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Ergonomic design of control centres —

Part 2: Principles for the arrangement of control suites

Conception ergonomique des centres de commande —

Partie 2: Principes pour l'aménagement de la salle de commande et de ses annexes

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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 11064-2 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 of this part of ISO 11064 is for information only.

Introduction

This part of ISO 11064 considers ergonomic principles, recommendations and guidelines for the layout of control suites.

ISO 11064 covers all types of control centres, including those for the processing industry, for transport and for the control and communication systems of emergency services. Though ISO 11064 is primarily intended for non-mobile control centres, many of the principles are relevant to mobile centres such as those found on ships, locomotives and aircraft.

User requirements are a central theme of this part of ISO 11064 and the processes described are designed to take the needs of users into account at all stages. The overall strategy for dealing with user requirements is specified in ISO 11064-1.

This part of ISO 11064 provides guidance on the design and planning of the control suite in relation to its supporting areas. Requirements for the layout of the control room are specified in ISO 11064-3. Requirements for the design of workstations, displays and controls, human-computer interaction and physical working environment are specified in ISO 11064-4 to ISO 11064-6. Evaluation principles are dealt with in ISO 11064-7.

ISO 11064-1 to ISO 11064-7 cover general principles of ergonomic design appropriate to a range of control sectors. The specific requirements appropriate to particular sectors or applications are specified in ISO 11064-8. The requirements specified in ISO 11064-8 are to be read in conjunction with ISO 11064-1 to ISO 11064-7.

The main beneficiaries of this part of ISO 11064 are the operators and other users in the control suite. It is the needs of these users that provide the ergonomic requirements used by the International Standard developers. Although it is unlikely that the end-user will read ISO 11064, or even know of its existence, its application should provide the user with interfaces that are more usable, a working environment that is more consistent with operational demands and result in a solution which will minimize error and enhance productivity.

Ergonomic design of control centres —

Part 2:
Principles for the arrangement of control suites

1 Scope

This part of ISO 11064 covers ergonomic design principles for control centres and, more specifically, the various arrangements of rooms and spaces in a control suite. The principles are based on an analysis of functions and tasks that have to be supported by the control room and functionally-related rooms. They include identifying functional areas, estimating the space provisions for each functional area, determining operational links between functional areas and developing preliminary layouts for the control suite to facilitate the transition between all the activities conducted in the control suite.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of ISO 11064-2. 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 11064-1, *Ergonomic design of control centres — Part 1: Principles for the design of control centres.*

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

EN 614-1, *Safety of Machinery — Ergonomic design principles — Part 1: Terminology and general principles.*

3 Terms and definitions

For the purposes of this part of ISO 11064, the terms and definitions given in ISO 11064-1 and the following apply.

3.1
task allocation
distribution of work tasks or work task elements between operators and systems

3.2
task zone
combination of a work task with associated space and location requirements

3.3
work environment
physical, chemical, biological, organizational, social and cultural factors surrounding a person in his or her work space

[EN 614-1]

3.4
work space
volume allocated to one or more persons in the work system to complete a work task

[ISO 6385]

3.5
workstation
combination of work equipment for a particular person in a work space

NOTE It is possible that several persons share a particular workstation, or that several persons alternate between several workstations within any period of time (that is, on an hourly, daily or weekly basis).

3.6
work system
one or more persons and work equipment acting together to perform the system task, in the work space, in the work environment, under conditions imposed by the work tasks

[EN 614-1]

3.7
work task
task
activity required to achieve an intended outcome of the work system

4 Design procedure for arrangement of control suites

4.1 General approach

A general approach to the design of work systems shall be in accordance with ISO 6385 and EN 614-1. The multipart standard ISO 11064 discusses the application of the general approach to the design, redesign or refurbishment of control centres. The objectives of the aforementioned standards are to design the work system in consistency with human capabilities, limitations and needs. Consequently, an analysis of the existing or a comparable situation is required. Clause 4 explains how to apply the general approach to the analysis when designing control centres. In particular, it concerns the activities needed to enable the architectural planning (for example space planning) of the general layout of a control suite. Detailed engineering design of the control room suite, operator workstations and the human-computer interfaces are covered in subsequent parts of ISO 11064.

The development of a site plan (also called plot plan) has particular implications for the control suite. A site plan is a mapping of all process units, major equipment, buildings and routing on a production site or within a production building. The site plan includes the location of production units, buildings, traffic systems and so on. The layout of the control centre includes the location of the control suite relative to the processes to be monitored and controlled, workstations and other equipment.

Emphasis of this part of ISO 11064 is on ergonomic considerations for the overall design of a control suite, based on such factors as the layout of the control centre, job content and work organization. It includes the location of the control room suite relative to the production site.

It is recognized that many other factors (for example economic factors, size, shape and surroundings of the area, existing parts of the site) will also be considered and will be of major importance for decision making. However, the user of this part of ISO 11064 should be aware that the physical location of a control suite relative to the sub-systems to be controlled and/or monitored establishes constraints for the design of the control room, workstations and jobs. Amongst other things, this part of ISO 11064 specifies routing, distances, communication patterns and the level of flexibility in job and work organization design. In some cases, the physical location is critical as the control room is operationally dependent on location (for example site security, reception), whereas, in other cases, location may be irrelevant.

Where physically challenged control suite users or visitors are expected, adequate facilities should be taken into account during design.

4.2 Steps in the design of control suites

The general layout of a plant or production unit, a process description, main process operating principles and the general layout of buildings are important considerations at the beginning of a project. The process of designing a control centre usually consists of several project phases, as follows:

Phase A: Clarification

Phase B: Analysis and problem definition

Phase C: Conceptual design

Phase D: Detailed design

Phase E: Implementation and operational feedback

For further information, see ISO 11064-1.

The principles of an ergonomic design (see ISO 11064-1:2000, clause 4) for control suite arrangement should be developed and used during phase C. In order to ensure effective input to a project concerning the layout of control suites, the following project steps are recommended (see Figures 1 and 2 of ISO 11064-1:2000, step 9A):

— during phase A, functional requirements are generated;

— the starting point for the conceptual design consists of a description of the intended performance of the work system (system functions) and an overview of tasks to be performed within the work system, including an allocation of tasks to human operators or technical equipment (see 4.3);

— the general layout of the site or production facility, including the location of a control suite (see 4.4), can be determined;

— an overview of space requirements for the control suite should be made. A useful approach to this is to list the tasks to be performed in the control suite, and to attach to each task an overview of the requirements imposed on the workstation and other facilities. The resulting task zones should then be arranged into workstations in such a way that the requirements are met (see 4.5).

Typically, the layout of the control suite is baselined at the start of phase D. During this phase any design changes shall be controlled.

User input shall be an integral part of the development of a control suite. User participation is a structured approach of employing future users and all others involved in the design project (see [2] in the Bibliography). User participation shall be organized by an expert in this field (for example an ergonomist). In general, the first communication between users and the project team arises at the time of a situation analysis. Assuming that such a communication has been established, the project team should consult the users on the layout of the control suite. Amongst the various tools that can be used to facilitate an effective consultation on building layout are, for example, a scale-model or layout board (for example a magnetic space planning board), or a three dimensional computer graphics model.

4.3 Starting point for layout of control suite

As a precondition to the design of a control suite arrangement, the following activities have been performed:

— specification of the system functions (the function of the plant built);

— allocation of functions to human operators or equipment and instruments (see EN 614-1);

— global definition of the jobs of the operational staff (that is job rotation, training level).

These three steps then provide the following information as a starting point for the design of the control suite:

— a list of system functions;

— the work tasks, their relationships, length, frequency and workload;

— the job of every member of the operating staff, grouping all tasks allocated to one person;

— a preliminary description of the equipment to be installed in the control suite.

All this should then be used to specify the work places and other working areas (see 4.5).

For a completely new control suite design, it is possible that no or little information from comparable installations is available. In the absence of practical experience, the starting point can only be a rough overview of staffing level and work tasks. It has to be completed as the design progresses. Where accurate information is not available, working assumptions may be used.

In the case of the redesign or modification of an existing facility, the starting point is the result of the situation analysis. A complete function analysis might then be replaced by an overview of the current work tasks, in combination with an analysis of the constraints to be observed when proposing changes to the work organization. This situation analysis also enables direct participation of users in the design process.

4.4 Location of control suite

In order to determine an appropriate location of the control suite on a site, the user of this part of ISO 11064 should consider, amongst other rules, the following interacting ergonomic aspects:

— visibility requirements; in other words, if it is important that a process or site/area is visible to particular operators, that work area should be located such that visual inspection is unobstructed;

— distances between control suite, process units, local control rooms and local workstations;

— control suite accessibility and emergency exits;

— job and work organization design proposals, including requirements concerning communication and interpersonal interactions;

— user task interaction with equipment;

— consideration of the movement of operators, other personnel and visitors within the control suite;

— consideration of adequate space for service and maintenance activities.

Environmental aspects to be considered:

— adequate light and windows;

— adequate control of room temperature;

— adequate protection against or avoidance of high noise levels;

— adequate protection against or avoidance of draught, wind, dust and toxic hazards;

— adequate protection against or avoidance of vibrating environments;

— in the case of alternating electromagnetic fields of external equipment (for example radar, electromagnetic separators), workplaces should be located such as to minimize their influence, because the effects on human health are not yet sufficiently understood. For further information, see ISO 11064-6.

Technical aspects to be considered:

— civil construction of a building;

— relationships between process units (interacting processes), areas to be guarded and so on;

— pipe, cable and duct routing;

— accommodation for future expansion.

Other aspects to be considered:

— some safety aspects of the control suite, for example blast-proof building or not, toxic hazards, whether the control suite is to be used as a shelter, and so on;

— security; access to the public, special security checks and gates;

— public relations (this also concerns access to the public);

— control suite visibility for reasons of security or public relations;

— architecture; the building shall fit into the general environment.

NOTE As a tool for evaluation, clause 6 gives ergonomic considerations.

4.5 Overview of task zones in the control suite

An overview of task zone requirements for the control suite shall be made.

The overview of task zones concerns the control suite and all the rooms that have a functional relationship to the tasks performed in it (see clause 6).

The specification should include the following factors:

— number of users per room (including the variability in the numbers);

— estimated sizes of fully equipped workstations per room and their estimated space requirements;

— requirements for handover during shift changes and team briefing;

— location of noise sources, such as printers, phones, alarm signals and associated requirements;

— space allowances made for future modifications and extensions.

A useful approach is to specify a task zone for each work task. These task zones should then be allocated to workstations according to one or several of the following principles:

— certain task zones can be organized in one room. For example, all control and supervision task zones (that is the operator desks) and a rest area can be in one room;

— task zones can be merged. For example: the task zones for control and supervision tasks can be merged with the task zone for an administration task (that is both tasks are performed by the same person at one workstation);

— a task zone can be in a separate room (excluding other tasks).

4.6 Design of the layout of the control suite

The functional design of the control suite should be made based on the overview of the task zones and the requirements of each ot these task zones.

Important aspects to be considered are:

— task requiring links between task zones;

— access to task zones;

— environmental constraints (for example: windows in relation to computer screens);

— architectural principles for the overall layout of the building: shape, floor level(s), columns or steel structures, traffic and service passages;

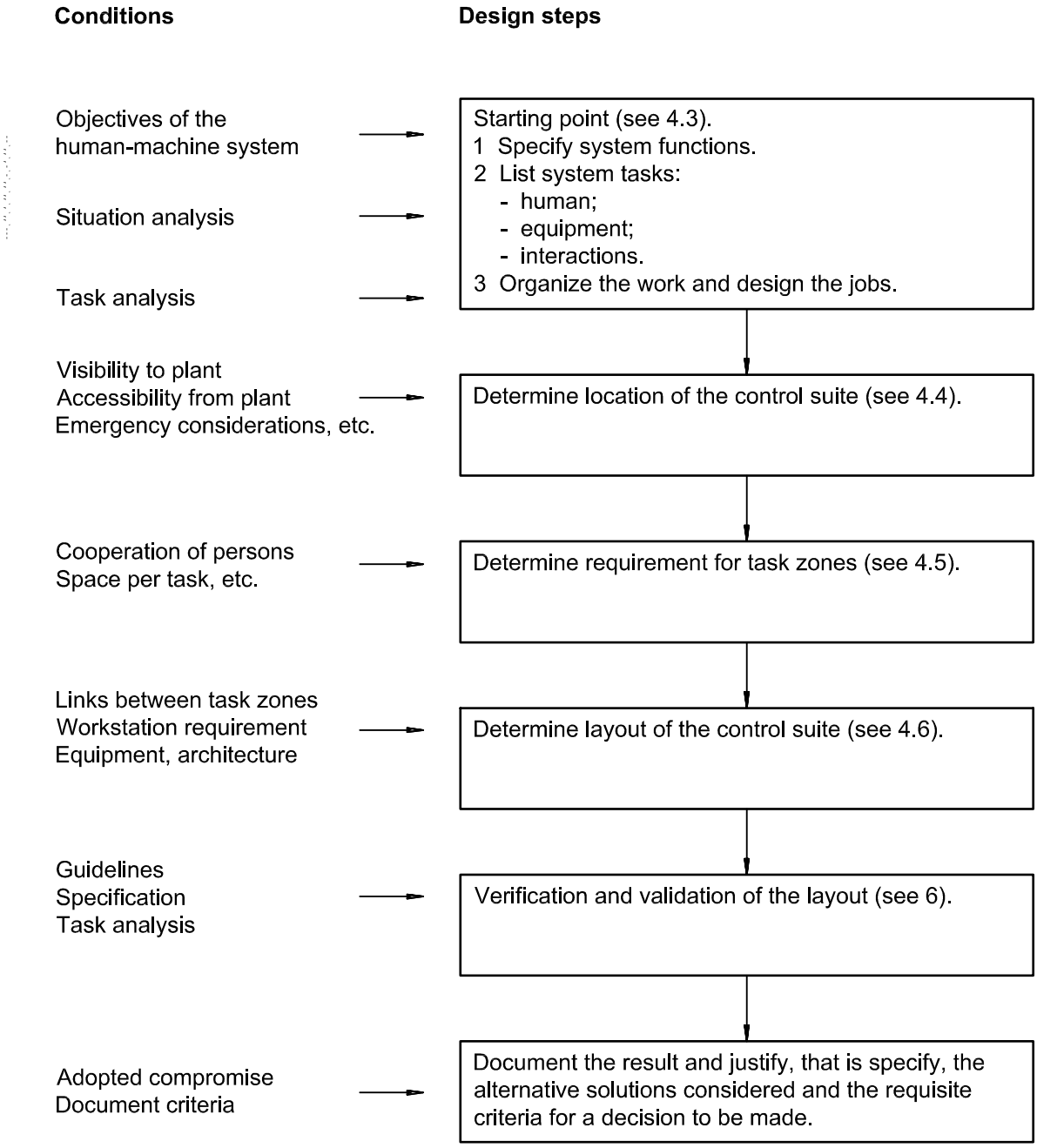
— equipment housing and maintenance access.

NOTE 1 As an evaluation tool, clause 6 gives ergonomic considerations.

NOTE 2 Detailed design of the shape of the control suite will be discussed in ISO 11064-3. Detailed design of other rooms in the control suite, and of local control rooms, can be achieved by applying the same guidelines.

5 Ergonomic aspects to be considered

The ergonomic aspects in this clause have to be considered when designing the arrangement of a control suite. The flow chart (see Figure 1) shows the process for integrating these factors. Link analysis is a tool for analysing job task patterns to determine optimum equipment placement for individuals and for team operation and/or maintenance (see [3] in the Bibliography).



NOTE 1 For further aspects to be considered see clause 5.

NOTE 2 Each design step may result in a feedback loop to one of the earlier steps.

NOTE 3 Participation of the users is included in every step.

Figure 1 — Design steps for a control suite

5.1 Communication

The following should be considered:

— task zones of individuals requiring frequent verbal communication with each other should be located close to each other;

— control suite equipment should be located such that visual contact between operators is possible where and when needed;

— communications that are extraneous to the control suite functions should not distract personnel;

— rooms and locations with different functions should be physically separated to avoid potential sources of disturbance.

5.2 Traffic and routing

The following should be considered:

— distances should be minimized to take travel and communication needs into account;

— if there is a need to directly and visually monitor a certain part of a site, the workplace for this monitoring task determines the location of the control suite on the site;

— any restrictions placed on access for unauthorized personnel should not impede access for authorized personnel;

— special consideration should be given to undesirable walking routes, such as short cuts using emergency exits. The layout of the site should be such as to permit easy access to all areas that might legitimately need to be visited;

— users may feel uncomfortable sitting with their backs to an entrance or frequently used walkways. It should also be possible, from a normal position, for the operator to observe persons entering a room with minimum distraction. This may also be needed from a security point of view. See also ISO 11064-3.

5.3 Entrances and exits

The following should be considered:

— doors and passageways in the control suite should enable access to and transport of most equipment. In this respect, thought should be given to future extensions of equipment and to maintenance and replacements, which might require access through the floor or ceiling;

— space to enable supervision of the entrance(s) should be taken into account;

— ready access to first aid equipment, emergency equipment and emergency exits shall be considered.

5.4 Environmental conditions

The following environmental factors should be considered:

— materials used for floors, walls and ceilings should be such that glare, reflections and large contrasts are controlled. Where needed, noise should be minimized by appropriate means;

— potential sources of disturbances should be identified and considered. The location of the control room should be planned in such a way that the impact of these disturbances is minimized;

— location of the control suite to minimize possible risk of exposure to hazards such as toxic materials, pollution and radiation is required where such hazards may be present.

5.5 Cleaning

Aspects to be considered:

— the use of durable building or construction materials, which require minimum cleaning and are easy to clean, is recommended;

— provisions should be made to minimize dirt and contaminates in the control suite;

— storage and use of cleaning agents should not present a risk to personnel from fumes or contact.

5.6 Maintenance

The following should be considered:

— it should be possible to perform maintenance with the minimum disturbance to the operation of the control suite;

— equipment should be easily accessible for maintenance purposes. Account should be taken of equipment needing periodical maintenance (for example lighting tubes, fire and gas detection systems, climate control systems);

— cabling, ventilation ducts and so on should be properly concealed, but easily accessible at all times for maintenance and repair. Possible future extensions of cabling should be taken into account.

NOTE The impact of maintenance (and cleaning) tasks and associated facilities may differ depending on the operational times of the control centres (24 hour operation, 7 days a week, other situations).

5.7 Visitors

In designing an arrangement for a control suite, accommodation should be made for visitors. It is necessary to distinguish between professional and public visitors. Both groups should be systematically studied to establish their respective requirements.

Aspects to be considered:

— public visitors should be guided through the control suite in a way that minimizes potential distractions and disturbances. The operator's activities should not be affected by the presence of visitors. Facilities should be created for adequate reception of public visitors (for example outside the central control room);

— facilities should be designed to accommodate the viewing of displays by professional visitors without unnecessary distraction and disturbances to the control room operators;

— space for safety shoes, helmets and so on should be considered.

5.8 Supporting information

Some of the information that operators and others use will be in document form (for example drawings, handbooks and manuals, possibly stored in electronic systems).

The following provisions should be made:

— the information should be stored and structured in such a way that information used frequently can be easily retrieved;

— filing and storage facilities should be adequate for the anticipated volume of material;

— special provision should be made for easy access to material that is required in emergencies;

— in order to save space and speed up research, the use of computer assisted documentation should be considered, particularly for emergency procedures.

6 Verification and validation of layout of the control suite

For the verification and validation of the layout of the control suite, the following shall be applied:

— verification in order to compare design features to design criteria (system specifications, handbooks or standards) to assure compliance;

— care shall be taken that the validation is operationally realistic;

— evaluation of functions and usability (validation);

— link analysis may be used to validate traffic patterns and communication links;

— the use of walk-through and talk-through techniques, where the idea is to work through scenarios or sequences in the new design. Care should be taken that the mock-up or simulation is sufficient for the complete task;

— the use of simple representations of the new design such as drawings, photographs, as well as mock-ups. Another possibility is the use of virtual reality techniques;

— different task analysis techniques such as link analysis or time-line analysis where communication and coordination can be tested;

— the principles for the evaluation of control centres as given for information in ISO 11064-7.

Generally, many compromises will be made during the process of the design of a control suite. Many starting points for the design of control suites are possible and a wide range of aspects shall be considered when locating the control suite and rooms within the control suite. Therefore, each major design decision and compromise shall be documented to enable verification and validation (see [7] in the Bibliography).

Annex A
(informative)

Some detailed considerations for specific rooms and areas

Designing the layout of a building, such as that of a control suite, is a complex matter because of the diversity of requirements to be considered. In order to facilitate the design process, this annex gives an overview of possible rooms and working zones in the control suite. It may also be used as a list to check the completeness of a control suite design.

The considerations given in clauses 4 and 5 should be applied to each of the rooms mentioned. In view of the large number of design requirements and outcomes of the control suite design process, the project team should document relevant considerations.

A.1 Control room

Usually, control and monitoring tasks and associated task zones are situated in the control room. The location of the control room within a control suite should be determined by applying such considerations as:

— security and safety (for example direct entrance, special entrance doors/gates, entrance route via several security checks);

— operational and social links related to the level of the control room (ground level or not).

NOTE For plants or facilities (partly) housed in a building, ground level should be taken to mean the main operating level, where most of the field workstations and field operators are usually found.

The control and monitoring task zones may be in the same room, or might be integrated with the following task zones:

— documentation task and associated task zone

  consider the facilities needed for documentation purposes and possibly other administrative work tasks, including the use of electronic aids such as personal computers, visual display terminals (VDTs), integration in process control system;

— administrative task and associated task zone

  shift book, notes and so on (see previous item);

— analysis/diagnostic tasks and associated task zone

  apply the same considerations as for documentation task, including the possibility that several persons will be discussing certain problems;

— supervisory tasks and associated task zone

  consider possible conflicting factors such as the work organization (team work versus hierarchical distance between operating personnel and supervisory staff), privacy aspects, a general view on the process and so on;

— permit and visitor handling task and associated task zone

whether such a task zone (for example counter) should be part of the control room or a separate room depends on conflicting considerations, such as the work organization (work permit delivery and visitors), coping with peak hours, knowing exactly what is going on in the field and maintaining a quiet environment in the control room;

— shift turnover.

A.2 Equipment and maintenance areas

The design of equipment and maintenance areas also requires ergonomic considerations. These considerations should be elaborated in close co-operation with manufacturers, suppliers, maintenance engineers and so on.

Aspects to be considered:

— computer area, electrical equipment area, cable racks area

many details of these areas (for example rack room, electrical room) will be supplied by the computer manufacturer. Consider environmental factors (for example illumination levels), as well as access for initial installation and future maintenance activities;

— maintenance area, workshop(s), application engineers area

all kinds of hardware and software maintenance and development work tasks may be performed in connection with a control room. In case of VDT-based activities, see also ISO 9241;

— storage area (spare parts)

consider access, volume and weight of equipment.

A.3 Welfare areas

Aspects to be considered:

— emergency exits and equipment

consider, for instance, storage of personal protective equipment, communication equipment and defensive/security equipment;

— relaxation area, kitchen or kitchenette, smoking area

several aspects might be considered, largely depending on company policies concerning rest periods, food and smoking. Also consider easy access to the control room, in case of sudden special circumstances;

— personal storage area

consider personal storage areas for private belongings, study books, training manuals, working cloths, equipment, tools and so on;

— toilets, showers, washroom

consideration should be given to contaminating material coming from other parts of the site, the cleaning and upkeep of the control suite;

— visitors' room

reception area for non-professional visitors;

— area for particular cultural requirements

  designers should always check whether special rooms or arrangements are to be included in the control suite, according to local habits and cultural backgrounds (for example prayer room, wearing of shoes prohibited in control suite or offices and so on);

— first aid area/facilities

  check local regulations.

A.4 Miscellaneous

Although the task zones listed below are considered as separate rooms, it may be possible to combine task zones depending on the following aspects to be considered:

— conference zone, training/study/simulator zone

  list possible number of attendees and the equipment and materials requiring floor space. This listing can be a basis for estimating the number and size of such rooms/areas;

— security zone

  consider the need for a barrier between (part of) the control suite and other facilities in relation to access needed by colleagues, staff and so on;

— technical support centre;

— areas for contractor personnel;

— emergency room;

  in the case of major incidents, a separate facility, generally fitted with special communication equipment, might be necessary. Consider whether the control room could fulfil this role.

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