BS ISO 15686-1:2011

BSI Standards Publication

Buildings and constructed assets — Service life planning

Part 1: General principles and framework

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National foreword

This British Standard is the UK implementation of ISO 15686-1:2011. It supersedes BS ISO 15686-1:2000, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee CB/101, Service Life Planning.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Buildings and constructed assets — Service life planning —

Part 1: General principles and framework

Bâtiments et biens immobiliers construits — Conception prenant en compte la durée de vie —

Partie 1: Principes généraux et cadre

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 15686-1 was prepared by Technical Committee ISO/TC 59, *Buildings and civil engineering works*, Subcommittee SC 14, *Design life*.

This second edition cancels and replaces the first edition (ISO 15686-1:2000), which has been technically revised to condense ISO 15686-1 into a more generic process of service life planning and to better reflect the other parts of ISO 15686.

ISO 15686 consists of the following parts, under the general title *Buildings and constructed assets — Service life planning*:

— *Part 1: General principles and framework*

— *Part 2: Service life prediction procedures*

— *Part 3: Performance audits and reviews*

— *Part 5: Life-cycle costing*

— *Part 6: Procedures for considering environmental impacts*

— *Part 7: Performance evaluation for feedback of service life data from practice*

— *Part 8: Reference service life and service-life estimation*

— *Part 9: Guidance on assessment of service-life data* [Technical Specification]

— *Part 10: When to assess functional performance*

The following Technical Report is under preparation:

— *Part 11: Terminology*

Service life planning using IFC-based building information monitoring will form the subject of a future Technical Report (ISO/TR 15686-4).

0 Introduction

0.1 Service life planning

Service life planning is a design process that seeks to ensure that the service life of a building or other constructed asset will equal or exceed its design life. If required, service life planning can take into account the life-cycle cost(s) of the building and its life-cycle environmental impact(s). Service life planning provides a means of comparing different building options. During the project delivery phase, to ensure that the design meets the functional requirement levels, consideration of different conceptual design solutions can be used to assess the impact of design changes on the design life.

This part of ISO 15686 is intended primarily, but not exclusively, for the following user groups:

a) building owners and users;

b) design, construction and facilities management teams;

c) manufacturers who provide data on long-term performance of building products;

d) maintainers of buildings;

e) value appraisers of buildings;

f) insurers of buildings;

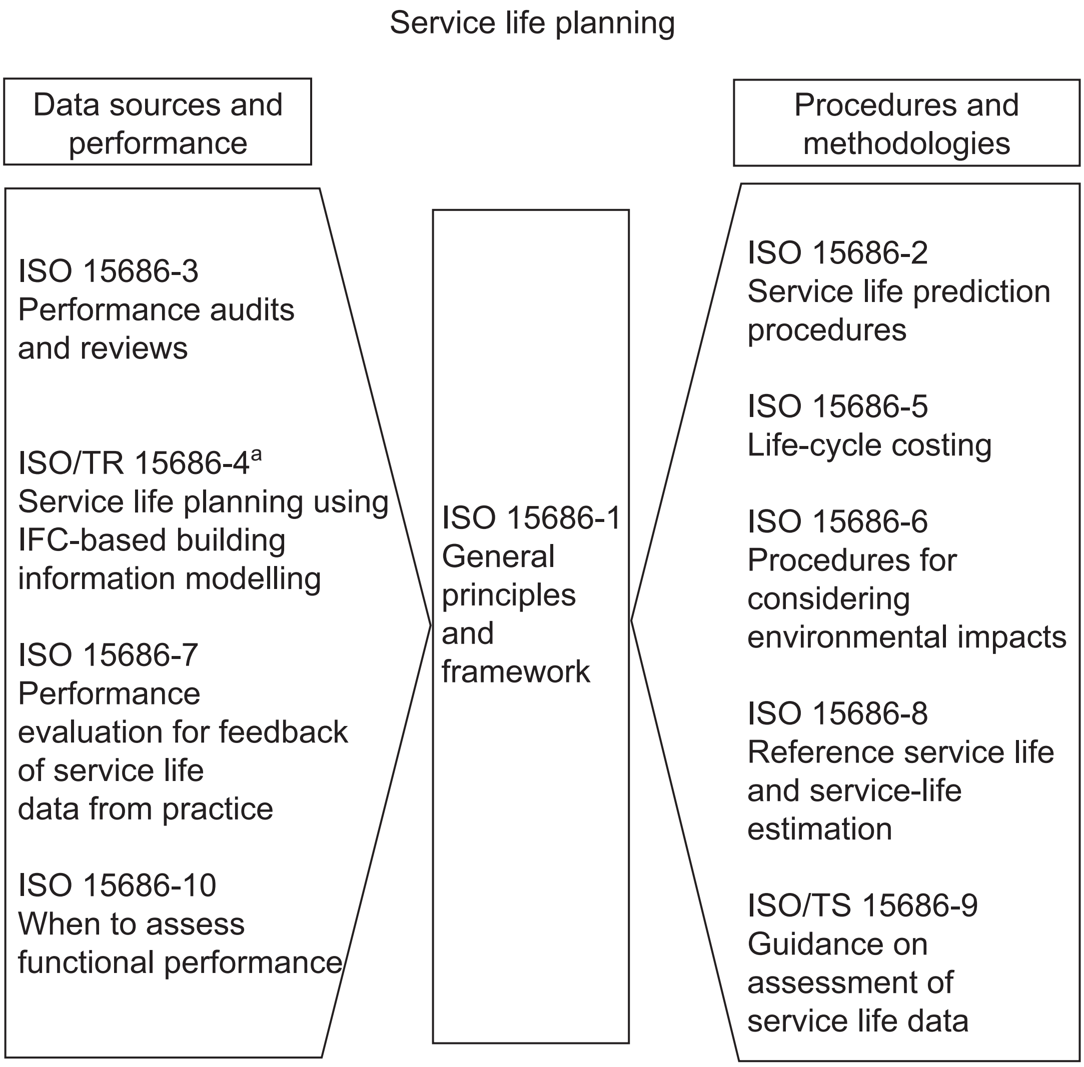
g) technical auditors of buildings;

h) developers of building product standards;

i) clients, funders, and sponsors of buildings.

By requiring an estimate or prediction of how long each component of a building will last, service life planning aids the making of decisions concerning specifications and design detailing. Also, when the service life of the building and its components are estimated or predicted, life-cycle cost and maintenance planning and value engineering techniques can be applied, reliability and flexibility of use of the building can be increased, and the likelihood of early obsolescence can be reduced.

Figure 1 indicates how the parts of ISO 15686 are intended to relate to each other and their associated topics.



[a] Under development.

Figure 1 — Relationships between the parts of ISO 15686 and the service life planning of buildings

0.2 Structure of ISO 15686

This part of ISO 15686 specifies the general principles of service life planning of a building or other constructed asset and presents a framework for undertaking such service life planning. These general principles can also be used to make decisions on maintenance and replacement requirements. This part of ISO 15686 serves as a guide to other parts, including general principles to be applied. Together, they provide requirements and guidance on the estimation or prediction of the service life of a building's components, which contribute to the service life of the building.

ISO 15686-2 specifies principles and procedures that facilitate service life predictions of building components. It provides a general framework, procedures and requirements for conducting and reporting such studies, but does not describe specific test methods. It may also be used as a checklist for assessing completed service life prediction studies.

ISO 15686-3 is concerned with ensuring the effective implementation of service life planning audits and reviews. It describes the approach and procedures to be applied to pre-briefing, briefing, design, construction and, where required, the life care management and disposal of buildings to provide reasonable assurance that measures necessary to achieve a satisfactory performance over time will be implemented.

ISO/TR 15686-4 is under development and will describe the data required to undertake service life estimation. This is primarily intended to define the data relating to service life that may be required in computer models. The formatting of such data for inclusion in calculation of models is expected to be presented in accordance with ISO 12006 (all parts).

ISO 15686-5 specifies procedures for performing life-cycle cost analyses of buildings and their parts. These assessments take into account cost or cash flows, i.e. relevant costs (and income and externalities if included in the agreed scope) arising from acquisition through operation to disposal. This assessment typically includes a comparison between options or an estimate of future costs at portfolio, project or component level. The assessment is over an agreed period of analysis, which can be a time frame that is less than the full life-cycle of the constructed asset.

ISO 15686-6 specifies how to assess, at the design stage, the potential environmental impacts of alternative designs of a constructed asset. It identifies the interface between environmental life-cycle assessment and service life planning.

ISO 15686-7 provides a generic basis for performance evaluation for feedback of service life data from existing buildings, including a definition of the terms to be used and the description of how the (technical) performance can be described and documented to ensure consistency.

ISO 15686-8 provides guidance on the provision, selection and formatting of reference service life data and on the application of these data for the purposes of calculating estimated service life using the factor method. It does not give guidance on how to estimate either the modification part or the values of factors A to G, using the given reference in-use conditions and the object-specific in-use conditions.

ISO/TS 15686-9 gives guidance and provides a framework for the derivation and presentation of reference service life data. In response to market demand, manufacturers and producers can develop, voluntarily, service life declarations for use in service life planning, according to this part of ISO 15686 and ISO 15686-8.

ISO 15686-10 establishes when to specify or verify functional performance requirements during the service life of buildings and building-related facilities and when to check the capability of buildings and facilities to meet identified requirements using procedures for establishing scales for setting levels of functionality or assessing levels of serviceability for any type of facility and any gaps that may exist between demand and supply profiles.[1] ISO 15686-10 is applicable to the use, management, ownership, financing, planning, design, acquisition, construction, operation, maintenance, renovation and disposal of buildings and other constructed assets.

0.3 Purpose of ISO 15686

ISO 15686 is relevant to service life planning of new and existing buildings. In existing buildings, service life estimation will apply principally to the estimation of residual service lives of components that are already in service, and to the selection of components for, and the detailing of, repairs and new work.

The informative annexes to this part of ISO 15686 provide supplementary information and illustrate the use of methods specified in the normative clauses. Differences in climatic conditions and building techniques in different parts of the world require separate aspects of service life planning to be developed for specific circumstances, and to take account of locality and microclimate.

NOTE 1 The approach to service life planning presented in ISO 15686 is based on documents published by CIB and RILEM, standards published in the UK, Japan, Canada and the USA, and on practical studies carried out in many countries.

NOTE 2 In the European Community, the Construction Products Directive includes a requirement that the "essential requirements" of construction products be retained for an "economically reasonable working life", if necessary by maintenance.

1) International Standards for the determination of levels of functionality (demand) and levels of serviceability (supply) are the responsibilty of ISO/TC 59/SC 3.

Buildings and constructed assets — Service life planning —

Part 1: **General principles and framework**

1 Scope

This part of ISO 15686 identifies and establishes general principles for service life planning and a systematic framework for undertaking service life planning of a planned building or construction work throughout its life cycle (or remaining life cycle for existing buildings or construction works).

The life cycle incorporates initiation, project definition, design, construction, commissioning, operation, maintenance, refurbishment, replacement, deconstruction and ultimate disposal, recycling or re-use of the asset (or parts thereof), including its components, systems and building services.

This part of ISO 15686 is applicable to the service life planning of individual buildings.

NOTE A series of service life plans can be used as input data to the strategic property management of a number of buildings.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6707-1, *Building and civil engineering — Vocabulary — Part 1: General terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6707-1 and the following apply.

3.1
building
construction work that has the provision of shelter for its occupants or contents as one of its main purposes and is usually enclosed and designed to stand permanently in one place

3.2
constructed asset
anything of value that is constructed or results from construction operations

3.3
design life
DL
intended service life (deprecated)
expected service life (deprecated)
service life intended by the designer

NOTE As stated by the designer to the client to support specification decisions.

3.4
environment
natural, man-made or induced external and internal conditions that can influence performance and use of a building and its parts

3.5
environmental aspect
element of an organization's activities or products or services that can interact with the environment

[ISO 14001:2004, 3.6]

3.6
environmental impact
any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects

[ISO 14001:2004, 3.7]

3.7
estimated service life
ESL
service life that a building or parts of a building would be expected to have in a set of specific in-use conditions, determined from reference service life data after taking into account any differences from the reference in-use conditions

3.8
factor method
modification of reference service life by factors to take account of the specific in-use conditions

3.9
failure
loss of the ability of a building or its parts to perform a specified function

3.10
in-use condition
any circumstance that can impact on the performance of a building or a constructed asset, or a part thereof, under normal use

NOTE See ISO 15686-8.

3.11
life-cycle cost
LCC
cost of an asset or its parts throughout its life cycle, while fulfilling its performance requirements

3.12
life-cycle costing
methodology for systematic economic evaluation of life-cycle costs over a period of analysis, as defined in the agreed scope

3.13
maintenance
combination of all technical and associated administrative actions during the service life to retain a building, or its parts, in a state in which it can perform its required functions

3.14
obsolescence
loss of ability of an item to perform satisfactorily due to changes in performance requirements

3.15
performance
performance in use
qualitative level of a critical property at any point in time considered

3.16
performance characteristic
physical quantity that is related to a critical property

NOTE In some cases, the performance characteristic can the same as the critical property, e.g. gloss. On the other hand, if the critical property is strength, for instance, thickness or mass can be utilized as a performance characteristic, working as an indirect measure of strength.

3.17
performance evaluation
evaluation of critical properties on the basis of measurement and inspection

3.18
performance over time
description of how a critical property varies with time

3.19
performance requirement
performance criterion
minimum acceptable level of a critical property

3.20
predicted service life
service life predicted from performance recorded over time in accordance with the procedure described in ISO 15686-2

3.21
reference in-use condition
in-use condition under which the reference service life data are valid

NOTE 1 See ISO 15686-8.

NOTE 2 The reference in-use conditions can be based upon information gathered through testing or from recorded performance and actual service life data of a component.

3.22
reference service life
RSL
service life of a product, component, assembly or system which is known to be expected under a particular set, i.e. a reference set, of in-use conditions and which can form the basis for estimating the service life under other in-use conditions

3.23
reference service life data
RSL data
information that includes the reference service life and any qualitative or quantitative data describing the validity of the reference service life

NOTE 1 The RSL data are reported in a data record.

NOTE 2 Typical data describing the validity of the RSL include the description of the component to which it applies, the reference in-use conditions under which it applies, and its quality.

3.24
service life planning
service life design (deprecated)
design process of preparing the brief and the design for the building and its parts to achieve the design life

NOTE Service life planning can, for example, reduce the costs of building ownership and facilitate maintenance and refurbishment.

3.25
service life
period of time after installation during which a facility or its component parts meet or exceed the performance requirements

4 Service life planning and building design

4.1 General

This clause gives the objectives of service life planning for a building and presents issues that should be considered in planning to ensure the adequacy of the service life of the building.

4.2 General principles of service life planning

The key principle of service life planning is to demonstrate that the service life of a proposed building will exceed the design life. The following principles should guide the process.

The service life plan should provide sufficient evidence to give reasonable assurance that the estimated service life of a new building on a specific site, operated as specified in the design brief and with appropriate maintenance and replacement, will be at least as long as the design life.

Where the design brief places limits on the acceptable life-cycle cost or environmental impacts of the building, the estimated service life shall be achieved within the specified constraints.

The service life of a building is determined using available knowledge about the service life of each component that is to be used in the building. Service life planning is a process of estimation and/or prediction of future events, and therefore complete accuracy can not be expected.

If the estimated service life of any component is less than the design life of the building, a decision should be made as to how the essential functions are to be maintained adequately (e.g. by replacement or other maintenance).

Service life planning should include projections of the needs for, and timing of, maintenance and replacement activities over the life cycle of the building. The projections will be based on data which should be assessed for robustness and reliability, and records of the data sources should be kept.

NOTE 1 Service life planning provides input to the assessment of life-cycle cost and environmental impact of the building over its life cycle. LCC methodology is specified in ISO 15686-5; assessment of environmental impacts is specified in ISO 15686-6; and life-cycle assessment is the subject of ISO 14040. In addition, ISO/TC 59/SC 17 is developing further International Standards relating to the sustainability of buildings.

NOTE 2 Service life planning facilitates the making of decisions regarding value engineering, cost planning, maintenance planning and replacement cycles.

NOTE 3 Replaceable components include windows, boilers, and air-conditioning units.

4.3 Scope of service life planning

Service life planning should consider the following:

a) the likely performance of the components of the building within the building life cycle in the expected external environment and conditions of occupancy and use;

b) the life-cycle cost and environmental impact of the building over its life cycle;

c) operating and maintenance costs;

d) the need for repairs, replacements, dismantling, removal, re-use and disposal, and the costs of each;

e) the construction of the whole building, installation of components and the maintenance and replacement of short-life components.

NOTE 1 For most clients, service life planning is used to help achieve an advantageous combination of capital, maintenance, and operating costs over the life of the building.

NOTE 2 Obsolescence inevitably results in waste, since the whole building, or parts that are still functional, will be replaced. A secondary objective of service life planning is to reduce the likelihood of obsolescence and/or to maximize the re-use value of the obsolete building or components.

NOTE 3 If the principles of this part of ISO 15686 are applied to existing buildings and components, many of the choices will have been pre-determined, since the building will already be some way through its service life. Therefore, service life planning would normally be focused on assessing the residual service lives of components and programming of replacements so as to minimize costs.

For buildings that are designed to have very long design lives (e.g. important State buildings), ease of maintenance is likely to determine the service life. If the service life of an essential component is less than the design life of the building, it should be possible to replace, repair or maintain the component.

4.4 Service life planning and the design process

Service life planning should be integrated into the building design process, since most design decisions will affect the service life. Service life needs to be considered from the earliest stages of design, when the client brief is being developed. As the design develops in more detail, the service life will need to be estimated in more detail and compared with the required design life identified in the client's brief, to ensure that the predicted service life is adequate.

Service life planning usually requires iterations of the design process to identify the preferred way of meeting the performance and maintenance requirements at an acceptable cost.

Service life planning requires access to relevant performance data on components at appropriate stages of the design process. The generation and provision of this data are the subject of other parts of ISO 15686, as shown in Figure 1.

The final stage of service life planning is the communication of results to parties who will occupy and maintain the building so that they are aware of assumptions made about the in-use environment and the maintenance needed to achieve the estimated service lives of the building's components.

4.5 Record keeping

The basis for an estimated service life, including the sources and quality of the data used, should be clearly stated in a written report. The report should also provide a conservative estimate of the uncertainty and the assumptions underlying the estimations. Further guidance is included in ISO 15686-8. These records may be required for a subsequent review or audit of the service life planning, as described in ISO 15686-3.

5 Service life estimation

5.1 Introduction to service life estimation

Estimating the service life of a building is the key task of service life planning. The service lives of the individual components need to be built up, from the smallest elements, into an estimate for the whole building. The performance of each component under the expected conditions, including likely failure modes, causes of loss of serviceability, risk of premature failure and their effects on service life need to be considered. The most common agents affecting the service life of building materials and components are outlined in Annex A.

Ideally, to predict service life, the microclimate, the performance of the component under the intended conditions and the construction and maintenance regime for the building should all be known. In practice, this data is not often available and so data on performance in similar conditions will need to be used. This data can come from a variety of sources including real-life exposure, feedback from use according to ISO 15686-7 or testing for the purposes of service life prediction according to ISO 15686-2. ISO/TS 15686-9 gives further guidance on sources of service life data at a component level.

For a building in service, maintenance and replacement schedules may be based on the service life plan, which may be modified based on the inspected condition according to ISO 15686-7.

To be used for a specific building, the data from these various sources needs to be adjusted to suit the particular design conditions. This adjustment may be carried out using the factor method specified in ISO 15686-8, which details the use of service life data.

The relationship between the various sources of service life data and the factor method is shown in Figure 2.

NOTE Data on service lives for components and even buildings might be available to the designer. Such sources include papers in scientific journals, manufacturers' literature and publications from construction research organizations. Any specific set of data will generally have been generated under a set of reference conditions and is therefore called a reference service life.

5.2 Objective of service life estimation

The objective of estimating the service lives of the components of a building is to provide a quantitative basis for establishing whether the building can be expected to achieve its design life with adequate reliability.

An estimated service life, together with an estimate of its uncertainty, is used to demonstrate that the design life can be achieved and to guide design decisions.

5.3 Service life prediction procedures

ISO 15686-2 specifies procedures that facilitate service life predictions of building components. It provides a general framework, procedures and requirements for conducting and reporting such studies. It may also be used as a checklist for assessing completed service life prediction studies.

Data produced using these procedures may be used directly for service life estimation, or may be adjusted using the procedures in ISO 15686-8.

5.4 Service life estimation using reference service lives

A reference service life is the expected service life of a component under a particular set of in-use conditions. ISO/TS 15686-9 describes the various sources of data that can be used to provide reference service lives.

Reference service life data can rarely be used satisfactorily as found, because the in-use conditions specific to the design object differ from the in-use conditions used to determine the reference service life. The designer shall therefore establish what differences there are between the reference service conditions and the conditions applying to the design object and determine how these will affect the service life.

ISO 15686-8 details a procedure, known as the factor method, which provides a simple framework for considering site-specific conditions and adjusting reference service lives to produce estimated service lives for specific in-use conditions.

5.5 Use of service life data from practical experience

Data from practical performance of components may be used for service life estimation, as described in ISO 15686-7. This requires a judgement of the comparability between the conditions in which the available data apply and those to which the component will be exposed in service. Where appropriate, service life data from practice may be adjusted using the approach specified in ISO 15686-8.

5.6 Innovative components

Innovative products can provide superior performance and overcome long-standing problems. For the service life estimation of buildings constructed with innovative components, estimates therefore have to be based on interpretation of the performance of the materials and components in short-term exposure tests. In this case, test procedures according to ISO 15686-2, failure mode and effect analysis (FMEA) and the application of knowledge of material science should be used to determine a minimum service life for the innovative component.

5.7 Data quality

The quality of service life estimation depends in part on the quality of the data used to generate the service life estimation. A possible problem with observations *in situ* is that agents (e.g. weather conditions) might not be reported, or those reported might not be typical, and might not reflect conditions comparable to those to which a component would be exposed in service. Anecdotal evidence of performance is less reliable than scientific evidence, but might be all that is available. In addition, selective reporting of data can be encountered when commercial interests are involved (e.g. a supplier might report positive, but not negative, exposure results). It is to be expected that the situation will improve when criteria are established for the scope and quality of data to be supplied by manufacturers and others for inclusion in databases, and as computer-integrated knowledge systems for service life estimation are developed.

5.8 Uncertainty and reliability

The reliability of service life estimation depends on the quality of the data available and the appropriateness of assumptions made. Therefore, it should be decided early in the service life planning how uncertainty in the estimated service life should be taken into account.

Distributions of various aspects of performance, including service life, can be expected within any group of similar items, including buildings and their components. In making service life estimations, the form of the distribution should be determined, if possible; otherwise, it should be assumed. Regarding reliability of service life estimations based on accelerated exposure tests, evidence should be sought by investigating the degree of correlation between *in situ* performance and laboratory test results.

Due to the number of variables involved and the uncertainties in each, and to the inherent variabilities of buildings, service environments, site workmanship, and future maintenance activities, it is not possible to estimate the service life of a building or its components precisely.

There will usually be some defects which cause failures to occur very soon after the occupation of a building. While these “premature defects” do not necessarily lead to wide-scale failure, they should be identified and corrected.

NOTE Generally, a higher degree of uncertainty will be acceptable for maintainable components than for components intended to function without maintenance for the life of the building.

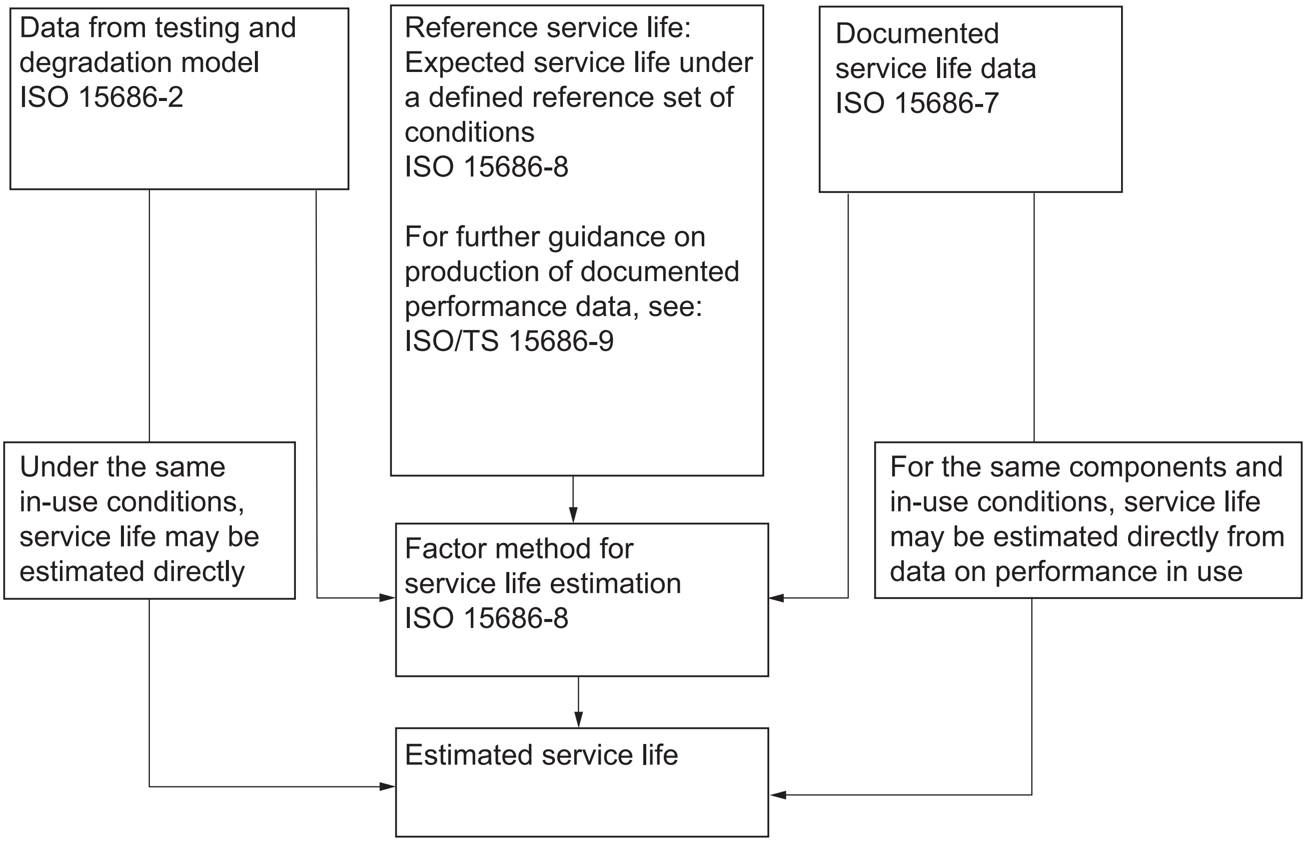


Figure 2 — Approaches to service life estimation

6 Financial and environmental costs over time

A major reason for planning the service life of a building and its components is to facilitate planning of the costs of ownership and to estimate environmental impacts.

Estimating the future cost of constructing, operating and maintaining the building gives clients advance notice of the costs of ownership, and allows them to reduce the financial risks of commissioning, purchasing, or retaining a building, thereby assisting their business planning. ISO 15686-5 addresses life-cycle costing.

In addition to financial costs, a building and its components may be evaluated for their environmental impacts. ISO 15686-6 addresses environmental aspects of service life planning.

ISO 15686-5 and ISO 15686-6 give guidance on setting the boundaries for analysis of life-cycle cost and environmental impacts.

Service life information is needed when the maintenance and replacement of components are expected to happen by undertaking service life planning, as this will trigger costs when they occur and additional environmental impacts or burdens.

NOTE Monitoring historic costs can provide a basis with which to compare and validate estimated costs, though they might not be accurate because of technological developments and the introduction of new products.

7 Obsolescence, adaptability and re-use

7.1 Obsolescence

Replacement due to defective performance needs to be distinguished from obsolescence. Obsolescence arises when a facility is no longer able to be adapted to satisfy changing requirements. Reliable data for estimating obsolescence are rarely available, since it tends to result from unexpected changes, often unrelated to the construction. Estimates of the time to obsolescence should be based on the designer's and client's experience and, if possible, documented feedback from practice.

ISO 15686-10 establishes the principles and generic requirements for defining and determining levels of functionality and serviceability.

NOTE It might be desirable to consider components based on the likelihood of their becoming obsolete within the design life of the building. Where this is considered probable, owners might wish to include provisions for obsolescence, i.e. to allow for easy replacement in conjunction with other planned maintenance activities. The importance of service life planning is not reduced, but it then becomes a matter of ensuring that performance remains acceptable for the reduced design life of the component.

7.2 Types of obsolescence

Obsolescence can be functional, technological or economic. While replacements can also be made for reasons of changing fashion or tastes, there is often an economic reason underlying such replacements (e.g. lettability of the building). Table 1 gives some examples of each type of obsolescence.

Table 1 — Types of obsolescence and examples

Type of obsolescence	Typical occurrence	Examples
Functional	— Function no longer required	— Obsolete industrial process — Unnecessary facility office partitioning removed during remodelling
Technological	— Better performance available from modern alternatives — Changing pattern of building use	— Change from vitreous clay to stainless-steel sinks — Change to open-plan layout in factories to allow installation of new plant — New insulation for enhanced thermal performance
Economic	— Fully functional but less efficient — More expensive than alternatives	— Replacement of sectional boilers with condensing boilers

7.3 Minimizing obsolescence

Economic obsolescence occurs because maintenance has become unreasonably costly or disruptive, or because cheaper alternatives to maintenance are available. Maintenance planning, including replacement of components, should be included in the design stage. Items to be considered should include those where access costs are high (e.g. scaffolding is required) or where normal use of the building would have to be suspended (e.g. replacement of a factory floor).

Refurbishment and upgrading are the major strategies to counter obsolescence. The most efficient designs will be flexible and allow for changes in future requirements. The risk of obsolescence will be reduced by designs which permit internal replanning, extensions, changes in service systems, or changes in partitioning of the building, but at a cost. This can be particularly relevant to offices and particular consideration should be given to the building frame or structure. Strategies include allowing for different floors to be let separately and making generous provision for building services, sanitary facilities and fire escape routes.

7.4 Future use of the building

A building is generally a very durable capital asset. The initial client might only have a limited use for it. Service life planning can facilitate design to enhance the prospects for future sale or re-use by subsequent owners, thereby increasing the residual value of the building. Extending the service life of the building and reducing component maintenance and replacements also contribute to achieving sustainable development and preservation of scarce resources. Where a building has a service life plan, this will provide detailed information to assist in planning a change of use.

7.5 Demolition and re-use

In order to reduce waste and facilitate re-use of materials or components at the end of its service life, demolition of a building should be taken into account at the design stage. This might also be a requirement of national or local building codes covering safety of building work on re-usable or recyclable components within the building, enabling the client to obtain greater value on disposal.

NOTE Matching the component service lives to that of the building reduces the waste at demolition. This is particularly important for temporary buildings. Ability to separate the components to leave uncontaminated materials is important for recycling.

Annex A
(informative)

Agents affecting the service life of building components

Table A.1 — Agent categories in terms of nature and class

Nature	Class	Examples
Mechanical agents	Gravity	Snow loads, rainwater loads
	Forces and imposed or restrained deformations	Ice formation, expansion and contraction, land slip, creep
	Kinetic energy	Impacts, sand storm, water hammer
	Vibrations and noises	Tunnelling, vibration from traffic or domestic appliances
Electromagnetic agents	Radiation	Solar or ultraviolet radiation, radioactive radiation
	Electricity	Electrolytic reactions, lightning
	Magnetism	Magnetic fields
Thermal agents	Extreme levels or fast alterations of temperature	Heat, frost, thermal shock, fire
Chemical agents	Water and solvents	Air humidity, ground water, alcohol
	Oxidizing agents	Oxygen, disinfectant, bleach
	Reducing agents	Sulphides, ammonia, agents of combustion
	Acids	Carbonic acid, bird droppings, vinegar
	Alkalis (bases)	Lime, hydroxides
	Salts	Nitrates, phosphates, chlorides
	Chemically neutral	Limestone, fat, oil, ink
Biological agents	Vegetable and microbial	Bacteria, moulds, fungi, roots
	Animal	Rodents, termites, worms, birds.
NOTE This table is taken from ISO 6241, which has additional examples. Note that the agents are classified according to their nature. In general, external to the building, the origin of agents is the atmosphere or the ground, whereas internally the origin is either occupancy or design and installations.		

Annex B
(informative)

Service life planning in the design process

B.1 General

Service life planning should be integrated into the design process from the start of the project. All members of the design team should be aware of the performance requirements in relation to service life at the outset.

B.2 The brief

Decisions critical to the service life of a building begin with the drafting of the brief. At this stage, the environment of the building and other local conditions should be identified and the fundamental requirements to be met in planning the service life of the building should be established. Decisions should be made on the following:

a) the design life of the building;

b) minimum functional performance criteria for each component over the building's design life;

c) components that must be repairable, maintainable, or replaceable within the design life of the building.

These decisions should normally be made by the client and the designer at an early stage in the briefing process. The client should, as far as possible, provide well-defined and comprehensive requirements for the building.

B.3 Environmental characterization

Because the environment within and around each building is unique, environmental characterization is required to determine which agents are likely to have detrimental effects on the service life of the building and its components. Depending on its criticality, the characterization can be at a general level or it can be more specific. Annex A contains a list of environmental agents which can cause degradation. More detailed guidance is provided in ISO 15686-2. Data that should be sought includes the average intensity or concentration of each degradation agent, and the frequency of cycling between states (e.g. from wet to dry, or through freezing points, or from maximum to minimum daily temperatures, or intermittent exposures to salt spray).

Normally, environmental characterization need only be undertaken once for each project. Locations with different micro-environments should be considered separately. Identifying these locations will depend on which agents are relevant to each. The following list, while not complete, gives examples of the types of location which might need separate consideration:

— specific locations: the exterior of the building envelope, semi-sheltered internal locations, and areas on tall buildings subject to meso-environmental variations such as increased exposure to water and pollutants and to wind-driven rain;

— locations with ground contact: areas exposed to ground water or to soil agents;

— locations subject to heavy use: communal internal areas, refuse collection points;

- locations subject to unusual agents: areas exposed to blood, oil, phenols, chlorides, milk, acids, or other aggressive agents, including emissions from local industrial processes (e.g. nitrogen oxides and sulphur dioxide);
- locations subject to condensation: sub-floor voids, window reveals, and roof voids;
- locations subject to wetting: kitchens, bathrooms, laundry rooms, and pools;
- locations subject to aggressive maintenance: de-icing, bleaches, and graffiti removal;
- locations with special uses: operating theatres, hospital wards, and corridors;
- locations where maintenance will be unlikely: high-level, inaccessible, and confined areas.

NOTE For many buildings, one external assessment and two internal assessments (for dry and wet areas) can be sufficient.

B.4 Conceptual and initial design

In making initial design choices, professional judgement and expertise are required to check that:

a) the design life of the building is achievable within the project constraints (e.g. budget, time, performance, maintenance requirements, site-specific issues, and environmental impact);

b) the design meets the performance requirements defined in the brief (e.g. for non-replaceable components);

c) allowance has been made for maintenance, repair, replacement, or upgrading of critical components to avoid undue disruption to the use of the building.

If these conditions are not met, it should be decided whether one or both of the brief and the initial design should be modified.

NOTE Building codes might require inaccessible components to have service lives at least as long as the design life of the building.

B.5 Detailed design

Detailed design includes selection of components. Choices might be limited by the components available. The process of proposing a component, checking its estimated performance against the brief and amending selections, if required, should be repeated until the requirements of the brief can be met.

Components should be assessed for compliance with performance requirements, recognizing that the performance of each component will deteriorate at a rate depending on:

a) the environment;

b) the design of the building and the installation detailing of the component;

c) the quality of site work;

d) the materials of which the components are made and their reactions at interfaces with dissimilar materials;

e) maintenance;

f) usage.

Communication between the designer and component suppliers will help identify which degradation agents are relevant and which, if any, components are suitable. Component suppliers should be given as much information about the intended end use as possible.

Responsibility for avoidance of interfaces between incompatible materials and components should be clearly identified as it is critical to performance. The design of the building determines the environment for each component considered, with the neighbouring materials being part of its environment (see ISO 6241 for further details). However, specific references to interfaces are made throughout this part of ISO 15686 as their effects are sometimes overlooked in assessing component performance.

B.6 Specification

B.6.1 General

The specification includes the designation of appropriate components and installation details; it may also require that techniques such as value engineering or life-cycle costing be used to support decisions. The specification should state minimum performance criteria. In B.6.2 to B.6.4, important issues that should be addressed in service life planning are described.

NOTE The specification concerns many aspects of the performance of a building and its components other than service life. Guidance on reviewing and auditing service life plans and associated specifications is given in ISO 15686-3.

B.6.2 Installation detailing

Where practical, installation detailing and interfacial environments should be adjusted by design to extend the service lives of components by providing protection against agents of degradation and their effects.

NOTE Some protective strategies are the provision of overhanging projections, site-applied coatings, the removal of aggressive agents in the ground, isolation layers, and ventilation.

B.6.3 Selection of components

Components vary in their reactions with agents of degradation and some materials might be seen to be unsuitable on initial consideration without further evaluation. Recognizing that suitable data might not be available for all relevant agents (as described in ISO 15686-8), test data for use in identifying suitable materials should be sought from manufacturers and others. For this purpose, manufacturers should be provided with details of the performance requirements (as described in B.8) and agents in the local environment. Manufacturers should also be asked for information on maintenance requirements of candidate components. Moreover, consideration should be given to whether certain component designs will reduce the effects of agents (e.g. by incorporating sacrificial or protective layers) or aggravate them (e.g. by permitting contact between incompatible materials).

EXAMPLE Macro-environment-level consideration of a project might indicate that the most aggressive local agent is the salt spray in a marine environment. Readily available test data might indicate that lightly galvanized mild steel is unsuitable without detailed consideration of the specification. Specification would then dismiss that option, but would still include the possibility of a plastic-coated steel. Choosing a suitable metal or non-metallic alternative might require more research or testing that takes account of other local agents.

To achieve a balance between the use of familiar components, whose performance is known through test data or experience or both, and innovative ones which, in spite of a lack of service life data, appear likely to achieve better performance, a designer should seek assistance from a materials expert.

B.6.4 Site work

In service life planning, a particular margin of error should be allowed to account for the occurrence of less-than-perfect conditions on the work site. If factors such as the local environmental conditions during construction, or the materials being used, or the levels of workmanship do not meet the manufacturer's recommendations, or do not comply with code requirements, or fail to meet the specifications in any way, it should be decided whether the required service life can still be met. If it cannot, corrective action should be taken to prevent inadequate performance.

If it is judged that it might be difficult to achieve the specified conditions needed for construction on site (e.g. for the moving of materials, or construction with small tolerances, or application of coatings and sealants), consideration should be given to moving fabrication from the work site to a factory, or using components that are more familiar and more tolerant of adverse installation conditions, or both.

NOTE No matter how good the design, unauthorized alterations or substitutions made on-site can result in loss of some or all of the benefits of service life planning.

B.7 Maintenance plan

In this part of ISO 15686, maintenance is defined broadly to include cyclical maintenance (such as regular redecoration), reactive condition-based maintenance (repairs to correct defective performance) and major refurbishment. Planning the service life of a building should include production of a schedule of dates for replacement of components. The schedule can also include likely dates for major refurbishment and for replacement of subsidiary parts of assemblies (such as door and window hardware, glazing and window seals, and roof flashings). Service life planning requires knowledge of the service life of each component and its sub-components. Apart from its use in the scheduling of maintenance activities, it is needed for rationalization of maintenance costs.

The estimated service lives of components, and the schedule for their maintenance and replacement, should be communicated to the client and the user. The schedule will help those responsible for maintenance by making them aware of operations and cyclical maintenance that were anticipated at the design stage. It should also alert them to agents (e.g. cleaning agents) that were not anticipated by the designer. It might also help them plan maintenance costs, with some provision being made for unforeseen costs.

Maintenance activities that can be reasonably anticipated, and which should be taken into account in planning the service life of a building, include the following:

a) change of interior finishes (including decorative finishes and, for example, retiling of kitchens and bathrooms);

b) removal or rearrangement of partitioning (particularly in offices);

c) replacement of roof coverings (the likelihood of this will vary with the design life of the building and the type of covering);

d) changes to, or replacement of, electrical, plumbing, and other service installations (these are highly probable for most types of building);

e) alterations to below-ground drainage (these are relatively rare and normally occur following extensions or change of use);

f) partial removal or replacement of load-bearing elements (normally during refurbishment or changes of use).

Assumptions made in service life planning should be recorded for future reference. Estimates of service lives can be invalidated by changes in activities that take place during the life of a building.

NOTE 1 Estimation of maintenance costs is dealt with as part of life-cycle costing in ISO 15686-5.

NOTE 2 National or local building codes can require the designer to consider future maintenance requirements and safety.

B.8 Performance requirements and acceptability

B.8.1 Permanent, replaceable or maintainable construction

Buildings and their components should be identified as being either replaceable or permanent.

Table B.1 is an example of minimum design lives of components for particular design lives of buildings, based on accessibility for maintenance. The figures can be used as a starting point for discussions about appropriate design lives; they should not inhibit choice of design lives for economic reasons (e.g. to match replacement cycles to the design life of the building, or to seek alternatives where components with the suggested durability might be excessively costly).

NOTE 1 Building components will often need replacement or maintenance during the service life of the whole building. It can be uneconomic, or impossible, or not functionally desirable, to require all components to retain acceptable performance without maintenance for a typical building with a design life of many years. The most likely exceptions are structural components or assemblies (such as foundations, frames or embedded fixings), which are so disruptive to repair or replace that their failure can trigger replacement of the building. The feasibility of safely demolishing the building or component and disposing of waste might also be relevant.

NOTE 2 For temporary buildings, it is generally desirable to match the design lives of components to that of the whole building. Ease of disassembly will aid recycling or re-use. Buildings with very long design lives might need continual repair and replacement to achieve their design lives. Thus, ease of disassembly and reassembly to retain the existing building fabric might be a design objective, together with ease of repair.

Table B.1 — Suggested minimum design lives for components (DLC)

Design life of building	Inaccessible or structural components	Components where replacement is expensive or difficult[a]	Major replaceable components	Building services
Unlimited	Unlimited	100	40	25
150	150	100	40	25
100	100	100	40	25
60	60	60	40	25
25	25	25	25	25
15	15	15	15	15
10	10	10	10	10

NOTE 1 Easily replaced components may have design lives of three to six years.

NOTE 2 An unlimited design life should rarely be used as it significantly reduces design options.

[a] Including below-ground drainage.

B.8.2 Performance limited by degradation

For service life planning, the service life of a building is limited by the degradation of non-replaceable components or the degradation of replaceable or maintainable components, or both, when replacement or maintenance results in unacceptable costs, safety issues, or disruption of use. Maintenance (including replacement of components) is the major strategy to counter degradation, but replacement of poorly performing replaceable components should be considered if repair is not economically justifiable.

Service life planning can only address foreseeable changes. Since service life planning is concerned with foreseeable risks, it is not applicable to the estimation of obsolescence (see Clause 7) or to defective performance resulting from unforeseeable events or processes.

EXAMPLE Today, demolitions of houses having fully functional frames are also occurring, above all in municipal housing stocks due to a weak local market.

To reduce the likelihood of needing to replace components due to inadequate visualization of future demands on the building, consideration should be given to the consequences of foreseeable mechanisms of degradation.

B.8.3 Acceptability

While the design brief defines the performance requirements set by the client, it may also include requirements imposed by national or local building codes and regulations. A building, or a building component, may require replacement or repair if the requirements of codes and regulations are no longer met.

As mentioned in B.4, criteria of minimum acceptable performance of important components should be identified in the brief or initial design. These criteria determine the aspects of performance which can trigger replacement of a component if it ceases to meet the performance criteria for an essential function. Defective performance can end the component's service life (unless economic maintenance or repair can restore performance). The rest of the process of service life planning consists of estimating how long it will take for a component to reach the level of unacceptable performance. It is also desirable to facilitate possible future changes.

The client should identify components whose performance is critical, and highlight potential failures which might not be obvious causes for the building to become unacceptable (e.g. uneven colour loss on cladding).

Unacceptable performance can require maintenance (e.g. cleaning, partial replacement of sub-components, or repair) or replacement of the component. Replacement can also be necessary if maintenance is too costly or if repair is impossible (e.g. due to unavailability of spare parts).

EXAMPLE A window can need replacement if it ceases to do any of the following:

a) remain safe and secure;

b) open and close;

c) be uniformly transparent;

d) prevent water leakage around the frame;

e) retain acceptable appearance;

f) provide adequate thermal insulation.

NOTE 1 It is important to recognize that not all decreases in the properties of a component affect critical aspects of its performance. The performance of many components does not affect the acceptability of the building. However, which failures are relevant is determined largely by the operational activities within the building. For example, temporary high levels of condensation can be detrimental to computers used in the building.

NOTE 2 Replacements may also take place due to obsolescence or to changes in use of the building.

B.8.4 Consequences of failure

If component failures might cause hazards to health and safety, possible failures should be categorized by their consequences. The need to avoid unacceptable risks to health and safety, or other matters critical to building owners or users, might require that component reliability be given particular weight when evaluating component service life. Table B.2 (modified from BS 7543[25]) suggests a hierarchy of seriousness of consequences, but particular concerns might change the ranking (e.g. interruption of customer access to a retail shop).

To reduce the risk of failure occurring within the design life of the building when the consequences of failure are judged to be critical, it might be necessary to require particularly long design lives for specific components or to strengthen the requirements for inspection and maintenance. This might be the case if, for example, a dangerous substance were to escape, or if large numbers of people were to be injured if a component failed to maintain its critical properties. Ideally, the decision should be made based on a probabilities-based approach.

Table B.2 — Suggested hierarchy of safety consequences

Category	Consequence	Example
1	Danger to life	Sudden collapse of structure
2	Risk of injury	Loose stair tread
3	Danger to health	Serious damp penetration
4	Costly repair	Extensive scaffolding required
5	Costly because repeated	Window hardware replacement
6	Interruption of building use	Heating failure
7	Security compromised	Broken door latch
8	No exceptional problems	Replacement of light fixtures

B.8.5 Functional acceptability

Functional acceptability of performance in areas related, but not limited, to health, safety, utility, or property protection should be maintained over a building's service life.

Table B.3 — Examples of functional critical properties

Performance requirements	Examples
Safety and security	Safety during fire, in use, during maintenance, as a response to hazards (such as earthquakes, floods, or after lightning strike)
Legal requirements	Non-conformity with codes (note that changes in building use can change applicable codes)
Structural performance	Resistance to static and imposed loads
Protective performance and weather tightness	Ability of envelope to shield structural frame from environmental actions, protection of occupants and stored goods
Comfort, hygiene and environment	Control of indoor temperature, relative humidity, acoustic and visual performance, ability to clean surfaces as required
Aesthetics	Where good appearance is needed to let or sell the building, or to impress visitors
Operation of moving parts	Resistance to wear and corrosion

Table B.4 — Examples of economic critical properties

Performance requirements	Examples of failing
Acceptable maintenance costs	Frequent replacement of sealed glazed units
Running costs in use	Energy costs of inefficient heating systems
Availability of spare parts at reasonable cost	Boiler castings which require individual tooling
NOTE The guaranteed availability of spare parts can indicate the limit of service life for components which require regular replacement parts, e.g. boilers.	

B.8.6 Economic acceptability

Normally, component replacements are economically justifiable if maintenance or repair is unacceptably costly or if better performance from new components would reduce operating costs.

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