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BSI Standards Publication

Ergonomics methods

Part 2: A methodology for work analysis to support design

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National foreword

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Ergonomics methods - Part 2: A methodology for work analysis to support design

Ergonomie - Partie 2: Méthodologie d'analyse du travail à l'appui de la conception

Verfahren der Ergonomie - Teil 2: Eine Methodologie für die Arbeitsanalyse zur Unterstützung von Entwicklung und Design

This European Standard was approved by CEN on 23 January 2016.

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European foreword

This document (EN 16710-2:2016) has been prepared by Technical Committee CEN/TC 122 “Ergonomics”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2016, and conflicting national standards shall be withdrawn at the latest by September 2016.

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

EN 16710 consists of the following parts under the general title *Ergonomics methods*:

— *Part 1: Feedback method - A method to understand how end users perform their work with machines* (Technical Report)

— *Part 2: A methodology for work analysis to support design*

These present independent methods that can be used to support the implementation of ergonomics principles, for example as advocated in EN ISO 12100 and the EN 614 series.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The ergonomic design approach involves considering human capabilities, skills, limitations and needs. It is developed on the basis of a decision process, which calls upon not only scientific and technical knowledge data provided by existing standards but also expression of the “know-how” capitalised by the intended user population. Know-how and other knowledge data provided by standards can only become meaningful when based on preliminary analysis of real-work.

Ergonomics design focuses on the actual activity of operators. The methodology described in this European Standard therefore increases the effectiveness and efficiency of the machinery or system being designed; improves human working conditions; and reduces adverse effects on health, safety and performance.

This methodology can lead to one or more suitable solutions embracing situations to be confronted by future users. Applying this will raise productivity, improve work quality, reduce technical support, maintenance and training needs, and will enhance user/operator satisfaction.

Application of this methodology will be most effective when management is closely involved (adoption, communication, etc.).

Extensive ergonomics knowledge exists in relation to organizing and establishing an efficient design process. Applying this knowledge, this present European Standard structures a user-based approach and proposes corresponding requirements for project managers. This approach complements existing design methods and requires reference to ergonomists.

This process concerns both established, as described by EN ISO 12100, and emergent risks and their association with the independent evolution of any system, user variability and conditions of equipment usage.

In this respect, the methodology for work analysis presented in this document is based on the resultant design being at least partly determined by anticipated future developments, especially those indicated by the client.

This is a shared procedure, in which the client provides specifications detailing the knowledge helpful to a design suited to the needs and expectations of users. Examples of the contribution of an ergonomics design approach to preparing specifications are included in informative Annex A.

Design based on an ergonomics process is necessary to meet any “performance obligation” (i.e. obligation of result).

This European Standard complements knowledge generated by work activity analysis to enhance the quality of references and other solutions validated within a participative framework. This is indeed the case when a compromise solution cannot be found in relation to a specific point because the underlying knowledge cannot be validated. This European Standard facilitates orientation towards a shared final decision.

1 Scope

This European Standard describes a procedure for analysing human activity in relation to specifying and refining the human component in the design or redesign of machinery and work systems.

NOTE 1 The ergonomics methodology described in this European Standard could also be applied to the design or redesign of products and non-work systems.

This European Standard is intended to assist project leaders in implementing human and physical resources, methods and schedules as well as in preparing the documents necessary to meeting related requirements.

The ergonomics methodology described can be applied to all different stages in design projects from the earliest concept to the final “prototype” or “mock-up”, whatever the industrial field or sector.

The objective of this European Standard is to achieve a solution that takes into account as many situations as possible which all users - including operators, maintenance staff and installers, may encounter. This will ultimately allow improved usability of the machinery and more robust technical solutions, combined with significantly greater system resilience, user autonomy and accessibility.

NOTE 2 Examples of the application of the methodology described in this European Standard are provided in Annex A.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
ergonomics
scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance

[SOURCE: EN ISO 26800:2011, 2.2]

2.2
worker
operator
person performing one or more tasks within the work system

[SOURCE: EN ISO 6385:2004, 2.8]

2.3
work activity
manner in which a prescribed task is, in reality, performed

2.4
work system
system comprising one or more workers and work equipment acting together to perform the system function, in the workspace, in the work environment, under the conditions imposed by the work tasks

[SOURCE: EN ISO 6385:2004, 2.16]

2.5
accessibility
extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of characteristics and capabilities to achieve a specified goal in a specified context of use

[SOURCE: EN ISO 26800:2011, 2.1]

2.6
work equipment
tools, including hardware and software, machines, vehicles, devices, furniture, installations and other components used in the work system

[SOURCE: EN ISO 6385:2004, 2.7]

2.7
assumption
proposal relating to the explanation or interpretation of phenomena, observable facts and solution principles, assumed temporarily before being subjected to checking

Note 1 to entry: In observing workers the observer should verify any hypotheses concerning knowledge acquired regarding the work and its translation into solution principles with the workers concerned.

2.8
prescribed task
formal description of how a task is expected to be performed

EXAMPLE prescribed and prohibited tools, conditions of use, procedures, order of operations etc.

3 General requirements in specifying the human components

3.1 User experience and resultant activity

Ergonomics design involves considering all work situations that may be encountered by intended users. Users of machinery and of other systems performing the same or similar functions, possess a variety of levels of skills (including procedures for anticipating and avoiding risks) and knowledge of various constraints concerning individual and collective performance (described by the term "know-how"). Systematically collecting this know-how is fundamental to decision making in developing the design of a new machine and or work system. The know-how of an individual has a strong influence on their activity. It is essential to understand the motivations induced by the work system and the experiences of the user, which determines their observed activity.

To maximize accessibility, the design shall take account of the full range of users depending on the objectives of design including, where applicable, older people and those with disabilities. This requires the designer to consider characteristics which are associated with increasing age. It might also include identifying specific subgroups that should be included, for example people with impaired hearing, those with cognitive impairment, and people who are already using assistive technologies or who might require individualized solutions or alternative means of access. For this purpose, the approach described by this European Standard firstly requires identification of reference situations, in which work analysis will be performed. Reference situations are situations close enough to the design situation to enable the extraction of the knowledge data required, to enrich the specifications for the system (machinery, work system, product, etc.) to be designed.

A key part of that knowledge data will be the assumptions made by individuals in operating existing systems (machines and or work systems) in these reference situations.

This type of knowledge, concerning real work situations, is valuable in specifying system functionality consistent with work system requirements.

Figure 2 (see 5.1) illustrates the work activity's central position in understanding work system operation. It is necessary to proceed iteratively in establishing relationships between different components of the overall work situation. The work activity analysis methodology is described in 5.3. The knowledge generated by these analyses and their translation into specifications requires validation by the intended personnel. 7.2 describes the validation of the outcomes.

3.2 Limitations of the scientific and technical knowledge provided by existing ergonomics standards

A standard aims to smooth out differences to produce a standard applicable to all situations and conditions. However, it is unable to integrate specific characteristics of the work context. Both existing variability criteria and an ergonomic design approach require consideration of these differences.

Variability can be:

— industrial: raw material quality, adherence to delivery times, etc.;

— inter-individual: age, gender, morphology, experience, know-how, etc.;

— intra-individual: chronobiology, ability to act, etc.;

— contextual: organization, daily period, yearly period, night work, etc.

It is these sources of variability that essentially qualify the real operation of work systems and hence production systems. They should therefore be taken into account.

Within an ergonomics design framework, the standard implemented as an assessment tool appears to be a component contributing to the resulting validation process. The two processes, involving assessment by standards and work knowledge validation by intended operators, combine to reinforce decision-making rigour, a guarantee of design system sustainability.

4 Fundamentals

4.1 Participatory approach

Personnel participation in implementing and developing a project is a valuable part of the design process. It simultaneously enriches the knowledge generated in relation to user activity and validates the principles behind solutions or other references to be considered in the design. Clearly defined at the start, these objectives are immune from any risk of the approach being instrumentalized, e.g. by seeking acceptance by relevant personnel in relation to technical options selected without their involvement.

Participation is particularly beneficial when the personnel involved form a population similar to the one destined to operate the planned system. It is therefore a key factor in that it facilitates appropriation of future situations.

The ergonomics design process described in this European Standard envisages a participatory approach between all parties involved. As illustrated in Figure 1 for example, particularly for lager projects, this could involve the formation of a steering committee, responsible for formulating the design. Under the leadership of a project manager, this steering committee would be the decision-making body (final validation). Membership of such a committee should include representation from users, supervisors and managers, and project designers, as well as personnel with ergonomics and occupational health and/or safety knowledge and expertise. The participative structure of the ergonomics design process outlined, establishes a system for transfer of information between a steering committee and working groups established by that committee.

The working groups should include one or more “operator” working groups (WGO_1, WGO_2 ...), made up from volunteers drawn from appropriately experienced operators within the workforce (professionally qualified where appropriate). Inclusion of supervisory personnel in an “operator” working group is likely to focus the thinking of that group on technical options rather than understanding human and social issues. It is therefore recommended to include them in a specific “supervisor” working group (WGS).

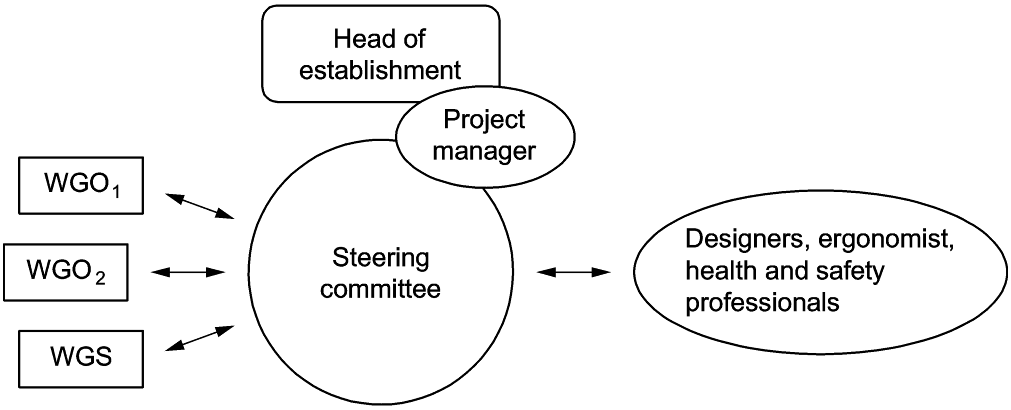

Figure 1 — Organisational structure of steering committee and working groups

Under the leadership of an ergonomist, the personnel in a working group discuss the knowledge derived from the analysis of work, performed under current or similar reference conditions. They should observe and analyse the work performed by a number of operators in real conditions. It is important to gather information about actual task performance. Based on this analysis, and drawing on their own knowledge and expertise, they propose, and provide the initial endorsement of possible solutions. At this level, standards or other technical and scientific knowledge are helpful for assessing results and consolidating potential solutions.

Based on knowledge acquired by themselves, working groups provide a forum for “proposals”, while the steering committee seeks the best compromises and validates specifications to be forwarded to the designer(s), albeit under the responsibility of the company manager.

4.2 Work analysis

Work analysis is based on methods and a corpus of scientific knowledge involving human functioning, as well as other knowledge relating to work organization, preventive health and safety regulations and standardization. All these areas contribute to the consideration of physical and mental health in designing work situations and equipment.

In analysing work activities, it is important to differentiate between the operations prescribed (e.g. instructions, procedures, checklists) for carrying out work tasks and those actually performed. Limiting work analysis to analysing tasks as prescribed is insufficient. It is essential to analyse how tasks are actually performed by considering the influences of work situation, context and operator variability in relation to their performance. This is then referred to as the analysis of an actual work activity. The activity is what is implemented by the operator in order to achieve the task goal.

Analysis of the work as it is really performed requires application of a combination of observation, description and interpretation methods, and assigns the operator to a central position in the analysis process.

The prescribed task is a reference or benchmark for optimal conditions and the analyst should avoid placing undue emphasis on this in carrying out the analysis and being judgemental due to expectations of how the task should be performed.

The analysis is not limited to observable behaviour. It is necessary for the analyst to understand contextual and other factors, which influence why the operator does not perform the task as prescribed.

The approach is heuristic, guided by uncovering new working hypotheses, which may lead to solutions that are innovative and best adapted to the variability of contexts and situations.

Analysing key factors within the overall work situation, together with reference to appropriate standards, aids the interpretation of the results provided by the work activity analysis and assists in understanding any operating difficulties identified during discussions with the relevant operators (see Figure 2, showing overlapping of means/resources and activity).

In order to optimize the relationship between a human and his environment (ergonomics) it is therefore essential to go beyond analysing the prescribed task to understand observed activity. Involving intended users as co-designers provides the basis for sustainable implemented solutions whose underlying principles will have been detailed in the design specifications.

5 Elements of methodology

5.1 Analysis of overall work situation components

Figure 2 shows the overall work situation in terms of the “Resources” and “Means” required to implement the work activity. It illustrates the interrelationships and interactions between all parts of the overall work situation. A work situation is qualified as “overall” insofar as it requires consideration of the links between its various internal and external components, which may affect the work activity.

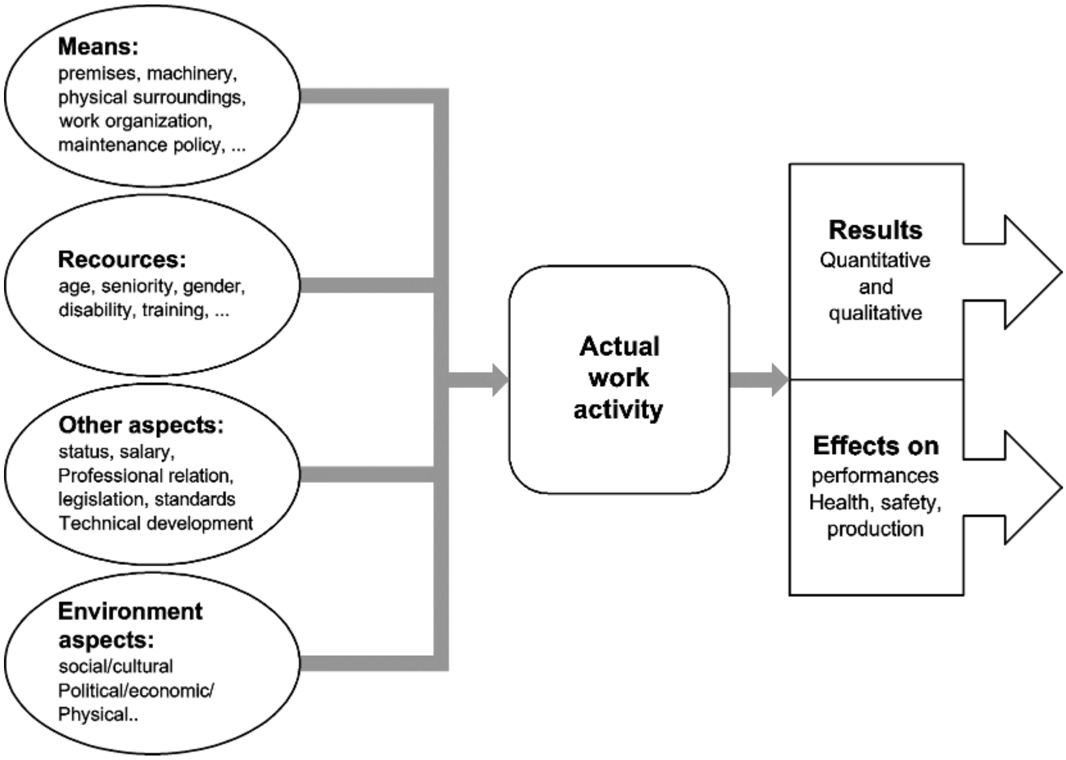

Figure 2 — Overall work situation

Analysis initially concerns a set of determining factors grouped under the headings “Resources” and “Means”.

"Resources" are the characteristics of the human operators in a work situation; such as characteristics relating to age, gender, morphology, visual and motor capabilities, training, skills, length of service at enterprise or job, as well as components of life outside work (when these influence the work situation). Their analysis stresses the importance of considering existing criteria concerning inter-operator variability. It should be noted that human operators are "naturally" subjected to extensive internal variation resulting from accumulated fatigue, tensions due to a difficulty encountered, biological rhythms that vary sharply and cyclically during the day, and feelings of growing discrepancy between wishes, and the reality of everyday life.

"Means" groups together the "working conditions" data that enables operators to perform their task: characteristics of the production process, tools, machinery, work stations, work physical environments, and collectively-established work relationships. They also encompass safety rules and other means of injury and disease prevention, procedures, work organization, etc.

Data on the physical environment are given in EN 614-1. However, they should be analysed in relation to the real work to be performed, and to the activity to be deployed, depending on the context.

EXAMPLE Noise represents a work stress likely to have a harmful effect on personnel. But noise also provides helpful information in some cases and its elimination can disturb an activity and thereby generate new safety-related risks. Comparing the results of physical measurement with the relevant standards is not enough.

The approach to the work situation should also consider the different sociocultural, economic, technological and regulatory contexts, in which work activities are created and subsequently develop.

5.2 The "activity-focused work system"

To understand closely a work system operation, it is necessary to consider work activity in relation to all work situation components. It is essential to examine and understand the way in which different aspects of the work system influence and are influenced by the work activity.

These are illustrated in Figure 3, (derived from Figure 2), which highlights the interrelationships between "Means", "Resources", "Results", "Effects" and "Work activity".

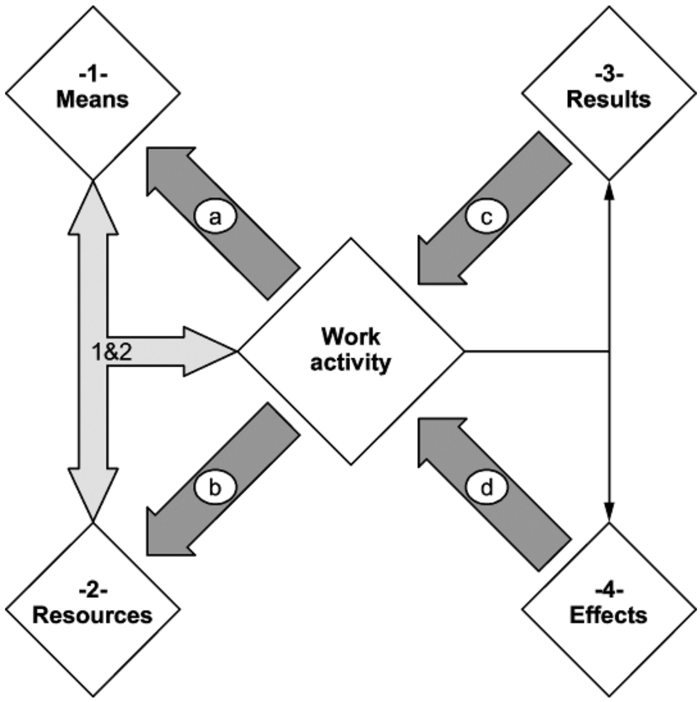

Figure 3 — The "activity focused work system"

A work situation arises out of the technical and organisational means provided (1 - Means). It is specified based on personal characteristics (2 - Resources). Interaction between the means available to carry out the work activity, coupled with the resources brought by the individual operators, influences the outcome of the work activity. It can be analysed as a system because, at the same time, it enables a level of economic performance to be achieved (3 - Results), affects personal satisfaction, or is harmful to health (4 - Effects).

In common with all systems, this type of system has a degree of operating independence. This is because there is no deterministic link between resources, means provided and "outputs" expressed in terms of overall performance (Results and Effects). In other words, it is impossible to foresee the exact consequences of technical and organisational decisions on the economic performance and health of personnel.

Indeterminacy is inevitable because the nature of the operators' "Work activity" (5) is not determined "a priori", but built up by operators themselves, based both on their experience and on the variability of situations encountered.

Human operators thus optimize their work activity implementation conditions by controlling and changing components of the means provided (1), in particular the initially planned task (arrow a).

EXAMPLE Operators can adapt every component of organisational flexibility to improve working areas and storage facilities or even to create new work procedures that are more efficient than those specified in instructions, even if this remains "unsaid".

In doing this, the level of "Resources" (2) available changes (arrow b), especially through operators acquiring new individual or collective know-how. However the level of resources can also reduce, through possible deterioration of overloaded functions and resultant premature aging.

Depending on the work context and cyclic production fluctuations, human operators adjust the desired level of contribution to "Results" (3) or "Effects" (4), while endeavouring to maintain performance (arrow c), without going beyond what they consider to be their personal limits (arrow d). For example, they intensify their work to save time; they take advantage of waiting times to anticipate the next operations, they carry out several tasks at the same time and adopt uncomfortable postures to succeed in repairing a machine.

It should be noted that "Results" (3), such as production quantities, compliance with deadlines, customer satisfaction and dysfunctions, are generally presented as a set of indicators of the production system's operation. The "Results" should also be linked with the constraints concerning the implementation of the work activities.

"Effects" (4) are harder to identify than the results. Occupational injury statistics and analyses provide an initial idea of this. Statistics can provide indications of absenteeism, staff turnover and requests to change of work station or workshop; these are criteria for assessing satisfaction at work.

Effects can also be positive, for example when they result in greater expertise or a feeling of motivation and satisfaction at work.

To understand closely a work system operation, it is necessary to consider work activity in relation to all work situation components.

5.3 Principles of work activity analysis

5.3.1 General

Analysing work activity allows work-related knowledge to be generated, based on comfort, safety and efficiency criteria and, furthermore, to transform these criteria into recommendations or other requirements to be included in work equipment design specifications.

The three key stages of work activity analysis are:

— observation;

— description;

— interpretation.

Examples showing the different stages to be carried out are given in Annex B.

5.3.2 Observation

Observation of activity is the first level of analysis. It requires appropriate preparation and cannot be properly fulfilled by a "quick look" or by the temptation to "put oneself in the operator's place". It should not be performed without operators being given all necessary guarantees (e.g. respecting operators privacy, confidentiality) and explanations concerning process objectives, conditions of both implementation and data collection operation.

Close cooperation with relevant operators is necessary in relation to identifying variations in activity attributable to night, morning, afternoon and weekend work, regular production lines or specific product ranges, normal system operation or degraded phases, etc. The choice of situations to be observed/analysed results from hypotheses regarding work variability based on this analysis of the overall situation.

The choice of situations and contexts leads to the selection of appropriate recording and analytical techniques: manual transcription of observables onto charts, audio-video recording of a significant work sequence (involving one or more operators), etc.

Observables should be continuously collected during a full work sequence to understand the underlying intent and display the reasoning during the interpretation phase. If appropriate, a video recording can facilitate this collection process. This can help in reviewing the data and assists in its interpretation.

Observation of conditions should not interfere with performance of the real activity. A preliminary time period is required to allow the viewer to immerse himself in the work situation, to identify significant observables and to familiarise operators with the observer's (or camera's) presence.

5.3.3 Description

This process, which prepares for the results interpretation stage, effectively reviews the observed or recorded data.

The data can be reviewed using charts or columns and the data to be extracted therefore includes factors such as visual attention areas, postures adopted, actions taken on machine controls, etc. An example of a chart can be found in Annex C. All relevant information on simultaneous machine or system operation should be recorded in parallel: operating mode, various signals, alarms, etc.

Description may also involve drawing up an analysis graph of the operation in progress, to enter, in separate columns, events that occur (noise, office entry of another operator, phone calls, etc.); actions (what the operator is actually doing); and communications (dialogue in room, telephone calls, etc.); based on their meaning and underlying intent.

5.3.4 Interpretation

Interpretation should clarify characteristics of the activity and work situation as independently as possible from the area of operator wishes and opinions, though they may provide a valuable source of information and should be recorded.

This process concerns both the directly observable and the non-obvious parts of the real activity.

It can only be properly implemented by questioning the relevant operator on the sequence to be analysed, a process known as "verbalisation". Thus, even when statistically analysing observables, it is important to understand the reasons for the observed activity from the relevant operator's viewpoint. For example, it may be found that the operator spends a significant amount of his time "greasing a roller", so the questioning will seek the operator's reasons for this.

Verbalisation also accesses those parts of the activities which are not directly observable, in order to facilitate the understanding of intentions, meanings, representations, reasoning, emotions, etc.

Verbalisations are invariably required for proper interpretation of observables. One benefit of the use of video-recording is that it enables the operator to be subsequently questioned about particular activities, without any need to interrupt him during those activities.

Verbalisations should ideally be performed "in context", i.e. in the workplace (on the job) or in a nearby reserved area, in which the filmed sequence to be analysed can be viewed. A process known as "verbalisation in self-confrontation"; it constitutes a particular form of semi-structured interview, which involves placing the operator in conditions as close as possible to those of the real activity to prompt his narration and commentary. Carrying this process out in (or close to) the workplace can help in assisting the operator to explain or demonstrate particular aspects of the activity where necessary.

Verbalisations can thus help to explain the difficulties experienced and to highlight implemented components of the operator's know-how.

Further inferences regarding the activity can be obtained by developing working hypotheses through linking the outcomes of statistical analyses or operator answers with scientific knowledge and available standards.

It may happen that certain actions or events cannot be interpreted because the operator does not know; does not remember exactly; or quite simply cannot explain their chosen activity. This provides additional clues that reveal, for example, the difficulty of solving a problem, incomprehensible dialogue with a colleague or a control interface, a resolution deadlock, which represent as many missing conditions for system reliability and form highly significant paths for improving a situation.

5.4 Knowledge validation process

Individual verbalisation work is concluded by an iterative process of interpreting the knowledge generated from the observed work and reflecting the outcomes back to the operators for validation. This is a first step in the iterative validation process, which progresses from individual, to collective (working group(s)) and decision (Steering Committee) steps.

At a "collective" level, the validation process allows movement from the acquisition of operational knowledge and its individual validation to compromise and renegotiation of results in the Working Group. Validation involves ensuring that the descriptions produced are:

— a fair reflection of real activities in terms of diversity and as they take place in most situations;

— appropriate to their operator or management staff interpretations.

Based on test results validated at "collective" level and on know-how that may be provided by certain of its members, the Steering Committee then decides, in full knowledge of the facts, either to validate the knowledge data presented or to suggest other paths requiring supplementary analysis.

This iterative process of knowledge validation, illustrated in Figure 4, ensures that the practical dimension is fully integrated into the development of the specification from the inception of the design.

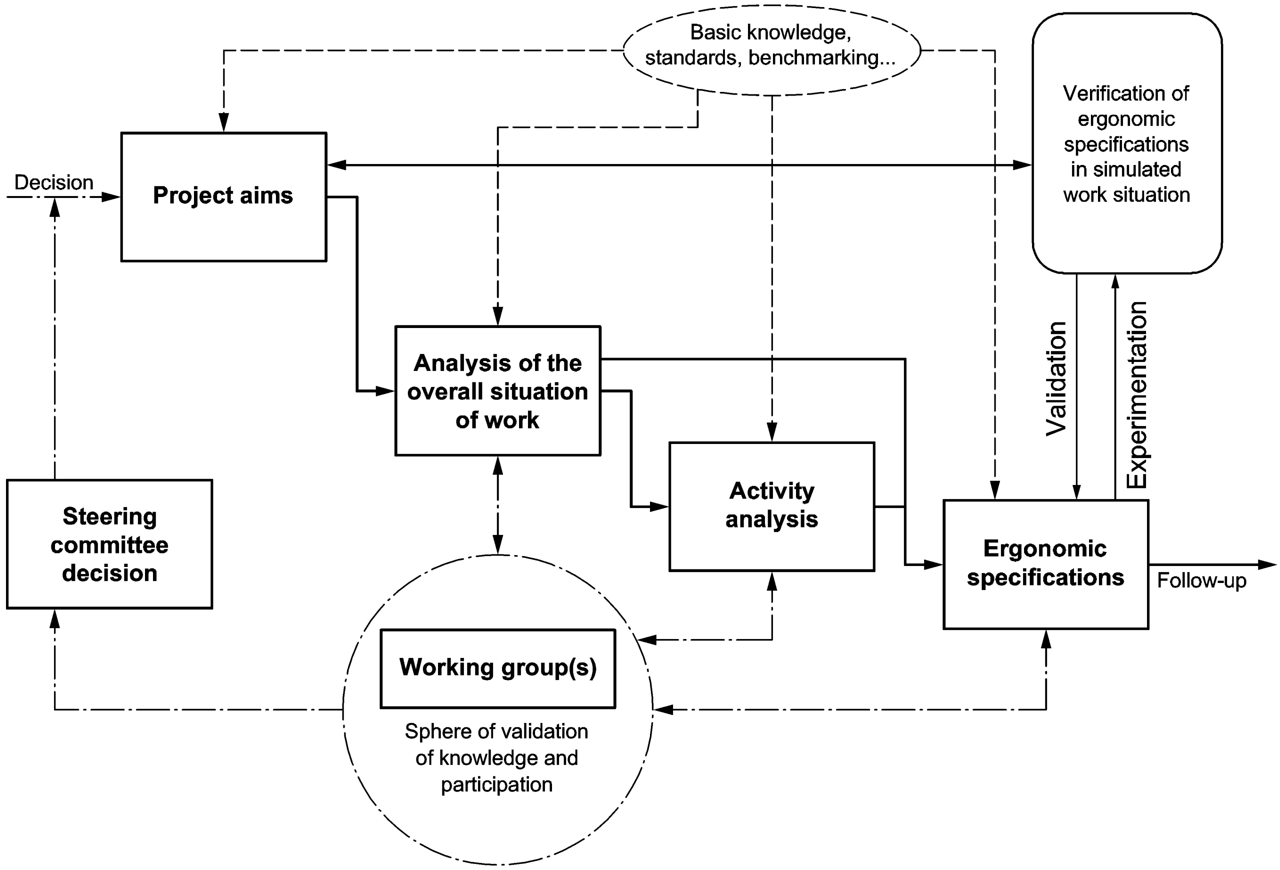

Figure 4 — Iterative process for producing ergonomic specifications

6 The work activity in the design process

The work activity analysis approach described in 5.3 represents a method of assessing real needs, which makes it possible to specify requirements for design consideration.

More precisely, the process implies:

a) implementing regulatory, normative, methodological and technical monitoring solutions and using analysis-generated knowledge to develop design proposals;

b) illustrating principles and/or formulating design solutions using simulations, models, mock-ups, etc. to designers to make their decisions more explicit;

c) offering users the possibility of testing design solutions under real conditions or on a virtual test bench (numerical models, simulations, etc.) and considering test results (feedback, proposals);

d) assessing several design solutions or several design alternatives in relation to usefulness and usability (from both performance and user satisfaction viewpoints);

e) continuing the necessary iterative process in conjunction with the designer until the activity associated with human operator-centred aims is reached.

7 Recording the process and reporting the outcomes

7.1 Traceability

The results of design operations, performed to meet the requirements listed in Clause 6, should be recorded to ensure management of the iterative design process. This recorded information can be entirely in document format or can include actual design productions, e.g. hardware or software prototypes.

Specifications include:

a) the source of knowledge generated in relation to the activity (work sequences, ranges, context, etc.);

b) existing standards to be complied with and suggested method of application;

c) the type of problems identified and design modifications considered for solving them;

d) basic requirements and the rules of best practice to be integrated into the design process, to ensure that the designed equipment will fulfil its expected operation more closely;

e) constraints imposed on the team (e.g. financial, timescales, manufacturing).

7.2 Assessment outcome and validation

Conclusions of all resulting assessments should be recorded and validated to control the iterative design progress.

In particular, relevant evidence should be provided to demonstrate that:

a) suitable sample of operators from the user population took part in activity analyses and working groups and that these users were representative of those identified for the equipment usage context;

b) data collection and activity analyses were processed using valid methods: data statistical processing mode, assumption formulation mode, applied analysis methodology, scientific knowledge reference frame, and considered standards;

c) data on the overall work situation should be verified (confirmed) by objective measures of the physical environment;

d) test conditions defined for implementing possible simulations are respected;

e) the result is validated by stakeholder assessment; this validation contributes to appraisal of the results assessment and supports decision-making.

7.3 Assessment report

Depending on the aim of the assessment, three forms of reporting can be useful:

a) Reporting of design feedback. This report should:

   — be at an appropriate time during process development, such as during design reviews;

   — be based on suitable assessment sources (e.g. knowledge based on real activity analyses validated by users);

— provide design feedback in a format that supports design decisions;

— result in demonstrable changes in the system, where applicable.

b) Reporting of assessments with respect to specific standards. This report should:

— identify relevant standards and provide a rationale for their use;

— provide evidence that assessment was conducted by a competent person using appropriate procedures;

— provide evidence that enough system parts (in the workplace or otherwise) were tested to provide meaningful results for the system as a whole;

— report how non-conformities were dealt with in the design;

— justify any deviations from applicable standards.

c) Reporting of usability/health and safety issues in connection to use of product. This report should:

— define the usage context selected for assessment;

— provide information on operator/user and organizational requirements;

— describe task environment tested and its status, e.g. mock-up or prototype;

— describe metrics performed, operators/users involved and methods applied;

— contain results backed up by relevant statistical analyses;

— indicate a pass/fail decision in relation to requirement compliance.

8 Coherence with other standards

Application of this European Standard complements the principles described in parts of the EN 614 series and in EN ISO 12100. It also complements ergonomics standards like EN ISO 26800 or EN 9241 series.

Annex A
(informative)

Example of requirements specification to be integrated into tender submission for ergonomics design for work equipment

A.1 General

The tender submission is a contract document binding the company and its product suppliers or service providers. It is intended to clarify needs and constraints associated with a machine or work system design request. It embodies a process for drawing up a set of specifications. The edited document, called the tender submission, also enables a supplier to represent a proposing force.

Tender submission preparation should promote a proper understanding of the needs of the company to ensure successful supplier consultation. In this connection, the document is based on:

— Functional analyses describing the system (e.g. machine) and technical components (expected functions and technical characteristics);

— An expected performance assessment (quantity, quality);

— Specifications derived from analyses of work under conditions similar to those envisaged. These specifications are intended to clarify real production needs by integrating human and organisational operating requirements (working comfort, safety and efficiency). The table below contains a guide list of specifications to be integrated into the tender submission;

— Clauses listing particular constraints: delivery times, maintenance conditions, etc.

As this European Standard shows, tender submission preparation is further based on a structured organization cooperating with relevant personnel and open to discussions with retained suppliers.

A.2 Example specifications

A.2.1 EC marking

— Responsibility: designation of an EC-marking supervisor (if there are several manufacturers).

— Approach: enrich the approach by setting up a practical test for checking that envisaged solutions effectively take into account recommendations of both current European Standards EN 16710 and EN 894-4 before any final installation.

A.2.2 Expected performance in terms of:

— Operation;

  — productivity, availability;

  — operating rate, cycle time;

  — quality level;

  — costs;

    - allowable down time and frequency of failures and other unforeseen incidents;
- occupational health/safety and well-being;
    - integration of optimization indicators for:
        - level of occupational accidents, and disease seriousness;
        - level of absenteeism;
        - employee turn-over;
        - user experience and satisfaction.

A.2.3 Technological options

- Check compatibility between activity analysis results in reference situations with:
    - envisaged technology;
    - level of automation, taking into account automation paradoxes in relation to human behaviour;
        - the higher the level of automation, the more the role of the human operator is accentuated/determined, i.e. the higher the level of automation, the lower the human control capacity and the greater the potential importance of a human control failure;
        - greater technical expertise is inversely proportional to greater human expertise, especially under disturbed conditions;
        - integration of a protection system, designed outside real work requirements, introduces an illusion;
        - a high level of automation is accompanied by formalization, in the form of procedures that partially obscure solution variability and prompt emergence of new risk situations (determined thoughts);
        - multiple interfaces make the operating system more opaque;
        - automation is, on the one hand, reflected by a reduction in personnel and, on the other hand, introduces a strong need for collective work, and thus a need to define an ad hoc organization;
    - automation design (basic operation, failure-based operation);
    - loading and unloading methods, tooling and fabrication changeovers;
    - automatic, manual with automatic or procedure-dependent safety devices;
    - separation of power and control systems;
    - running modes (production, adjustment, diagnosis, setting, maintenance, cleaning, etc.);
    - accessibility of adjustment devices;

- operating modes after failure (degraded mode, manual take-up during cycle, etc.).

— opt for:

- an "error tolerant" system;
- Man Machine Interfaces designed based on user logic, facilitating perception-action combination and operation-based cognitive accessibility (to "make the invisible visible");
- clear fault display (for a digitally or PLC-controlled machine);
- kinematics adapted to movements.

A.2.4 Resources

— Assessment of personnel requirements:

- level of human resources (personnel numbers) is related to production objectives and should be detailed based on real needs expressed by analyses under reference conditions;
- consideration of specific needs for aging and/or handicapped personnel, irrespective of gender, to allow accessibility to the new situation for performing the required work;

— training and information of personnel;

- provide a future user-training package integrating;
  - user-information on action plans decided by the steering committee;
  - usage conditions and special procedures (adjustments, maintenance, etc.), usage counter-recommendations, risk information, associated prevention measures and systems, all work performance-related information required by users;
  - facilitation of tool-based learning and training through consideration of usage/operation logics;
- propose a skill recognition system based on real work implementation requirements.

A.2.5 Means

— Product to be manufactured, processed, transported, etc.;

- general description;
- description of critical situations such as those identified under reference conditions;
- corresponding constraints: weights, dimensions, temperature, gripping, packaging, etc.;

— process and related constraints;

- energy requirements: power supplies compatible with available sources and associated equipment;
- raw material storage and flow;

  - waste product removal, storage and disposal;
  - cleaning operations to be performed;
  - physical accessibility (layout and available space);
  - mental accessibility (software);
  - equipment design compatible with existing equipment (layout and technical compatibility) and know-how.
- organization;
  - define reference conditions, under which activity analyses will be conducted, by integrating various scenarios and possible situations;
  - propose an approach that will structure the feedback experience and facilitate operation by relevant stakeholders: project manager, designers, prevention specialists, operating and maintenance personnel concerned;
  - outline future organisations, in which future users will work, taking into account:
    - seasonal variability, night and/or weekend work, etc.
    - knowledge acquired from activity analyses performed under reference conditions;
    - characteristics of operators concerned: expert and inexperienced, elderly or young, etc.
- standards and company internal regulations;
  - at design stage, take into account:
    - ergonomic standards;
    - protection system brands and types existing at the company (suited to its culture and stereotypes) as recorded during activity analyses;
    - protector markings or colours;
    - control system voltage;
    - operating mode harmonization with other equipment;
- safety and working conditions;
  - take into account:
    - cognitive and physical accessibility requirements (detection, diagnosis and intervention);
    - manoeuvring and other handling forces, handling frequency, operator work rates (need for mechanised assistance, etc.);
    - running modes facilitating equipment understanding and operation, etc.

- prohibit:
  - access to hazardous areas during machine operation;
  - any layout preventing direct vision of protected area;
  - choice of non-standardised colours;
- ensure:
  - a layout that facilitates accessibility during inspections, adjustments and maintenance, as well to loading/unloading areas;
  - protection system and protector/guard types suited to real work requirements;
  - arrangement of controls designed to be consistent with both the outcome of analyses conducted under reference conditions and recommendations;
  - an adequate level of "average lighting to be maintained" in work areas, taking into account specific work contexts and seasonal variations in natural lighting;
  - an acoustic environment that preserves health and quality of helpful information;
- provide a risk analysis demonstrating that:
  - solutions retained are valid with respect to health and safety regulations (noise-, chemical substance-, biological substance -related, etc. risks);
  - risks are not displaced;
  - problems and risks that can be created under production and maintenance conditions are taken into account;
  - capacities for machine integration into the production line are not adversely affected under any circumstances.
- develop and define:
  - adequate preventive solutions for each of the preceding risks, without displacing the risk;
  - frequency of inspections to be performed.

— maintenance;

- draw up a document showing:
  - distribution of maintenance operations, based on whether they need to be performed by the user company or remain the responsibility of the equipment manufacturer (provide a maintenance contract in the latter case);
  - parts that are critical or subject to wear;
  - frequency of preventive maintenance operations;
  - the machine availability factor;

    - use of diagnostic aids;
    - desired brands for electrical, hydraulic, pneumatic, etc. components;
    - special equipment assembly or disassembly conditions.

- environment-related impacts;
  - consider the equipment's impact on its environment and vice versa, for example:
    - characteristics of electrical, hydraulic and pneumatic systems (provided by the supplier);
    - risks of disturbing surrounding machinery and installations (e.g. electronic control systems) and vice versa;
    - temperature, noise, vibration, radiation (electrical, electromagnetic, laser, etc.), hazardous materials and substances (gases, liquids, dusts, etc.), relative humidity, etc.;
  - detail the harmful effects of the machine and, if possible, provide numerical data based on descriptions of the relevant measurement protocols.

A.2.6 Operating instructions

- The instruction manual should:
  - be drafted in a language understood by the end-users;
  - include information on installing, commissioning, operating, maintaining, adjusting, assembling and disassembling the equipment;
  - specify operations to be performed on components affecting the safety of personnel during maintenance, parts replacement, etc.;
  - give instructions for operations, equipment or measures to be implemented to perform safely specific and exceptional operations along with a list of wear parts;
  - include different drawings and diagrams required to operate the equipment (automation, electrical, pneumatic systems, etc.);
  - specify intended usage conditions and counter-recommendations;
  - state the noise emission level (acoustic pressure and/or power, as required).

A.2.7 Transport, delivery

- Transport, insurances, packing;
- availability of equipment for safely lifting and handling the machine or parts thereof.

A.2.8 Unloading

- Who, when, how?;
- prevention plan.

A.2.9 Location and installation

- Detail:
  - preliminary work required: pits, mass concrete, power supplies, etc.;
  - system and network connections;
- specify:
  - safety conditions: cooperation between contractors, prevention plan;
  - installation conditions: cranes, specialist contractor, etc.

EXAMPLE Passageway width, door headroom and floor strength is specified (to allow movement of mobile machinery).

A.2.10 Installation, acceptance and commissioning

- Lay down commissioning conditions;
- state technical acceptance conditions:
  - based on standard parts and ranges;
  - equipment and parts reserved for testing;
  - productivity, quality, etc.;
- check equipment compliance:
  - marking;
  - compliance declaration: reference texts and standards;
  - inspection by company or competent body;
- provide instruction manual, various drawings and diagrams.

A.2.11 General conditions

- Names and positions of company representatives;
- commercial and administrative conditions;
- delivery/completion times, penalties, guarantees.

Annex B
(informative)

Some techniques used for work analysis in an ergonomic approach

B.1 General

In order to develop a diagnosis of a given existing work situation, ergonomists make use of a number of different techniques. These can be regarded as complementary, with one or more being used as appropriate. They are all essentially focused on the acquisition of data or information which can inform the analysis and subsequent design.

They can be classified as objective or subjective.

The choice of a particular technique (or techniques) will depend on the objectives of the design project and the stage of the design process in which they are being used.

Techniques based on the collection of objective data:

— **Review of documents.** This is important for the overall understanding of the situation studied and the identification of demographic characteristics of the population (age, gender, experience, culture, etc.). It is based on official texts including:

  — Internal to the company: organisational charts, standard operating procedures and instructions, records and reports of accidents or occupational health, etc.;

  — External: regulations, standards, scientific literature, etc.

— **Metrology.** Physical measurements are essential for the analysis and design of work stations. They can involve: the measurement of the physical work environment (noise, temperature, humidity, lighting, etc); anthropometric measurements; and some biomechanical or physiological measurements.

— **Observation.** Observational techniques can assist in meeting the objective of collecting a large amount of information about a specific situation (defined by space and time). Such observations can be of '*in situ*' or simulated situations.

  — Observations made *in situ* of the actual work activity are "technical", allowing the diagnosis of the existing situation and the production of ergonomic design specifications.

  — Observations of simulated work activities can involve using various media (models (physical or computer), paper, simulators, mock-ups, etc.) with the objective of testing and validating the design choices.

Techniques based on the collection of subjective data:

— **Questionnaires** are a widely used technique which can be used to record the views of a large number of individuals, through questions carefully defined in advance;

— **Interviews** of an individual or group provide a subjective technique which can be used to collect detailed views, usually from a relatively small number of individuals.

Each situation to be analysed is unique; the ergonomist has to construct and adapt these analysis tools to fit the specific needs of the situation. This can include: establishing a method for collecting relevant documents; devising a procedure for measuring quantifiable factors; developing an interview guide or observation guide; preparing a written questionnaire; and the development of data handling, processing and analysis procedures. It is essential, from an early stage in the process, to ensure that analytical tools are developed to interpret the material (data) to be collected.

In summary, there is little value in accumulating data without clear aims (objectives); without a clear method for data collection; or without the means of analysing the results obtained.

B.2 Analysis techniques (tools) based on objective data

B.2.1 Review of documents

B.2.1.1 General

Relevant documents are numerous and very varied in nature. A few are detailed here.

B.2.1.2 The organization chart

The organization chart is a diagram of the organizational structure of a company or service. It is useful to see and especially to discuss with a competent person of the company. It identifies the nature of hierarchical relationships in force in the company (direct management, functional lines, matrix organization, network organization or even by projects).

The interest here is to understand how, where and by whom decisions are made. The analysis of the chart has two objectives:

— To contribute to the analysis of the work situation;

— to identify stakeholders (operators and other relevant personnel) who will decide or will facilitate the agreement of coherent decisions on the solutions to be implemented.

B.2.1.3 The flow chart

The flow chart is a diagram that enables the location of workers in the production process and aids in analysing any interactions with activities upstream and downstream from each production location.

In small organizations it is often less formalized, in this case, such details are often obtained through interviews. On this occasion, the analyst will clarify the history of the post, often revealing recent organizational changes, technical developments, projects, etc.

B.2.1.4 Plans and Drawings

A job, whatever it is, takes place in a given space with machines and tools arranged in this space. The organization of space is very important. It determines:

— location relative to the operator of places of information and control points for monitoring, controlling, or signalling the arrival and dispatch of material);

— postures (is it easy to get the tools or to see what is to be done or to perform the necessary actions);

— movement (on the job and from one workstation to another to exchange necessary information with colleagues and the hierarchy).

The analyst has to obtain such plans from the company. They can be used as a source of information or as a medium to record the flow of traffic, congested areas, etc. It is often of interest to compare the flow chart with the workshop plan with representatives from workstations and to examine the movement of goods and people from one workstation to another. The spatial organization of each workstation is also very important. In most cases, it will be necessary to make a scale drawing captioned with the location of parts and tools, lighting points, key features of the immediate environment, etc.

B.2.1.5 Statistical Indicators

Among the statistical indicators (sometimes found in the annual report of a company), there are some that reflect health, safety and working conditions such as the:

— frequency and severity of accidents;

— number of reported occupational diseases;

— characteristics of the workforce.

These indicators can be used to assess the company's health and safety performance by comparing its figures with those of the professional sector to which it belongs. They also allow the evolution of the company’s performance from one year to the next to be examined.

It is usually helpful to also examine such reported indicators at a local level (workshop or sector) to enable accident or injury ‘hot-spots’ to be identified.

Further analysis (e.g. time of accidents, the nature of the injuries sustained, or the ages of the victims) can also reveal critical information. Such information will be obtained in particular by examining the detailed reports of work accidents that contain much relevant information:

— information on the victims: age (date of birth); seniority (date of hire and specific workplace); professional qualification; function);

— information about the accident: day of the week and month when the accident occurred (date); time of the accident; indications for distinguishing accidents at work and commuting accidents (working hours of the victim, place, circumstances); period during which the accident occurred (e.g. before, after or during working hours of the victim); place where the accident occurred; parts of the body affected (nature and seat of injuries); gravity (nature and seat of the injury, hospitalization, with or without work stoppage, number of days off).

The latter information is often poorly detailed in the accident record and may be supplemented by reading accident reports. However, such activities can only be applied to those accidents and incidents for which detailed statements were collected.

Moreover, consultation of an accident register will allow reference to minor injuries or discomfort which did not lead to a work stoppage.

Such indicators can be complemented by taking into account other indicators of various kinds, such as the number of additional consultations requested of a nurse or occupational physician (in addition to any mandatory visits), absenteeism, high staff turnover, the frequency of accidental damage, power outages and extent of wastage.

B.2.2 Metrology

B.2.2.1 General

The ergonomic approach should involve a systematic measurement and appraisal of the work environment. These can include:

— physical and chemical agents such as noise, lighting, thermal environment, vibrations, presence of toxic chemicals, fumes, dust, etc.;

— physiological (work load) parameters such as heart rate, muscle activity, etc.;

— biomechanical data such as the frequency of movement, the distance covered by the operator, size and strength requirements, repetition, etc.).

B.2.2.2 Measurement and evaluation of the physical environment

Measurements should be obtained by competent persons using appropriate equipment and techniques (sampling frequency, location, etc.).

As well as the measurement of physical (and chemical) agents it is also necessary to quantify the physical demands placed on workers (e.g. weights handled or forces applied; frequencies of actions; distances moved; etc.)

In evaluating these measurements, there are usually regulations, standards and guidance available with recommended levels or with critical limits not to be exceeded and these should be consulted and complied with as appropriate. Note that some national legislation might establish more stringent limits than apply in other countries.

It is important to consider, not just the separate components of the physical environment but also to study their effects in combination. Furthermore, a comprehensive analysis will also include both objective and subjective effects. For example:

— a 68 dB (A) noise level can be unbearable for a person making a mental dominant activity, while at the same workplace, it is tolerated by a person who performs manual labour;

— a 81 dB (A) noise level, below the regulatory threshold, however, can lead to auditory fatigue; moreover, it can cause problems for operators if they need to communicate verbally as it will require them to raise their voice;

— lighting requirements might vary for certain aspects of a task at different times of the day;

— a visually impaired person needs better lighting than a person whose vision is normal;

— a 21 °C temperature, which might be considered comfortable in an office, is too high for strenuous physical work.

B.2.2.3 Measurement and evaluation of the effects of physical demands

Physical work activities will impose physical demands on the body, affecting in particular the musculoskeletal system. Such demands can be beneficial in helping to develop strength and stamina, but if demands are excessive, it can have negative effects such as many occupational diseases such as musculoskeletal disorders.

In addition, such activities can be affected by other factors such as repetition, inadequate work organization, time pressure, etc., which can increase the effect of any physical demands.

In evaluating such demands, it is important to recognize the variability in capabilities between individual workers (and in individuals at different times) and not restrict any evaluation to the effect on those on whom the measurements were obtained.

Other ISO and CEN standards are available which address these issues in more detail. The goal here is to recall the main technical measures of the five key indicators of the physical load: physical efforts, sizing, temporal characteristics, environmental characteristics, and organization.

The following deals only with measures of strain such as measuring the heart rate (HR) and the movements and displacements.

Heart rate measurements[1)] can be used to provide indications of the effects of physical work demands. Analyses can identify peaks in demand as well as sustained levels of demand.

Peak values should not normally exceed 85 % of the maximum age-related heart rate of the workers.

Sustained values should not normally exceed 50 % of the maximum age-related heart rate of the workers.

Heart rate measurements have the limitation that the heart rate is also affected by other factors such as the thermal environment and psychological influences.

Measurements of movements and displacements are used to evaluate the distances and frequencies of movement involved as observed in the operators. This can relate to movements of body parts (e.g. arm movements) as well as movements of the whole body. It can be used to verify operator-reported levels of activity.

Measurement of limb and body angles enables the objective description of body/limb postures and the quantification of angular movements. They can be used to assess the acceptability of a static (held) posture or of the frequency and range of movements involved.

Anthropometric measurements are used to describe the operators being studied in order to determine whether their body dimensions (static and dynamic) might influence the interpretation of the acceptability (or otherwise) of the workplace being studied.

Anthropometric data collected for this purpose might be compared against anthropometric templates/databases, safety distances and access dimensions (related to repair, and maintenance activities as well as use).

B.2.3 Observe a work situation

B.2.3.1 General and conditions

It is first necessary to ensure that those to be observed have been informed of the purposes of the observation and have given their consent. They have to be assured that the results of the observation will be communicated to them, and that these results will not be used against them.

The presence of an observer always transforms the usual work situation. The procedures for informed consent are intended to minimize any such effects. If the operators are aware of the value of this approach, they are less likely to alter their normal manner of work during the observation. Observation should be neutral and performed without judgment or interpretation.

The *in situ* observation of an activity or a workstation is a common technique in ergonomics with the objective of:

— becoming familiar with the work as actually performed;

— recognizing the variations which can occur and understanding actions taken by the operator to manage these variations and to recover incidents;

— understanding how and why the actual work procedures differ from the work as prescribed;

— formulating some hypotheses for diagnosis.

The observation of a simulated activity allows for its test and validates the recommendations from the ergonomic diagnosis.

1) EN ISO 9886 Ergonomics – Evaluation of thermal strain by physiological measurements

B.2.3.2 When to observe? The right choice of moment

B.2.3.2.1 General

The time of observation can be important as the manner of working may differ, depending on the time of the day (e.g. day or night shift) or the day of the week. It can also differ depending the period of activity (e.g. a peak or slack production period). It may be necessary to repeat the observation at different times, as well as with different operators.

B.2.3.2.2 What and how to observe?

Observations may be direct or indirect (delayed) through the use of video material. With direct observation, the observer records what is seen and takes notes.

With indirect observation, a video recording is obtained for later analysis.

Either has advantages and disadvantages and, in both cases, significant details may escape observation. For example, note-taking can divert attention from the observation process while a camera can reduce the field of view, limit the angle of view, or the angle may be poorly chosen and miss essential details (it is usually a good idea to film the process from several angles to avoid this).

On the positive side, the use of written notes is relatively easy, provided that they have been taken "without preconceptions (a priori) or interpretation" and that they are abundant and precise. A video can take more time, but offers advantages such as the ability to look back (flashbacks), and the use of slow motion or freeze frame functions. It can also provide opportunities for discussion and exchange with the operator to clarify certain points.

Whether direct or indirect observation is used, the observer will consider:

— the conduct of the activity over time (timed description of the successive phases of work);

— changes in activity over time (emergencies, interruptions, changes in flow, etc.);

— the visible signs of dysfunction (scrap, downtime, incidents);

— dysfunctions recoveries by the operator.

B.2.3.3 Different observation modes

B.2.3.3.1 Preliminary overall observation

The preliminary overall observation provides an initial view of the real work operations. It is used to make assumptions about the critical points of the work situation and seeks to collect data on:

— the individual: (gender, age, qualification, etc.);

— their work and what they do: (manipulates, moves, takes an action, looks, etc.);

— means and resources: the tools, materials, equipment used, etc;

— workspace and movement;

— obvious environmental factors (noise, lighting, vibration, dust, etc.);

— how operators work collectively (division of tasks, synchronization modes and organization, signals, verbal or gestural communication, communication barriers, risks generated by an operator to the other members of the team, degree of development common knowledge, skills and particular knowledge of risks).

During the observation, the observer should note the facts in narrative form as they unfold. A new line for each new action facilitates counting actions. The time will be given often, for example every 10 min, or at every change of action.

As noted above, there can be some advantage in repeating the observation at different times to capture any variations.

B.2.3.3.2 Systematic detailed observation (direct and indirect)

The systematic detailed observation aims to describe the action sequences of the chosen activity (in the overall observation) to verify all hypotheses or to study a particular aspect of the work situation.

It is organized around the questions addressed by the observer concerning the operator and focuses on what is observable in the work situation:

— operations / actions (grips, lifts, moves, positions, fastens, etc.): indicative of specific intentions of the operator and the associated physical cost;

— viewing directions: indicative of information gathering, monitoring, collaboration;

— displacements: indicative of workload, collective work, and space planning;

— communication: indicative of collective work if it is not itself the work tool (e.g. telephone);

— incidents and their recovery: indicative of dysfunction, variability of work, operators competence;

— postures: indicative of workload, difficulties related to the development of the post.

B.2.3.4 Observation of simulated conditions

Once the diagnosis is formulated and ergonomics recommendations or specifications proposed, it is then necessary to validate these. This validation step will then be conducted on a system or a simulated work or situation. The use of different observation techniques (discussed previously) in simulated conditions then allows the specifications from the ergonomics diagnosis to be tested and validated.

B.3 Technical analysis using subjective data

B.3.1 Analysis by Questionnaire (survey)

Designing and using a questionnaire remains in some cases a necessity to enable a large number of people to be addressed on a specific issue, and to gather opinions.

This technique involves several steps:

— defining the objectives of the survey: the purpose of the study and the population to be questioned (size and other characteristics), as well as the qualitative and quantitative processing tools;

— drafting questions, ensuring that they are formulated in appropriate language;

— testing the questionnaire;

— conducting the survey;

— collating and analysing the responses.

B.3.2 Question by interview

B.3.2.1 Why conduct an interview?

As with any observations, the purpose of the interview and use that will be made should be clearly explained to the interviewee. Questioning of the observed operator is an essential complement to the observation. The main purpose of the interview is to understand what the operator actually implements in its activity. This requires that the observer understands the operator’s goals and intentions.

Not everything can be observed. While physical and verbal actions can be observed, other details, such as the processing and decision-making that determined a course of action cannot be. Observable facts may not have any meaning for the observer if the reason for such a course is not known.

The purpose of the interview should be clearly defined (include a specific problem) and the questions focused on this objective.

B.3.2.2 What question/interview?

Generally, the operator is questioned on those unobservable aspects which guide their activities (cognitive), but also on the influence of any organizational aspects (e.g. production or quality targets), and finally if we can on any personal aspects which influence how the activity is performed.

Questions should be brief, using easily understandable words and vocabulary. Avoid issues containing negative assumptions or other leading questions.

If a question is poorly understood, it is usually better to rephrase than repeat.

It is sometimes useful to repeat or rephrase responses, both to ensure that the response has been correctly understood and as a means of obtaining more information.

Keeping trace of spoken words can involve either note-taking or recording. Notes should be absolutely faithful without reformulation or interpretation. Tape recording requires the consent of the person. Any notes or tapes should be destroyed once they are no longer required. Comparisons between information gathered during the interviews and observations and measurements made can be informative. They will often confirm and complement each other, enhancing overall knowledge. Sometimes however, contradictions can appear (a type of event will be, for example felt “very frequent” while observations show the opposite).

Reflecting on these contradictions can be interesting because they reveal the way in which the operators view their work. However, such contradictions should be explored carefully to ensure that they have not arisen as errors in the information-gathering process.

B.3.2.3 The timing of the interview

Several options are open depending on the goal of the interview. If the aim is to collect the prescribed work items it is better to interview the operator before any observations to know what the operator has been asked to do.

However, as not everything is visible and observable during the observation, informal “on the job” interviews during periods of observation allow the observer to seek clarification on what has been seen (without disturbing the work).

But if the idea of the interview is to confirm specific data assumptions and complete information gathered previously, the interview should be delayed until the end of the observation sequence.

B.3.3 The interview techniques

B.3.3.1 Confrontation

Confrontation (known in some countries as auto-confrontation) is a tool for the analysis of human activity. It involves showing or describing an observed activity to one or more participants (performed by the same people) and recording their explanations of why it was performed in that manner (video and / or audio).

Several types of such interviews can be distinguished:

— Single confrontation is the most widespread. It involves an interview confronting one operator with their own observed activity. Its purpose is to enable the operator to comment on and explain their action strategy and the difficulties and constraints they encounter. It helps the ergonomist to develop a better understanding of the cognitive processes (unobservable parts of the activity) brought into play by the operator.

— Cross-confrontation involves confronting an operator with the activity of another colleague. Comments obtained have the advantage of enriching knowledge of the work through the critical and objective views of another professional.

— Collective confrontation involves asking a group of operators to comment on the observed and filmed activity. This useful approach, offers the advantage of combining their knowledge and experience (including the risks and problems which can be encountered), and facilitates the construction, in a common culture and language, of the ergonomic specifications for a similar design system.

B.3.3.2 The structured interview

A structured interview uses closed questions that guide the interviewee to a selection of specific responses, framed within a fixed grid that leaves no opening towards other subjects than those chosen by the questioner (binary response). The use of such questions creates accurate answers, which are easily exploitable statistically. To ensure that all relevant information is collected, the questions should be well prepared before the interview. However, it does not allow the operator to expand on their responses to enrich questions and debate.

B.3.3.3 The semi-structured interview

The semi-structured interview does not use fixed (closed) questions but can guide the speech of respondents around different themes predefined by the observer and recorded in an interview guide (grid). Such an approach can complement and deepen specific areas related to the structured interview.

B.3.3.4 The non-directive (open) interview

The latter is based on open questions that invite the interviewee to respond with his own words with little attempt to steer or guide the interviewee. The answers are richer but require a subsequent content analysis.

Examples of questions asked in an interview about the workplace:

— “I noticed that you were moving frequently to see the product. Can you explain why?”;

— “How do you realize that ...?”;

— “Is your work is always carried out in the same way?”;

— “Why did you touch the cover of the machine?”;

- “When there are incidents on the machine, what do you do?”;
- “Do you still manage to ...?”;
- “What will happen when you do not succeed?”;
- “What is most tiring in this work?”;
- “Is there something else you would like to talk about?”.

Annex C
(informative)

The approach and ergonomic analysis applied to design: Stages and processes

There are usually a number of elements involved in the ergonomic design approach, focusing on the analysis of human activity:

— The ergonomist first reviews the project design in order to extract the characteristics where human activities (actions, information acquisition, etc.) will be needed.

— Then it is necessary to identify similar existing systems to conduct work analyses on in order to enable an ergonomic diagnosis to be made, and to identify the specifications for the new system to be designed. This is called the prognosis. The prognosis can be regarded as the prediction of the future performance of a planned system, and diagnosis as the analysis and synthesis of the actual operation of an existing system. These two concepts can be dynamically interacting in the sense that the diagnosis of work situations can enrich the prognosis for a future design.

— Following this, the specifications resulting from the diagnosis are tested and validated to confirm their feasibility. This can involve a number of different techniques including: simulation (work analysis of simulated situations), virtual reality, mock-ups, digital models, etc.

The systemic ergonomic approach that will be implemented is characterized by the following three properties:

— Multi-criteria: it allows the planned design to take into account the different contexts and areas where work activity is implemented; the risks related to the movement; physical environments; chemical and biological hazards; various constraints related to the implementation of the work activity (handling, isolation, psychosocial stress, etc); and the wider environmental influences (legal, economic, cultural, etc.)

— Participatory: it encourages the early involvement of those involved in the data collection to validate the assumptions made and the knowledge produced through the ergonomic diagnosis and involves them in the search for possible solutions.

— Iterative: it makes it possible, at any time, to re-examine the information and data collected to provide further validation and to enrich the choices made.

A work situation can be regarded as a “special system”, where the different critical factors related to humans, organisations and the enterprise are in constant and dynamic interaction. It is therefore essential to analyse the work situations by focusing the analysis on human activities.

The work analysis involves collecting data on the overall work situation. It also entails observing the activities and determining how to interpret the results obtained and validates the knowledge produced.

The stages of the ergonomic approach:

Overall analysis: Collect data

This stage involves the collection of data on all the critical factors of the work situation, without any interpretation at this stage. The data can come from different sources:

— documents (production records, safety and health records, employee turnover, company reports, etc.);

— interviews in which operators describe their work and the positive and negative effects they feel;

— others.

Overall analysis: Describe and observe

Observations of existing relevant workplaces helps to identify the concrete facts, reveal health issues, safety and efficiency, and provides a first indication of the differences between the work as prescribed and the observed activity. Such observations can be direct (in the actual workplace) or indirect (through video) or both. Direct observations, enable questions to be asked of operators during the observation (see Annex B). It is essential to ensure that observations are recorded in a clear and systematic manner for subsequent interpretation with the operator or operators concerned and are retained for further reference as required.

Formulate hypotheses

The analysis of all the data collected should be used to formulate hypotheses on the causal relationship between some of the evidence gathered (e.g. observations made) and the problems to be addressed. For example, one preliminary diagnosis might be that: "It seems that these critical factors mean that operators work in this particular way, which explains or generates the observed effects."

Validate these hypotheses

Testing these hypotheses involves objective analysis and measurement, complemented with the use of statements of the operators. These are obtained by confronting them[2] with their activity sequences as analysed. The validation exercise should seek to confirm both the activity of operators and the characteristics of the work situation.

Formulate a diagnosis

Diagnoses are developed of the links between determinants and operators activities, and the consequent effects observed on humans and on the system. The process of diagnosis is based on the results of the ergonomic analysis; on the results of discussions conducted within work group(s); and on scientific knowledge (engineering and biological sciences, humanities and social science in particular).

Propose actions / formulate specifications / formulate prognosis

The analysis conducted on an existing system can result in two types of action:

— Action to improve an existing system, (both to reduce any negative effects on health and safety, and to improve the overall work efficiency).

— The formulation of ergonomic design features to be integrated into a system similar in design.

At this point, it is essential to rely on comparable situations and standards to develop solutions, in consultation with relevant stakeholders. Any proposal requires a further validation phase. The solutions finally selected results from addressing (and accommodating) the different views from all stakeholders (operators, their leadership, management, occupational physician, etc.).

[2] Confrontation - see Annex B

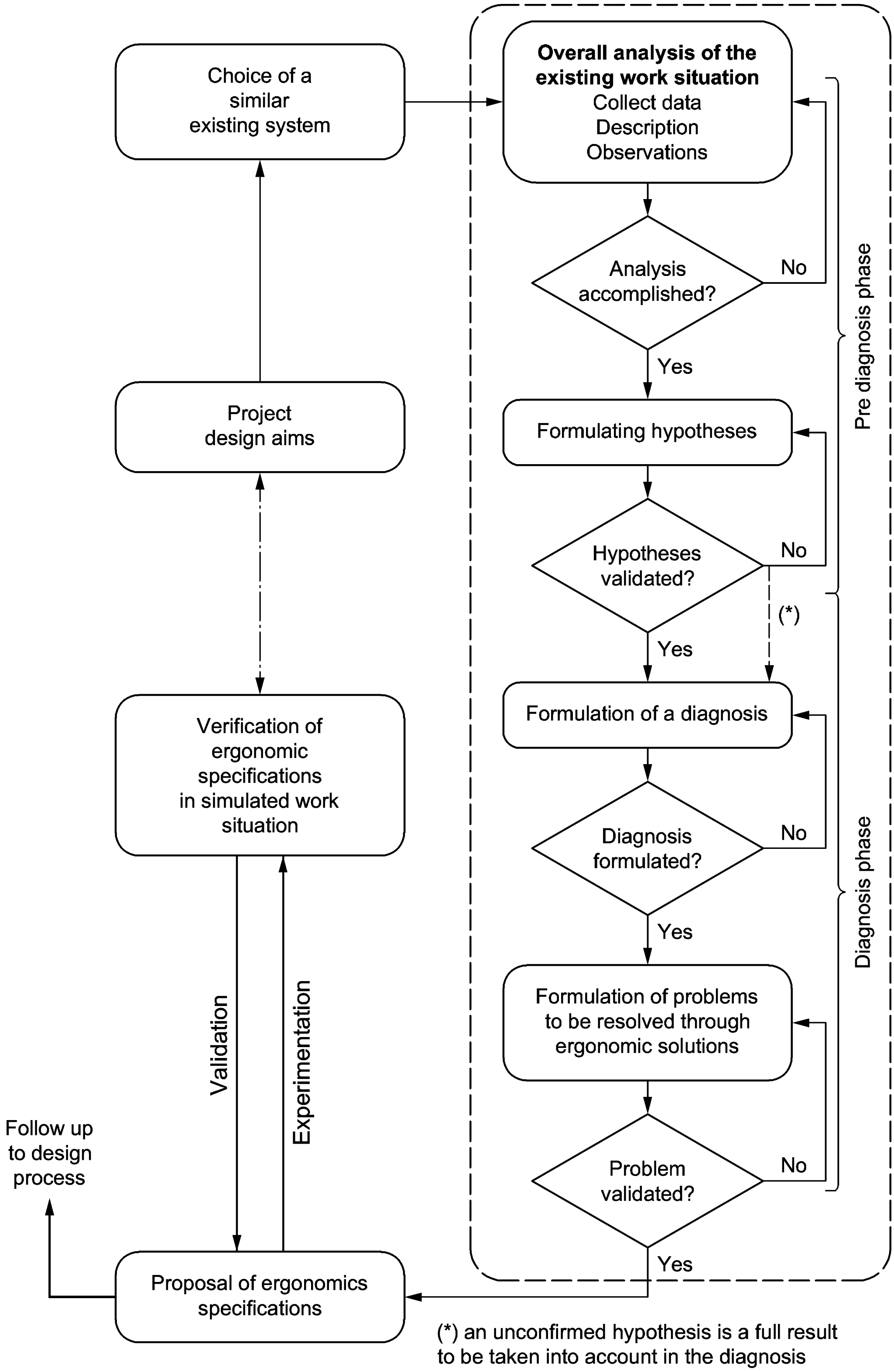

Figure C.1 — Example of Flow chart of ergonomic approach design centred on human activities analysis

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