International Standard

ISO 16813

Second edition
2024-11

Building environment design — Indoor environment — General principles

Conception de l'environnement des bâtiments — Environnement intérieur — Principes généraux

Reference number
ISO 16813:2024(en)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 205, *Building environment design*.

This second edition cancels and replaces the first edition (ISO 16813:2006), which has been technically revised.

The main changes are as follows:

— updated Clauses 2 and 3;

— revision of the flow diagram of the design process (Annex A);

— addition of the nine general principles of sustainability (NGPS) provided by ISO 15392;

— addition of subclauses on building environment parameters and variables, project team, commissioning, post-occupancy evaluation, and commissioning issues and lesson learned;

— deletion of Annex B on flow diagram of design process;

— addition of Annex B on building environment parameters and variables.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides general principles of building environment design and is intended for design team members, (e.g. architects, environmental designers and building system designers), as well as building clients, contractors, government officials and academic experts.

The aim is to assist these groups in applying an effective design process in order to achieve a balance between comfort and environmental considerations. This document specifies the design drawings and specifications to be evaluated at every design stage. This document also provides the framework for sustainability issues to be considered in the design requirements and the constraints to take into consideration from very early stages of the building design process.

Building environment design — Indoor environment — General principles

1 Scope

This document establishes the general principles of building environment design to achieve a quality building environment for the occupants and sustainability. This document promotes an approach in which the various parties involved in building environment design collaborate with one another to provide a high-quality building environment.

The design process aims to achieve the following:

— to address issues concerning sustainability over the building life cycle, including owning and operating costs at all stages of the design process;

— to assess the proposed design with rational criteria for the thermal, acoustic and visual environment, the indoor air quality, energy efficiency and performance of technical building systems at each design stage;

— to use an iterative design process in which each design stage is subject to design review and decisions before proceeding with the next design phase.

The building environment design involves not only the architectural design associated with the environmental quality, but also building system design including effective control methods.

This document is applicable to building environment design for new construction and retrofitting existing buildings.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
commissioning
sequence of events that ensures the building and the *technical building systems* (3.7) are functioning in accordance with the building environment parameters in the design specifications for the building lifetime

3.2
commissioning process
systematic application of processes and procedures designed to ensure that the project objectives are achieved and maintained throughout the building lifetime

Note 1 to entry: The commissioning process begins at project conception and continues through to the pre-design, design, construction, start-up, turnover and occupancy to the operation phase.

[SOURCE: ISO 16484-1:2024, 3.4, modified — Note 2 to entry has been deleted.]

3.3
design document
written description that formalizes and rationalizes the design at every design stage

3.4
energy efficiency
measures that ensure the building and system function in accordance with the design parameters by the efficient use of energy

3.5
life cycle
consecutive period of a building from planning to final disposal

3.6
life cycle cost
total costs of a building or its parts throughout its lifetime, including costs of planning, design, acquisition, operation, maintenance and disposal

3.7
technical building system
building component for heating, cooling, mechanical ventilation (filtration and exhaust), humidification, dehumidification, domestic hot water, water supply, drainage and sanitary equipment, lighting, building automation and control, and electricity production

Note 1 to entry: A technical building system can refer to one or to several building services (e.g. heating, cooling, lighting and domestic hot water).

Note 2 to entry: Lifts and fire extinguishing systems can be included in technical building systems.

Note 3 to entry: A technical building system is composed of different sub-systems.

Note 4 to entry: Electricity production can include cogeneration, wind power and photovoltaic systems.

[SOURCE: ISO 19454:2019, 3.16, modified — Specified building component uses]

4 Fundamentals

4.1 General

General principles of building environment design allow design teams to provide the desired quality of building environment in a sustainable way according to fundamentals of the design process. Annex A shows a flow diagram of the entire design process. The design team shall keep in mind energy balance over the life cycle of a building and life cycle costs.

The design process aims to ensure efficient building environment design providing the specified quality and performance level, i.e. safety, health, comfort and energy use as well as sustainability.

The nine general principles of sustainability (NGPS) are defined in ISO 15392. The NGPS encompasses the following subjects:

— continual improvement;

— equity;

— global thinking;

— holistic approach;

— involvement of interested parties;

— long term vision;

— precautions and risk;

— responsibility;

— transparency.

The design team shall define goals based on the requirements, constraints and actual conditions to be achieved, integrating the ownership and operating costs during the design stage.

The design team shall take a holistic approach to their design taking into consideration relationships, synergies or trade-offs, or a combination, of physical environmental factors. Building environment design requires long-term consideration of environmental and energy performance. Since combating climate change, as well as promoting sustainable development, is the present critical issue, the design shall prepare for uncertainties of design conditions caused by climate change, for example, selecting a sustainable solution that is expected to minimize the impact of building energy consumption on climate change. However, excessive provisions can waste resources and go against sustainability.

Successful building environment design results from identifying and involving interested parties. Key interested parties are neighbours, local authorities, local association professionals (service providers and operators) as well as end users. The project leader should monitor whether the interested parties are properly involved in the building environmental design process. The commissioning team should monitor for a balanced inclusion of participants. The design team shall execute the project locally, but with a global vision.

Responsibility and transparency shall be guaranteed by documenting and retaining all information of the design process. The design documents are utilized for continual improvement of the building.

4.2 Building environment parameters and variables

The design team shall determine the scope to be explicitly addressed in the building environment design. The scope shall be articulated in terms of the constituent elements to describe the environmental quality and the performance that are expected to be achieved in the project. Each of the constituent elements is expressed as a pair of a parameter and its value(s). The notion of building environmental parameters refers to such parameters. The values of building environmental parameters shall be determined as target values for each condition of thermal environment, acoustic environment, visual environment, and indoor air quality. The values of building environmental parameters shall be achieved regardless of the changing outdoor environmental conditions or predicted user behaviours, or both, during the occupancy and operation phase. Building environment parameters represent the following environmental and energy performances of the project:

— indoor air quality;

— indoor thermal environment;

— indoor acoustic environment;

— indoor visual environment;

— controls;

— energy use.

Building environmental parameters of the project are determined as objective variables of the building environment design. The objective variables are dependent variables whose values depend on changes in the corresponding design variables and accompanying control variables under certain conditions described by context variables. Variables related to building environmental design can be classified as follows (See also Annex B):

— Objective variables that are controlled by building environmental design and describing targeted environmental and energy conditions, such as temperature, humidity, sound level, illuminance, luminance and energy consumption.

— Design variables that are to be determined by the design team, such as a type of insulating material and the thickness, and window dimensions.

— Control variables that are controlled by design variables and bridge between objective and design variables, such as thermal resistance, transmittance, reflectance, sound absorption coefficient and sound transmission loss.

— Context variables that are external conditions, such as meteorological properties and disturbance conditions.

4.3 Project team

4.3.1 Design team

The design team is an organization of people who are responsible for the building design. The design team can consist of an architect, an interior designer, a lighting designer, a landscape designer, engineers in electrical engineering, illuminating engineering, heating, ventilation and air conditioning (HVAC) systems, structural engineering and construction management, and other specialists.

The design team is responsible for addressing human and technical issues on the project. An integrated multidisciplinary approach shall be adopted throughout the design process by:

— identifying the necessary professional skills;

— facilitating collaborative work.

The design process of some projects involves building users as well as the clients.

4.3.2 Construction team

The construction team includes those project members who are tasked with physically constructing the project. The construction team can consist of the project manager, main contractor, site manager, site engineer and sub-contractors.

4.3.3 Commissioning team

The commissioning team can consist of representatives from the owner, project manager, commissioning provider, design professionals (e.g. architects and engineers), operating and maintenance staff, general contractor, major subcontractors, vendors and suppliers. The commissioning provider leads, plans, schedules and coordinates the commissioning team to implement the commissioning process.

The commissioning team can be included in the design team but does not manage the design and construction of the project. The commissioning team is responsible for implementing the entire commissioning process.

4.4 Project information

Available project information that influences development of design concepts together with constraints and all requirements shall be documented. When assumptions are made in place of necessary information related to the codes, standards or regulations for building environment design, with respect to the building environment, those assumptions shall be documented. The project information that influences programming, development or design, or a combination, of building component and technical building systems shall also be documented.

4.5 Framework of generation and verification

Architectural design and building system design are goal-driven activities. The routes necessary to achieve the result are not straightforward and can be flexible. In some instances, the assumptions are made under uncertain conditions. Hence, the design process involves the use of generation and verification. The

generation process is a sub-process where a design solution is synthesized, while the verification process is another sub-process in which the design solution depends on different design criteria.

4.6 Framework of documentation at approval

Evaluation and approval processes shall be documented. The documentation process shall explicitly state what is to be provided by the project. The evaluation and approval processes shall demonstrate that the stated goals can be achieved. Every design document provided shall describe what will be achieved and then it shall be verified that it is achieved in practice. Approval should be obtained at each design stage.

The design documents issued during this design process shall cover the following questions:

— Is the stated definition adequate and feasible?

— Is the environmental design feasible?

— Is the specified structure expected to satisfy the constraints and requirements?

— Is the building capable of providing the quality and performance required?

4.7 Harmonization of architectural and building system design

Since the architectural design as well as the building system design contributes to the realization of the building environment, the general principles of building environment design should be used to harmonise the architectural and building system design.

The general principles of building environment design should not restrict creative architectural design. They do not predefine the order or precedence of individual task in both the architectural and building system design.

4.8 Commissioning

Commissioning is the quality-focused process for enhancing the delivery of a project. It focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, constructed, installed, tested, operated and maintained to meet the owner's project requirements. Building commissioning refers primarily to technical building systems such as heating, cooling, lighting, ventilation, domestic hot water and controls. It ensures the quality of the building. In general, the commissioning process is classified into the following major phases:

— project initiation (pre-design);

— design;

— construction;

— turnover;

— occupancy and operations (post-occupancy).

The commissioning process includes commissioning planning, commissioning review at each design stage, measurement and verification, system tests, adjustment, first-year monitoring and assistance with resolving commissioning issues, documentation, end-user training and handover of the system manuals. Specified design criteria shall be verified by measurement and testing, and if necessary, installations shall be adjusted.

A commissioning plan is necessary to ensure that the building components and systems meet the requirements. The commissioning plan shall involve systematic testing of the technical building systems and their controls to ensure they provide the specified performance, interact properly as a whole and fulfil the requirements.

A commissioning test (also called functional performance testing) shall be conducted according to the commissioning plan.

4.9 Post-occupancy evaluation (POE)

Post-occupancy evaluation (POE) is a process of evaluating a building after it has been completed. It is conducted to understand actual building performance against the project requirements and to obtain feedback and lessons learned for future projects. A POE should be conducted when the building is in use to understand the actual performance related to user satisfaction and lessons learned.

A POE is valuable in helping designers to identify potential problems and to constantly improve their designs through lessons learned from past projects. POE is carried out to understand an occupant's response to building environmental factors such as thermal, visual and acoustic conditions. A POE includes the measurement of physical environmental factors and a survey of occupants' psychological aspects.

4.10 Commissioning issues and lessons learned

Commissioning issues are identified during the commissioning process. However, all of them are not necessarily solved during the commissioning process of the project. Unresolved commissioning issues and lessons learned should be identified and used to improve future projects.

5 Design process

5.1 Stage I — Formulation of project definition

5.1.1 General

The objective of Stage I is to clarify the project constraints and requirements. The client defines the building requirements and the constraints but can be unaware of some of the constraints to the given project. In this case, the design team must provide the client with this important information.

All requirements and constraints shall be explicitly documented in Document I, which shall be approved in the sub-process Evaluation I, where the project requirements and constraints do not conflict with one another. The approved conditions form the basis of the building project definition.

The approved requirements and constraints can become variable when unknown conditions exist, even though they appear consistent at this stage. In this case, the project definition shall be revised to retain consistency.

5.1.2 Project definition

Project definition is a process of providing the relevant information for the design team to define the scope of the work. The project definition lists the project requirements, given constraints, theories and assumptions. It cannot be revised except when unexpected conditions emerge. All of these cannot be completely defined at this stage. Some of these can be revised in response to feedback at later stages of the design process.

5.1.3 Opportunities and constraints

The constraints are conditions that must be met by the project and characteristics of the building site. The characteristics of the building site include for example, climate, geometry, geography, culture and building codes. The conditions can be related to health and safety issues, energy availability, and environmental quality for the project. The constraints are fixed and, in principle, cannot be revised even when unexpected conditions emerge.

5.1.4 Requirements

The requirements describe the quality of the building environment, budget, schedule, sustainability and other restraints as well as building performance and the interior spaces required by the party concerned. Some requirements are latent and are not explicitly expressed at initial stages. The requirements can be inconsistent with the constraints and can be incompatible with the given constraints. In such cases, the requirements shall be revised.

5.1.5 Assumptions

The theories form a portion of the assumptions. Any issue that cannot be fully identified in the course of the design shall be assumed. The design team shall take these into account in the final design decision. Uncertainties should be dealt with as assumptions at the early design stage so that problems can be avoided at a later stage.

5.1.6 Philosophy, ethics and theories

Both the client and the design team can have a philosophy and set ethics concerning building environment in general terms. Philosophy and ethics are a base to which the target level of each environmental item is determined, and the design strategies are planned. A building is evaluated from different aspects. The client and the design team can decide which aspect they consider to be critical or less critical on the basis of their own philosophy and ethics. This consideration is possible, provided it does not violate the environmental design criteria. The theories also encourage the design team to employ a particular design strategy and to work on as the rationale on which the structural behaviour and functions of a building are based.

5.1.7 Output — Document I

Document I shall be issued as an output product of the project definition process and as an explicit description of the project definition, e.g. the requirements, the constraints and the assumptions.

5.1.8 Evaluation I

Evaluation I is the process of approving Document I. The consistency of the contents of the requirements, constraints and the assumptions shall be verified. The feasibility of the given requirements under the constraints and the assumptions should be verified. The main assessment of the evaluation is whether or not the project definition is adequate and optimal under the given constraints.

5.1.9 Output — Approval of Document I

When the Evaluation I process is successfully completed, approval of Document I shall be issued as an output. Proof of approval of Document I should contain the evaluation process for Document I together with the results of the evaluation. Stage II cannot be started unless Document I is approved.

5.1.10 Iteration

If Document I was not approved, it shall be revised by iterating the steps from the project definition.

If there is any contradiction in the compilation of the requirements and constraints described in Document I, some of the requirements should be revised and then iteration be started with the revised requirements.

5.2 Stage II — Schematic design

5.2.1 General

The objective of Stage II is to determine the schematic framework of the building and its environmental systems as requested by the client. The structure of the concepts and scheme will determine the following process, i.e. Stage III.

The schematic framework is expressed in terms of the building scheme, i.e. the zoning, the circulation, the prospective use, and the diagrams to describe the technical building systems, such as HVAC, lighting and water service. This process determines which technical building systems are employed.

5.2.2 Input — Background

Document I approved at Stage I represents both the input and the background to Stage II.

5.2.3 Output — Document II

The design concept shall be developed in response to Document I and should be outlined in a written narrative.

Document II should be issued as the product of the schematic design process. Document II is the explicit description of the framework of the building and its environmental systems. Document II also explains the rationale of the framework.

Document II shall be issued as the formal record, but the concepts, scheme and diagrams can be flexible due to the uncertainties involved.

5.2.4 Evaluation II

The consistency in the framework described in Document II shall be verified in reference to the design criteria and Document I. The fitness of the program and the diagrams shall be verified. The main assessment is whether the design is directed on the right track or not.

5.2.5 Output — Approval of Document II

When the Evaluation II process is successfully completed, Document II shall be approved. Proof of approval of Document II shall include how it was evaluated.

If Document II is found to be inconsistent with the requirements and constraints, Document II shall be revised, and iteration be made from the conceptual design and schematic design process or from the project definition process.

5.2.6 Iteration from conceptual design and schematic design

If the initial concept of a building established during the design process does not meet the requirements and constraints described in Document I, or when the target levels of the environmental elements are not met, the design team shall determine acceptability and act accordingly. Then an alternative concept and scheme shall be presented. Minor changes are possible in some instances. However, major changes are necessary in others.

5.2.7 Iteration from project definition

If no change in the concept and scheme is found necessary, the design may proceed to Stage III.

If changes in the requirements are made to provide improved solutions, then the project definition shall be revised.

If modification of the project definition does not improve the issue, then the building environment parameters shall be reconsidered.

5.3 Stage III — Detailed design

5.3.1 General

Stage III is the main stage of the design process where a detailed design is performed. The structure of the building, i.e. the shape and dimensions of the building elements and the relationship among them as well as the components of the building environmental control systems, shall be specified.

The structure of the building is determined during this process, and is expressed in terms of shape, dimensions and materials of the building components, spatial relations, or functional relations, or a combination, among the structural elements. All system designs shall be included.

Detailed predictions and analyses through either computer simulations or measurements with physical models, or both should be performed during this stage.

5.3.2 Input — Background

Document II approved at Stage II represents both the input and the background to Stage III.

The design team shall further develop the design with more detailed data and specifications of the building systems and components.

5.3.3 Output — Document IIIa

Document IIIa is the explicit description of the building structure. It consists of drawings and building specifications including the technical building systems.

5.3.4 Analysis

The building performance shall be predicted in the detailed design description in Document IIIa and be expressed in terms of both the physical properties of the building and the environmental systems of the building. Use of computer analysis of the environmental performance or energy demands shall be considered.

The functions to be provided by the building shall be determined by the design team based on the building performance.

5.3.5 Output — Document IIIb

Document IIIb is the explicit description of the results of the analysis process, i.e. the predicted performance of the whole building.

The performance shall be expressed in terms of the estimated values of the physical properties of the building, such as air quality, temperature, and energy use. The rationale of the derived performance shall also be considered.

The details of the criteria adopted shall be recorded for future evaluation.

5.3.6 Evaluation III

The results of the analysis described in Document IIIb shall be evaluated to determine if the requirements described in Document I are achieved without violating the constraints described in Document I and the issues in Documents II and IIIa.

5.3.7 Output — Approval of Documents IIIa and IIIb

While Evaluation III is under progress, Documents IIIa and IIIb shall be approved. Proof of approval of Documents IIIa and IIIb shall include how they were evaluated.

Stage IV cannot be started unless Documents IIIa and IIIb are approved. If it is found that the building design described in Document IIIa does not meet the contents of Document I, Documents IIIa and IIIb shall be revised by iteration against the project definition.

5.3.8 Iteration into detail design

If the current building design concept does not meet the contents described in Document II, then an alternative design shall be provided. At this stage, only minor changes requested by the client shall be made.

If Documents IIIa and IIIb show that the quality and performance described in Document II are not provided by the building design, then the current design shall be modified without changing the overall design concept. Building drawings and specifications shall be replaced according to the level of information needed.

5.4 Stage IV — Final design

5.4.1 General

Stage IV is the final stage of the design process where final construction documents are generated. The elements and the relations that are not finally determined yet shall be determined at this stage.

The final construction documents shall be delivered to contractors. The final construction documents shall include written specifications outlining the expected duties of the contractors. Applicable industry standards and code references shall be cited in the specifications.

At this stage, a detailed commissioning plan shall be developed, and cost estimations shall be conducted as well. If the cost estimations do not meet the client's budget, the design process should be repeated until a satisfactory agreement is achieved, or the budget reviewed.

5.4.2 Output — Final design document

The final design document shall consist of the building drawings and specifications, and the building service components to be installed complete with the results approved in the commissioning tests.

5.5 End of design

If no problems are found with the final design, the design work comes to an end and the realisation process can commence.

5.6 Construction and handover

Plans and specifications should be finalised as construction documents. The building must be built as designed. If the building environment and energy performance are to be delivered as designed, the design team should have an important role in the control and inspection in the construction phase.

At the completion of the construction phase, the building is handed over to the client. All information regarding the building is given to the client and staff. In order to preserve the building design performance, the design occupancy conditions, maintenance and management control of the building should be provided to the client and to the prospective users of the building.

6 Development of design criteria

The design criteria and energy efficiency shall be referred to in the evaluation of the proposed design at each stage of the design process. Different design criteria shall be included in documentation, and shall refer to international standards, or regional or national standards.

7 Development of design aids

Design aids on thermal, acoustic and visual performances, indoor air quality, and energy efficiency should be developed for the design team together with the design criteria for the efficient design process. The design aids summarize findings from the design process for use in future designs.

8 Cost evaluation

8.1 Estimation of primary costs

A qualitative comparison of initial and operating cost characteristics of the initial design is encouraged. This qualitative approach can be based on experience or by methods approved by the industry.

Since sufficient design details are not normally available at the initial design stage, cost comparisons are not necessarily based on data of the actual project, equipment and energy. Unless made clear by contractual arrangements, one approach is to proceed from the initial stage based on 8.2.

8.2 Evaluation of design benefits versus costs as required by the client

There are several levels of sophistication in cost analysis:

a) The basic cost of the initial construction;

b) The cost including operation and predictive maintenance of systems and components (owning and operating costs) can include building, plant and safety insurance costs;

c) The life cycle cost as a) and b) plus predictive consumption of resources and conservation measures;

d) As c) plus the whole life cycle costs including external environmental costs and demolition costs (life cycle cost and social cost, see ISO 15686-1);

e) As d) plus the benefits to productivity in the workplace by improving the building environmental quality.

Cost estimates at one of these five levels of detail should be developed. These estimates should be based on the actual project equipment and energy data to the extent that these have been determined at the final design stage.

The cost estimates shall be documented and evaluated for acceptability in terms of overall project requirements. If the cost estimates are unacceptable, the design detail or concept shall be reconsidered to achieve cost acceptability. Changes in the performance criteria shall be considered only when changes in the design detail or concepts cannot achieve cost acceptability or the benefits cannot justify the extra costs.

8.3 Compliance review

The plans and specifications for the aspects of the building environment in the designer's preview shall be reviewed and documented as:

a) meeting the legal requirements of applicable codes, regulations and laws;

b) capable of meeting the design performance criteria;

c) meeting the estimated cost within the project budget;

d) having no conflict with other building systems at this stage.

If the plans and specifications fail to meet any of these requirements, they shall be reconsidered to ensure compliance with these requirements. Changes in the performance criteria shall only be considered when changes in plans, specifications, design details or the design concept do not achieve these requirements.