distribution in the work space, the maximum luminance of the ceiling should not be so high that the ceiling itself becomes a glare source.

A.8.2.3 Indirect lighting

Luminaires with this characteristic direct the light towards the ceiling. Little direct light from the luminaires hits the workplace. Luminaires with this characteristic can be applied if the arrangement of workstations has to be made without any consideration of the lighting installation.

The efficiency of the lighting is highly dependent on the room characteristics, especially the reflection characteristics of the ceiling and the room height.

It is important that the luminaires have a wide light distribution and that the ceiling has a diffuse reflection characteristic.

NOTE Ceilings with high gloss can reflect the high lamp luminance and, thus, cause glare. Entirely indirect lighting can result in an environment with few shadows and poor contrast.

A.8.2.4 General lighting and individual workstation lighting

Individual workstation lighting, in addition to general lighting, is an appropriate way to provide lighting according to special needs at specific workplaces as a result of user and/or task characteristics.

The function of the individual workstation lighting is to provide illumination of the user’s immediate environment. The benefits of individual lighting are that

— it provides individual control over illuminance levels and directionality at the individual workstation,

— it enables the user to adapt lighting conditions to individual or changing task requirements, and

— it caters for personal needs which arise from individual differences in visual capabilities.

Local lighting should be provided, where necessary, to bring the illuminance level of a workstation up to the level required by the specific tasks performed by the users. Individual workstation lighting will be controlled separately from the general lighting. It should be positioned such that no direct glare or glare by reflection, or excessive contrasts, are created, or persons at other workstations are adversely affected.

Annex B
(informative)

Methods for measuring and evaluating sound

B.1 Noise measurements

The rating level (L_{AR}) is the characteristic value for noise immission. The rating level is determined for a specified time interval (see ISO 1996-1, ISO 9612, ISO 11690). When determining the rating level, no account is taken of acoustic events which serve the purpose of communication between the person at the workplace in question with other persons (conversations, communication signals).

The basic acoustic quantities for determination of the rating level and of the noise emission values are the A-weighted sound pressure level (L_{PA}) as well as the equivalent continuous A-weighted sound pressure level (L_{Aeq}) which can be measured by instruments in accordance with IEC 60651 and IEC 60804.

B.2 Noise sources

Noise nuisance arises in particular as a result of noise emission from machines, equipment and domestic installations (air conditioners) and the influence of machine and traffic noises from outside. Information-containing sounds from neighbouring workplaces, such as conversations, acoustic voice input/output of computers, telephone conversations and acknowledgement signals frequently have an effect, but in some cases noises emanating from the public also have a disturbing effect.

The A-weighted sound power level (L_{WA}) is the primary descriptor of the noise emissions from information technology and telecommunications equipment. It is supplemented by another emission quantity, the A-weighted sound pressure (L_{PA}) at the operator or bystander positions (ISO 7779).

Product literature should contain declared noise emission values in accordance with ISO 9296.

Additionally, a description of the character of noise information on impulsiveness and prominent tone should be given.

B.3 Noise level in work environments

B.3.1 Control of acoustic environmental conditions

Depending on the specific problem at a given work environment, a variety of measures can be taken (see Figure B.1). To determine the appropriate measures for a given situation, the nature of the problem should be analysed (for example, environment too loud for using the telephone). While selecting the appropriate action (for example, reducing sound level in speech frequencies) possible negative side effects should be considered.

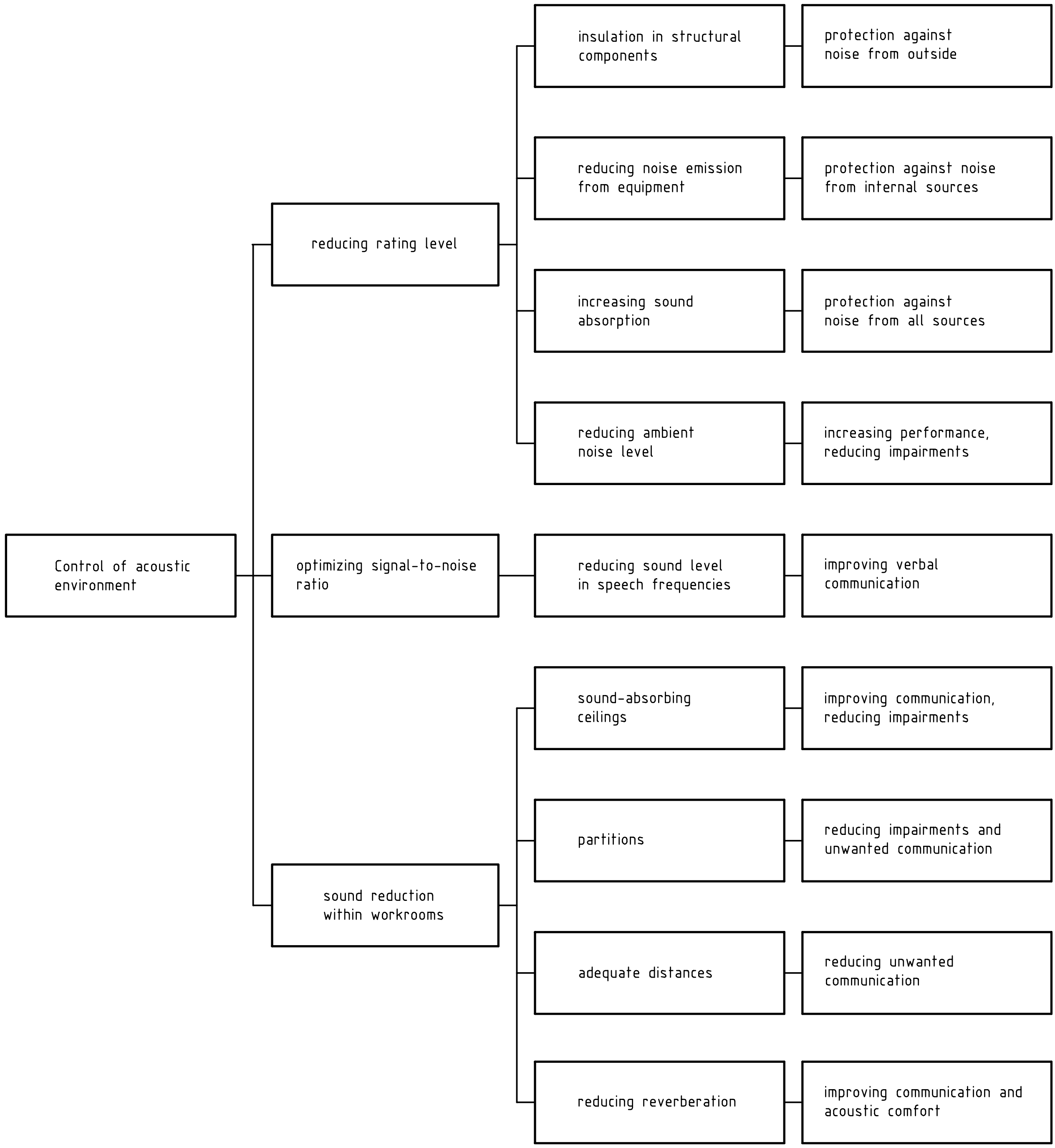


Figure B.1 — Control of acoustic environmental conditions, grounds, actions and primary targets

B.3.2 Sound insulation in structural components

In order to protect against noise penetrating the work environment from outside, the structural components (wall, ceiling, window) should be adequately insulated against structural and airborne sound. Because of the differences in room sizes, activities and interior noise level (background noise), the acoustic requirements to be met by the components can be adapted to the appropriate conditions (see Table B.1).

The requirements to be met by the sound insulation system can be selected in relation to the background sound.

Table B.1 — Recommendations with regard to the sound insulation of structural components for various office tasks and background noise levels (without activities and equipment) which should not be exceeded (derived from ISO 11690-1)

Type of activity	Acoustic recommendations insulation, restrictions	Type of room	Level of background noise, L_{Aeq} dB(A)
Tasks with temporary concentration, tasks occasionally repetitive	Good noise insulation from neighbouring offices; very good verbal communication	Single office with normal user requirements	35 to 40
Tasks with temporary concentration, tasks occasionally mechanized	Good noise insulation from neighbouring work areas and adequate screening from neighbouring workplaces; good verbal communication	Multiple office with normal user requirements	35 to 45
Tasks largely mechanized	Adequate noise insulation from neighbouring work areas and low screening from neighbouring workplaces; limited confidentiality, good verbal communication	Multiple office with low user requirements	40 to 45

B.3.3 Sound insulation within work environments

In order to reduce the sound transmission from a noise source (for example, conversations, equipment, machines) to neighbouring workplaces, the following measures can be adopted: sound-absorbing ceilings, walls and floor coverings, baffle boards, partitions, adequate distances between groups of workstations (see ISO 11690-1 and ISO 11690-2).

In larger work environments, a reduction in the sound level from 4 dB to 5 dB for each doubling of the distance should be established.

For reasons of good verbal communication and adequate “acoustic comfort”, the reverberation should be as low as possible. A reverberation time of 0,5 s to 1 s in the frequency range from 250 Hz to 4 kHz should be aimed for.

The maximum recommended reverberation time of a work environment depends on its volume. Table B.2 gives the maximum recommended times as a function of room volume.

Where the reverberation time exceeds the limits described in Table B.2, acoustic treatment of the ceiling should be undertaken first. For large work environments, more sophisticated treatment may be needed (see ISO 11690-1).

Table B.2 — Maximum reverberation time as a function of room volume

Volume of room m^3	Max. recommended reverberation time s	
	Conversational speech	General purpose
50	not specified	not specified
100	0,45	0,8
200	0,6	0,9
500	0,7	1,1
1 000	0,8	1,2
2 000	0,9	1,3

B.3.4 Noise emission from machines and equipment

Where available, information given in machine documents or contracts of noise emission from machines and equipment should be used when replacing or purchasing equipment and machinery for work environments (see ISO 11690-1).

Noise emission data consist of the noise emission values, for example, the declared A-weighted sound power level, the emission A-weighted sound pressure level. They may indicate whether prominent discrete tones or impulsive noise is present in the emissions (see ISO 9296, ISO 7779 and ISO 4871).

B.3.5 Noise at the workplace

It is recommended that the rating level should be lower than 35 dB(A) to 55 dB(A) in the case of difficult and complex tasks.

Depending on the acoustic requirement and type of activity, the background noise level should not exceed the values stated in Table B.1.

If verbal communication is necessary at the workplace, depending on the acoustic requirements and the quality of vocal effort and speech intelligibility (signal-to-noise ratio), the noise level should not exceed the levels listed in Table B.3 [see ISO 9921-1, Lazarus (1986), Lazarus (1987)].

For disturbance-free input of acoustic information, the A-weighted signal-to-noise ratio at the microphone should amount to 30 dB. The recommended maximum noise level for a corresponding quality when telephoning is given in Table B.4.

Table B.3 — Recommended maximum noise level L_{Aeq} at the workplace as a function of the effort by the speaker, the quality of verbal communication and the distance between the persons communicating (derived from ISO 9921-1).

Vocal effort	Speech level, L_{SA}, at 1 m	Recommended maximum noise level L_{Aeq} Verbal communication Signal-to-Noise Ratio L_{SA}-L_{Aeq} dB											
		perfect = 18			very good = 12			good = 7			satisfactory = 2		
		1 m	2 m	4 m	1 m	2 m	4 m	1 m	2 m	4 m	1 m	2 m	4 m
raised	66	48	42	36	54	48	42	59	53	47	64	58	52
normal	60	42	36	30	48	42	36	53	47	41	58	52	46
relaxed	54	36	30	24	42	36	30	47	41	35	52	46	40

L_{SA} is the A-weighted equivalent sound pressure level of the speech at the listener's ear, $L_{SA,\ 1\ m}$ at 1 m distance from speaker's mouth; L_{Aeq} corresponds to the rating level without adjustments.

The columns indicate the distance between persons communicating in metres.

Table B.4 — Relationship between the noise level of the disturbing noise and the quality of the verbal communication with acoustic media (for example telephone) (derived from ISO 9921-1)

Noise level L_{Aeq} dB	**Quality of verbal communication**
$<$ 40	perfect
40 to 45	very good
45 to 50	good
50 to 55	satisfactory
55 to 65	slightly restricted
65 to 80	difficult
$>$ 80	unsatisfactory

Annex C
(informative)

Measurements, evaluation and assessment of whole-body vibrations

The measured quantities for determining mechanical transmission of vibrations to humans are the accelerations in the three directions of the human body (see ISO 2631-1) and the duration of daily exposure.

The vibrations are measured directionally and evaluated for frequency in accordance with their biological effect to determine root-mean-square (r.m.s) values of the weighted accelerations. At workplaces where vibration-related visual impairment of performance can be expected (for example, due to the nature of the environment or the task), it is recommended that additional acceleration measurements are carried out on the forehead, close to the eyes, in y and z directions by means of miniature accelerometers.

NOTE This recommendation goes beyond the requirements of ISO 2631-1.

Narrow-band frequency analysers can provide information on the extent of possible impairment to visual performance.

The assessment of the degree of impairment caused by mechanical vibrations can be carried out by comparing the r.m.s. values with exposure limits given in different tables and figures of ISO 2631-1. Individual pulses or short-time vibrations with high amplitude may require a separate evaluation. The boundaries for the limits of exposure are related to three main criteria, i.e. fatigue, decreased proficiency, health or safety and reduced comfort.

Guide values for the maximum evaluation vibrational intensity K_r (see ISO 2631-2) from the aspect of avoiding any impairment of performance or disturbance or nuisance should be assessed markedly below the boundary values mentioned. This applies especially to workplaces where the activities are largely of an intellectual nature and to those which involve the recording of visual information or fine-motor activities. Since at these workplaces, entirely different effects on the health can be expected (for example, as a result of continuing compensation attempts to maintain visual performance) compared with the conditions on which the boundaries of exposure limits were based, the maximum recommended values should be lower.

Annex D
(informative)

Thermal environment

The values given below are applicable for mild climatic zones and for work areas where no specific codes for clothing exist. In countries outside the mild climatic zones, other aspects than those considered here can play a significant role, for example, deterioration of the microbiological climate in workrooms, or mould growth in the building and its ventilation system. Specific codes for clothing can limit the control of the users on their clothing. For these reasons, while planning or evaluating a work environment, all related aspects should be taken into account.

D.1 Recommended values for thermal comfort

Table D.1 presents recommended values for personal and environmental parameters to achieve thermal comfort in the winter and the summer periods. It is estimated that more than 80 % of the users will find these thermal conditions acceptable. The estimate is based on annex A of ISO 7730:1994, and assuming the metabolic rate for sedentary activity and 50 % relative humidity.

Table D.1 — Recommended values for personal and environmental parameters

Parameter	Winter period	Summer period
Personal parameters		
Clothing insulation	1,0 clo[a]	0,5 clo[a]
Activity level	1,2 met	
Environmental parameters for general thermal sensation		
PMV-index	$-0,5 < \text{PMV} < 0,5$	
PPD-index	< 10 %	
Environmental parameters for local thermal sensation		
Radiant temperature asymmetry[b]		
— Cool vertical surface (wall, window)	< 10 K	
— Warm horizontal surface (ceiling)	< 5 K	
Vertical air temperature difference	< 3 K	
Draught rating	< 15 %	
Mean air velocity [c]	< 0,13 m/s at 20 °C	

a 1 clo = 0,155 $m^2 \cdot °C/W$

b Recommendations for warm vertical surfaces and cold horizontal surfaces are less strict and are not included in ISO 7730.

c It is assumed that the air temperature is equal to operative temperature and the turbulence intensity is 40 %.

Values of parameters for other levels of acceptance may be estimated according to ISO 7730. Table D.2 shows the recommendations for three categories. In Table D.2, category B corresponds to Table D.1. The differences between the categories is the temperature range with the optimum operative temperature, i.e. the temperature where the maximum number of occupants are satisfied is the same for all categories.

Table D.2 — Relationship between environmental and personal parameters for three categories of PMV-index and PPD-index

Parameter	Winter period			Summer period		
Personal parameters						
Clothing insulation	1,0 clo[a]			0,5 clo[a]		
Activity level	1,2 met					
Environmental parameters						
Category	A	B	C	A	B	C
PMV-index	± 0,2	± 0,5	± 0,7	± 0,2	± 0,5	± 0,7
PPD-index, %	< 6	< 10	< 15	< 6	< 10	< 15
Operative temperature °C	22 ± 1,0	22 ± 2,0	22 ± 3,0	24,5 ± 0,5	24,5 ± 1,5	24,5 ± 2,5

[a] 1 clo = 0,155 $m^2 \cdot °C/W$

D.2 Estimation and measurement of thermal parameters

D.2.1 Personal parameters

The activity level may be estimated according to ISO 7730 or using more detailed information in ISO 8996. For sedentary work at display workstations, it is suggested that the value 1,2 met is used.

The thermal insulation of clothing may be estimated according to ISO 7730 or using more detailed information in ISO 9920. It is suggested that the values 1,0 clo for winter conditions, and 0,5 clo for summer conditions, are used.

D.2.2 Environmental parameters

The environmental parameters should be measured according to ISO 7726.

The operative temperature (PMV-PPD-index), radiant-temperature asymmetry and humidity is measured at the abdomen level, normally 0,6 m above the floor for seated persons and 1,1 m for standing persons. To evaluate draught and vertical air temperature differences, the air temperature, the mean air velocity and turbulence is measured at head and ankle level, which normally are 1,1 m and 0,1 m above the floor for seated persons and 1,7 m and 0,1 m for standing persons.

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