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Ergonomic design of control centres —

Part 1: **Principles for the design of control centres**

Conception ergonomique des centres de commande —

Partie 1: Principes pour la conception des centres de commande

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.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.

Attention is drawn to the possibility that some of the elements of this part of ISO 11064 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11064-1 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

ISO 11064 consists of the following parts, under the general title *Ergonomic design of control centres*:

— *Part 1: Principles for the design of control centres*

— *Part 2: Principles for the arrangement of control suites*

— *Part 3: Control room layout*

— *Part 4: Layout and dimensions of workstations*

— *Part 5: Displays and controls*

— *Part 6: Environmental requirements for control rooms*

— *Part 7: Principles for the evaluation of control centres*

— *Part 8: Ergonomic requirements for specific applications*

Annex A and B of this part of ISO 11064 are for information only.

Introduction

Driven by demands for safer, more reliable and efficient operations, innovations in information technology have led to the increased use of automation and centralized supervisory control in the design of user-system interfaces and their associated operational environments. Notwithstanding these developments, the operator has retained a critical role in monitoring and supervising the behaviour of these complex automated systems. As the scale of automated solutions has grown, so have the consequences of equipment and human failures.

The job of the operator can at times be very demanding. The consequences resulting from inappropriate operator action in control rooms, such as acts of omission, commission, timing, sequence and so on, can be potentially disastrous. Accordingly, this part of ISO 11064 has been prepared to set up a generic framework for applying requirements and recommendations relating to ergonomic and human factors in designing and evaluating control centres with the view to eliminating or minimizing the potential for human errors.

A specific control centre project is often part of a design project for a larger system. The design of the control centre should not be developed separately from the objectives and goals associated with the context of this wider system. Consequently, it is necessary to view the ergonomic aspects of a control room design in relation to issues which, at first sight or by tradition, may seem to fall outside the scope of ergonomic design projects. These judgements will need to be taken on a case by case basis and are not necessarily resolved by a prescriptive approach.

This part of ISO 11064 includes requirements and recommendations for a design project of a control centre in terms of philosophy and process, physical design and concluding design evaluation, and it can be applied to both the elements of a control room project, such as workstations and overview displays, as well as to the overall planning and design of entire projects. Other parts of ISO 11064 deal with more detailed requirements associated with specific elements of a control centre.

Ergonomic design of control centres —

Part 1: Principles for the design of control centres

1 Scope

This part of ISO 11064 specifies ergonomic principles, recommendations and requirements to be applied in the design of control centres, as well as in the expansion, refurbishment and technological upgrades of control centres.

It covers all types of control centres typically employed for process industries, transportation and logistic control systems and people deployment services.

Although this part of ISO 11064 is primarily intended for non-mobile control centres, many of the principles specified in this document could be applicable to mobile control centres, such as those found on ships and aircraft.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 11064. 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 11064 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 6385, *Ergonomic principles in the design of work systems.*

ISO 11064-3, *Ergonomic design of control centres — Part 3: Control room layout.*

3 Terms and definitions

For the purposes of this part of ISO 11064, the following terms and definitions apply.

3.1
control centre
combination of control rooms, control suites and local control stations which are functionally related and all on the same site

[ISO 11064-3:1999, definition 3.1]

3.2
control room
core functional entity, and its associated physical structure, where operators are stationed to carry out centralized control, monitoring and administrative responsibilities

[ISO 11064-3:1999, definition 3.4]

3.3
control suite
group of functionally related rooms, co-located with the control room and including it, which houses the supporting functions to the control room, such as related offices, equipment rooms, rest areas and training rooms

[ISO 11064-3:1999, definition 3.6]

3.4
design specification
detailed description of features of the control suite, including room arrangements, equipment, workstation displays and operator controls, which meets the control centre's overall requirements with regard to development, procurement and construction

3.5
function allocation
distribution of functions between human and machine

3.6
functional analysis
analysis identifying those requirements which need to be met by humans or machines in order to achieve the operational goal

3.7
functional specification
record, put together from functional analysis, of what the control centre is to include in terms of objectives, functions, support of users and machines, relationships with external systems, and physical and environmental attributes

3.8
human-centred design approach
approach to interactive system development, focusing specifically on making systems usable, and emphasizing the role of human operators as control agents who maintain authority within a working system

3.9
job design
process of determining what the job content should be for a set of work tasks and how the tasks should be organized and interlinked

NOTE For the purpose of this part of ISO 11064, a definition of job design is introduced which indicates the design of several jobs, instead of one job (such as specified in EN 614-1:1995, annex B).

3.10
local control station
operator interface that is located near the equipment or system being monitored and/or controlled

[ISO 11064-3:1999, definition 3.15]

3.11
primary user
person engaged in those job functions normally associated with control centre activities

EXAMPLES Operator, assistant operator, foreman or supervisor.

3.12
secondary user
person that occasionally uses or maintains the control centre

EXAMPLES Maintenance engineers, cleaners, managers or visitors.

3.13
situational analysis
task analysis in an existing situation to analyse all the behavioural aspects of the work system, such as revealing practical experiences, informal communication, expectations and complaints of current users and any other facts that might be useful for redesign purposes

3.14
task analysis
analytical process employed to determine the specific behaviours required of people when operating equipment or doing work

[ISO 9241-5:1998]

3.15
validation
confirmation by examination and tangible evidence that the particular requirements for a specific intended use are fulfilled

NOTE In design and development, validation concerns the process of examining a product to determine conformity with user needs.

[ISO 8402:1994, definition 2.18]

3.16
verification
confirmation by a systematic examination and tangible evidence that specified requirements have been fulfilled

NOTE 1 In design and development, verification concerns the process of examining the result of a given activity to determine conformity with the stated requirements for that activity.

NOTE 2 Tangible evidence is regarded as being information that can be proved to be true, based on facts obtained through observation, measurement, test or any other means.

[ISO 8402:1994, definition 2,17]

4 General considerations and principles of ergonomic design

4.1 General

Nine principles shall be taken into consideration for the ergonomic design of control centres. They are explained in 4.2 to 4.10.

4.2 Principle 1: Application of a human-centred design approach

ISO 6385 specifies ergonomic principles intended as a guide for the design of work systems. The objective is to design adequate working conditions with regard to human safety, health and wellbeing, whilst taking into account technological and economic efficiency. This part of ISO 11064 addresses the specific case of control centres.

In a human-centred design approach, the combination of humans and machines, in its organizational and environmental context, is considered as an overall system to be optimized. This optimization is achieved by developing solutions that emphasize and maximize the strengths, features and capabilities of both humans and machines in a complementary fashion. The human component, the machine (hardware and software), the work environment, and the control (operation and management) shall be harmoniously integrated during all phases of the design process, as shown in Figure 1. Included in those activities where human-centred design may be relevant are planning, conceptual and detailed design, assembly and construction, commissioning, user training and operations.

A human-centred design approach needs to be integrated into the traditional function-orientated design approach. It is essential that certain human characteristics form part of the basis of the design requirements which underly the final design specifications. The human characteristics to be considered shall not only include basic physical capabilities or limitations, but shall also emphasize the unique cognitive strengths of humans (such as perceptual ability, problem solving and decision making). In addition, knowledge about how operators feel and interact with operations and management, as well as with *designed objects* that include machines (both hardware and software), environments and so on, shall be considered. In addition to the immediate and obvious ergonomic requirements imposed by highly automated and large-scale systems, more subtle psychological demands may require special attention. These include self-fulfilment, motivation and cultural considerations.

If physically challenged people are routinely assigned to work in a control centre, appropriate designs shall be employed to accommodate their specific needs.

4.3 Principle 2: Integrate ergonomics in engineering practice

Ergonomics and its associated tools should be integrated into the project's management guidelines in order for the role of ergonomics to be taken into account by all designers and engineers involved in the planning, design, implementation and operational audit of a control centre. A project should be organized in such a way that an integration of technical and ergonomic expertise is encouraged.

4.4 Principle 3: Improve design through iteration

Design processes are inherently iterative in practice. Evaluation shall be repeated until the interactions between operators and designed objects achieve their functional requirements and objectives. Establishing the validity of an individual element of the design in isolation does not guarantee that the assembled system will be validated. Any modification, however minor, can cause undesirable side effects even if the modification itself is valid (see ISO 6385). There shall be a formal process that defines and controls mechanisms and procedures for scope changes in the design of all aspects of the control centre.

It should be noted that users, either consciously or unconsciously, may adapt their behaviour to modifications, and that such behavioural changes may not be consistent with good ergonomic practice. The incorporation of information obtained from operational experiences, that is operational feedback, is of particular importance in this iterative process (see Figure 1).

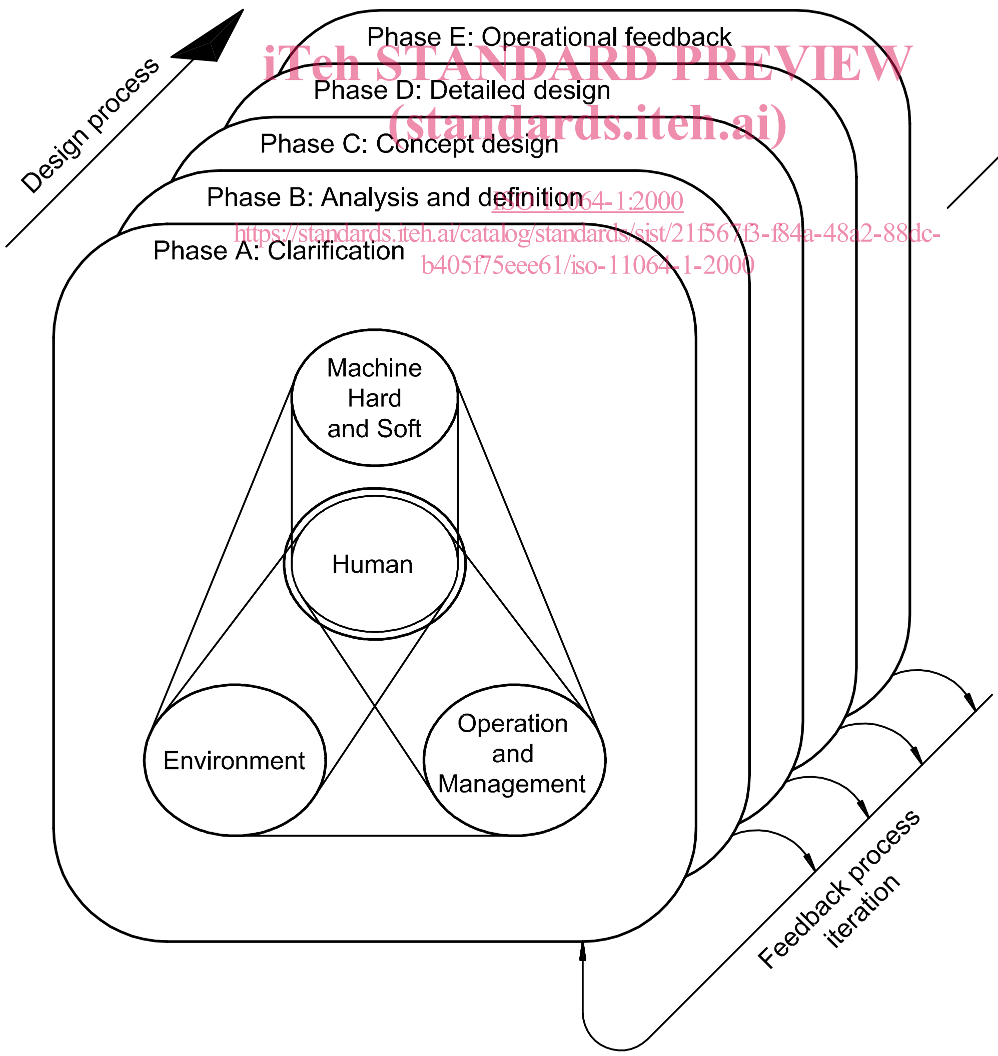

Figure 1 — Ergonomic approach to system designs

4.5 Principle 4: Conduct situational analysis

For any ergonomic design activity, including refurbishment projects, a situational analysis of existing or similar situations is recommended. In this way, the functions of the future system can be thoroughly understood and anticipated beforehand.

The means of performing situational analysis may vary, but include task analysis (see 4.6), operator interviews and incident analysis.

4.6 Principle 5: Conduct task analysis

The tasks delegated to individual control room operators, and to other significant users of the control centre, shall be fully understood (see ISO 6385). The analysis shall consider all modes of system operation including start-up, normal operation, shut-down, anticipated emergency scenarios, periods of partial shut-down for maintenance, the results used in the design process and the development of staffing plans. Some situations may require doubling or tripling staffing requirements and therefore shall be accounted for in the overall design.

An analysis of operator tasks shall be conducted in designing a plant, a control centre or any other system.

The task analysis methods may vary according to the scope and content of each individual project. In the case of an innovative design project, there may be few opportunities for studies of comparable situations. In other cases, for example that of combining several control rooms into one new control room, most of the operator tasks may be carried forward into the new design. Although inherently different, each of these situations should allow some degree of comparable analysis to positively influence the design of a future system.

4.7 Principle 6: Design error-tolerant systems

Human error cannot be totally eliminated. It is therefore necessary to strive for error-tolerant design. An important tool is the use of risk assessment for obtaining information on human error.

4.8 Principle 7: Ensure user participation

User participation is a structured approach where future users are involved in the design of a control centre. User participation throughout the design process is essential to optimize long-term human-machine interaction by instilling a sense of ownership in the design.

Experienced users can offer valuable empirical contributions to the control centre design. Their practical experience is not always documented or well known by designers. Operational feedback derived from user participation should be analysed to identify previous design successes and shortcomings.

4.9 Principle 8: Form an interdisciplinary design team

An interdisciplinary design team should be formed to oversee and influence all phases of the design project. Actual combinations of disciplines included in the design team may vary depending on the overall project scopes or the phase of design. This team may include system and process engineers, ergonomists, architects and industrial designers. For existing systems, users or user representatives shall be included as members of the team. For new systems, both experienced and future users shall form part of the design team.

The design team, including the users, shall be available at the appropriate time throughout the project's life cycle. Plans and accommodations for team participation should be specified in detail at the beginning of the project.

4.10 Principle 9: Document ergonomic design basis

Develop internal documents that reflect the ergonomic design basis for the project, for example fundamental reasoning or significant task analysis findings. The document should be updated whenever there is a change. An appropriate procedure should be developed for this process.

5 Framework for an ergonomic design process

Figure 2 shows a framework, consisting of five design phases, for the control centre design process (Figure 2 is simplified with only some of the iterative loops shown). Typically, all phases should be executed with the overall effort distributed in accordance with the scope of the design project.

The design of a control centre is generally complex, involving, for example, multiple clients, conflicting objectives, diversity of new technologies and possible solutions, ambitious schedules, first time applications and inexperienced personnel. The complexities of a design project can often be accommodated by implementing a methodical sequence of procedures that focus attention on particular topics, on design activities and on iterative reviews.

The framework listed below and given in Figure 2 involves the following phases:

— Phase A: Clarification

  clarify the purpose, context, resources and constraints of the project when starting a design process, taking into account existing situations which could be used as a reference;

— Phase B: Analysis and definition

  analyse the control centre's functional and performance requirements culminating in a preliminary functions allocation and job design;

— Phase C: Conceptual design

  develop initial room layout, furnishing designs, displays and controls, and communications interfaces necessary to satisfy the needs identified in phase B;

— Phase D: Detailed design

  develop the detailed design specifications necessary for the construction and/or procurement of the control centre, its content, operational interfaces and environmental facilities;

— Phase E: Operational feedback

  conduct a post commissioning review to identify successes and shortcomings in the design in order to positively influence subsequent designs.

Each of the above phases is discussed in more detail in clauses 6 to 10 respectively.

The numerous feedback paths shown in Figure 2 relate to the iterative nature of designing solutions for complex problems. New opportunities for enhanced solutions and unsatisfactory designs identified by frequent project reviews shall be recycled back into the process. Careful project budgeting and scheduling should allow for and encourage this iterative process.

NOTE This part of ISO 11064 is primarily concerned with phases A, B, C and E of the project framework shown in Figure 2.