INTERNATIONAL STANDARD

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Buildings and constructed assets — Service life planning —

Part 3: Performance audits and reviews

Bâtiments et biens immobiliers construits — Prévision de la durée de vie —

Partie 3: Audits et revues des performances

Reference number
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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 15686 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15686-3 was prepared by Technical Committee ISO/TC 59, *Building construction*, Subcommittee SC 14, *Design life*.

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

— *Part 1: General principles*

— *Part 2: Service life prediction procedures*

— *Part 3: Performance audits and reviews*

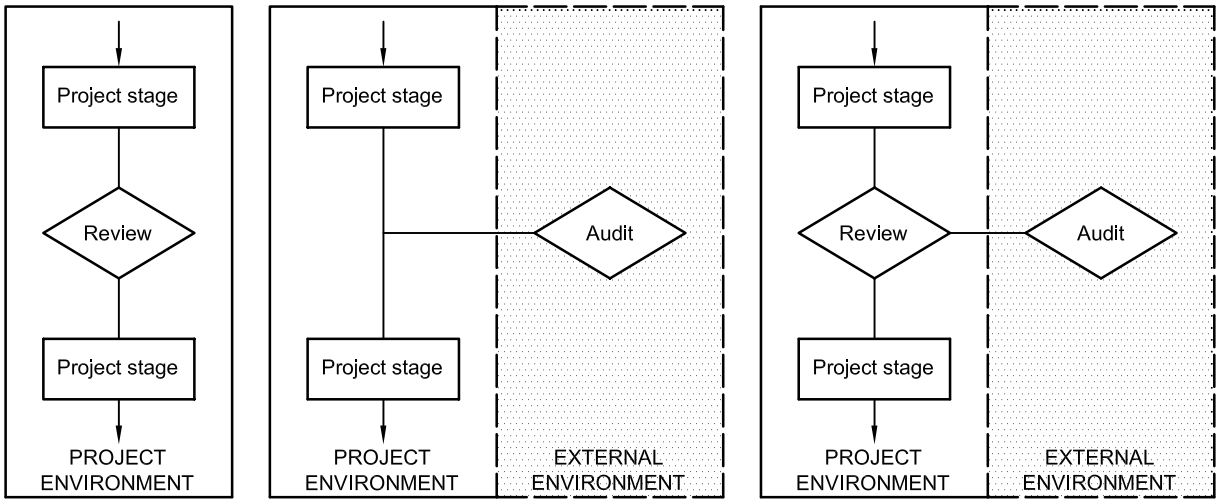
Annexes A, B and C of this part of ISO 15686 are for information only.

Introduction

Buildings and constructed assets require care from the initial proposals through to design, construction, operation, maintenance and disposal, to ensure they meet the required level of performance. ISO 15686-1 and ISO 15686-2 explain the principles of designing an appropriate service life for different types of constructed assets, components and assemblies. This part of ISO 15686 deals with measures to ensure that the life care of a constructed asset is considered through each stage of decision making from project conception and initial briefing, through design and construction, to occupancy and eventual disposal and reinstatement of the site.

This part of ISO 15686 provides a choice between formal independent audits carried out at key project stages (clauses 5 and 6); and service life performance reviews carried out alongside existing internal project review procedures (clause 7). The advantages of formal external audits can include greater independence and objectivity as well as access to wider experience of auditing procedures. Service life performance reviews benefit from greater familiarity with the specific project and the potential to integrate certain review procedures with other project validation procedures such as designers' quality management system checks.

NOTE There is also scope for integrating service life performance audit and review procedures within a project, such that the documented outcomes of the review process form the inputs into the audit process at a given project stage. The review then becomes the primary means of ensuring effective service life planning and the audit function is limited to that of verifying the outcomes of the review process (see Figure 1).



a) Reviews only **b) Audits only** **c) Reviews and audits**

Figure 1 — Three models for integrating performance audits and reviews into the procurement process

Both service life performance audits and reviews emphasize the pre-briefing, briefing and design stages of a construction project. It is the far-reaching decisions made at these early stages that affect what is built, the way it is constructed, its commissioning and operation, how it should be maintained and the options for dealing with the structure at the end of its life cycle. It has been found that more than 50 % of building failures can be traced back to the brief and to information passed on in, or missing from, the design and specification details that the constructor receives. Other failures can result from poor construction, inadequate commissioning, unsuitable use of the building, and inadequate life care. The service life performance audit and review process includes a means of checking back in these later stages to ensure that the original intentions are followed.

Auditing is a key management tool for ensuring that stated objectives are met. Procedures have been established for auditing quality management systems (ISO 19011) and for environmental auditing (ISO 14010, ISO 14011 and ISO 14012). Many of the techniques described here are similar to those used for quality and environmental auditing and there is an opportunity in service life performance audits and reviews to combine procedures in specific circumstances.

A service life performance audit or review of the pre-briefing stage and of the project brief should reveal where client requirements for service life are missing or inadequately defined. The requirements can then be defined before work starts on the detailed design. An audit or review of the detailed design will report on nonconformities, i.e. where the design does not meet the requirements of the brief. The design can then be amended, or the requirements redefined, before construction.

Further audits or reviews of the construction, commissioning, and future operation, refurbishment, adaptation and disposal of the constructed asset can be undertaken to ensure that the required service life performance is not compromised by such activities.

Figure 2 summarizes the main topics covered in this part of ISO 15686.

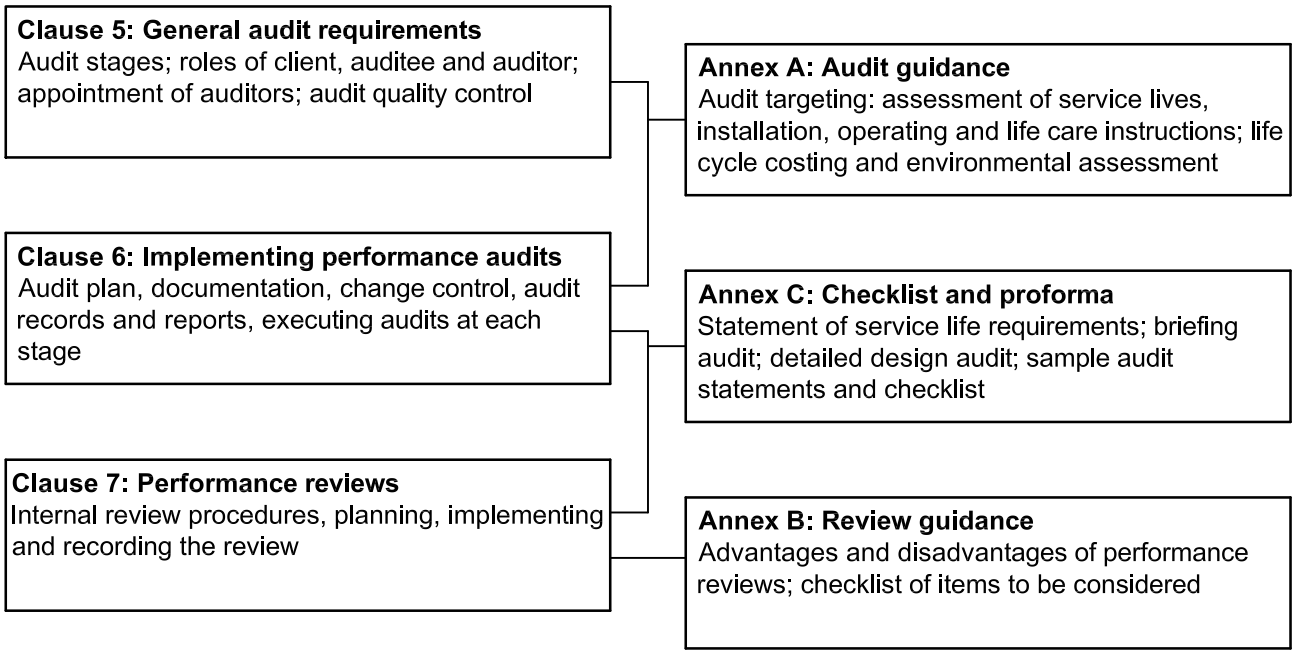


Figure 2 — Overview of this part of ISO 15686

The provisions of this part of ISO 15686 are intended primarily for

— construction clients,

— persons appointed to carry out service life performance audits (auditors),

— designers, and

— operational and maintenance personnel.

They are also relevant to the work of constructors, project managers, inspectors, asset and facilities managers, insurers and valuers.

In addition to this part of ISO 15686, six other parts are published or are in the course of preparation, as follows.

— Part 1 deals with general principles, issues and data needed to forecast service lives and provides a method for estimating the service lives of components and assemblies.

— Part 2 describes generic procedures for testing the performance of components, materials and assemblies to provide service life predictions.

— Part 4 will provide guidance on methods of presenting data and evidence to support forecasts and predictions.

— Part 5 will provide guidance on assessment of whole life costing.

— Part 6 will provide a procedure for considering environmental impacts.

— Part 7 will provide guidance on the performance evaluation and feedback of service life data from existing construction works.

— Part 8 will provide guidance on the provision of reference service life for use in the application of ISO 15686-1.

A major impetus for the production of ISO 15686 has been concern over the construction industry's need to control the cost of ownership of constructed assets, since a high proportion of the life cycle cost may be set by the time the facility is complete. In addition to reducing unnecessary expenditure, the use of ISO 15686 can contribute to the aim of "sustainable" development by promoting a less wasteful use of natural resources and to consequential protection of the environment.

Buildings and constructed assets — Service life planning —

Part 3:
Performance audits and reviews

1 Scope

This part of ISO 15686 is concerned with ensuring the effective implementation of service life planning. 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 and constructed assets to provide a reasonable assurance that measures necessary to achieve a satisfactory performance over time will be implemented.

The cost implications of service life planning and the broader issues of sustainability (e.g. embodied energy, land use) are not developed in this part of ISO 15686.

NOTE Throughout this part of ISO 15686 the term “constructed asset” is used to include buildings; infrastructure works such as roads, bridges and pipelines; structural works such as communications masts; and other engineering works such as power stations and chemical plants.

2 Conformance

Conformance with this part of ISO 15686 requires service life performance audits to be undertaken in accordance with clauses 5 and 6 and/or reviews to be carried out in accordance with clause 7. It shall be stated in all relevant documentation which of these clauses applies. Audits or reviews of the pre-briefing, briefing and detailed design stages of a project are the minimum “core” activities that shall be carried out whenever compliance with this part of ISO 15686 is required prior to construction. Further audits or reviews of the initial design, construction, commissioning, operation, alteration and/or disposal of the facility are discretionary but, where carried out, shall conform with this part of ISO 15686.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 15686. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 15686 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 15686-1:2000, *Buildings and constructed assets — Service life planning — Part 1: General principles*

ISO 19011, *Guidelines for quality and/or environmental management systems auditing*

4 Terms and definitions

For the purposes of this part of ISO 15686, the terms and definitions given in ISO 6707-1, ISO 15686-1, ISO 19011 and the following apply.

4.1
service life performance audit
systematic examination by an independent party of requirements, initial and detailed design proposals, and instructions for installation, commissioning and life care, to determine their adequacy in relation to service life performance

NOTE 1 In this context, an “independent party” is an individual or organization that is not directly accountable or responsible for the project activities being audited.

NOTE 2 A service life performance audit is not concerned with early failures (within the normal contractual warranty period) that are caused by faulty design, manufacture, handling or installation.

4.2
service life performance review
systematic second-party examination of requirements, initial and detailed design proposals, and instructions for installation, commissioning and life care, to determine their adequacy in relation to service life performance

4.3
pre-briefing
earliest stage in the consideration of a construction project when the need for constructed works is assessed and the suitability of sites is assessed

4.4
initial design
early stage in the development of a design before many of the materials, components or assemblies have been selected

4.5
detailed design
drawings, data, calculations and specifications from which constructed works, components and assemblies can be constructed

4.6
life care
measures that promote achievement of the design life, including cleaning, maintenance, servicing, repair, refurbishment, protection, control of use and avoidance of neglect

4.7
recovery management
planning and control procedures designed to maximize the economic reuse of resources committed to a constructed works project

4.8
reference document
project document and other supporting evidence, provided for auditing and/or review purposes, that demonstrate the project team’s response to the service life performance requirements in the project brief

4.9
reliability
probability that a component, assembly or system will perform its intended function under stated conditions for a stated period of time

4.10
serviceability
ability to meet or exceed relevant performance requirements

4.11
availability
periods during which a facility or service is serviceable

4.12
nonconformity
non-fulfilment of specified requirements

4.13
observation
statement of fact made during an audit or review and substantiated by objective evidence

5 General audit requirements and responsibilities

5.1 General

Service life performance audits are undertaken to ensure that performance over time has been adequately considered in the pre-briefing, briefing, design, construction, life care management (including refurbishment, alteration) and disposal of a constructed asset, and to provide a reasonable assurance that the required service life performance will be achieved. To ensure objectivity, consistency and reliability, service life performance audits are distinct activities carried out by qualified auditors that are independent of the project activities being audited.

Service life performance audits shall be conducted in accordance with clauses 5 and 6 of this part of ISO 15686. Audits shall be conducted according to documented and well-defined methodologies and systematic procedures. For any type of service life performance audit, the methodologies and procedures adopted shall be consistent and shall aim to ensure comparability and repeatability. Where possible, standard audit checklists, statements and proformas shall be used as a means of ensuring consistency and reliability in the audit process. Guidance and examples are provided in informative annexes A and C.

The scope and purpose of each audit shall be clearly defined before work on that audit starts. The detail and extent of the audit and its documentation shall reflect the specific context (e.g. legal, financial, environmental, health and safety) within which the findings are likely to be used. Where a particularly onerous reliance is likely to be placed on audit findings, the audit and its documentation shall be subject to an enhanced level of robustness and details. Records shall be kept of all reference documents and other documentation used in arriving at the audit findings. Following examination of the reference documents by the auditor, the output from the audit is a report to the client and/or auditee. The auditor may later be asked to assess the adequacy of corrective action taken to redress the nonconformities listed in the audit report.

The specific purpose of the audit will depend upon the stage in the asset life cycle at which it is undertaken and on the audit scope and extent as defined by the project client. Table 1 provides an overview of the service life performance auditing process related to specific stages in the asset life cycle.

Table 1 — Service life performance auditing related to asset life cycle

Stage in asset life cycle	Audit type/stage	Audit status[a]	Purpose of audit
Project initiation	Pre-briefing audit (6.6.1)	Core	To ensure that service life has been adequately considered in decisions on the need to build and the choice of site.
Project definition	Briefing audit (6.6.2)	Core	To ensure that there is an adequate basis for service life planning at the initial and detailed design stages.
Initial design	Initial design audit (6.6.3)	Secondary	To assess the service life implications of initial concept designs.
Detailed design	Detailed design audit (6.6.4)	Core	To ensure that the design conforms to the service life performance requirements of the brief; to ensure that adequate information on installation and commissioning is provided for those involved in the construction stage.
Construction	Construction audit (6.6.5)	Secondary	To assess whether correct or intended materials/ components have been used and installation instructions have been properly implemented.
Commissioning and handover	Commissioning and handover audit (6.6.6)	Secondary	To assess whether the commissioning instructions have been properly implemented; to ensure that adequate information on the operation and life care of the facility is provided.
Operation	Operation and life care audit (6.6.7)	Secondary	To assess whether the life care instructions have been properly implemented; to review the adequacy of the life care regime.
Refurbishment/ adaptation/ alteration/change of use	Refurbishment/adaptation/ alteration/change of use audits (6.6.8)	Secondary	To assess whether proposals/instructions for refurbishment/adaptation/alteration/change of use conform to the service life performance requirements of the brief for such works; to ensure that adequate instructions are provided for those involved in implementing the works. To assess whether the instructions have been properly implemented.
Disposal/ decommissioning/ deconstruction/ recovery/site reinstatement	Disposal/ decommissioning/ deconstruction/recovery/ site reinstatement audits (6.6.9)	Secondary	To assess whether proposals or instructions for disposal, decommissioning, deconstruction, material recovery, site reinstatement, etc. conform to the requirements of the disposal brief and/or the original project brief and detailed design. To assess whether disposal work, etc. carried out complies with those instructions.

[a] See 5.2.

5.2 Audit stages

Table 1 relates the audit types to stages in the asset life cycle. It also defines the purpose of the audit at each stage and distinguishes between core and secondary audits. Core audits are the minimum audits that shall be carried out in order to comply with the auditing clauses (clauses 5 and 6) of this part of ISO 15686. Further "secondary" audits may be carried out at the discretion of the client and/or project team. In deciding the quantity and types of audit to be carried out on a given project, due regard shall be given to the project size and complexity and to the perceived level of risk in relation to service life performance.

NOTE The distinction between core and secondary audits defined above is not intended to be definitive or prescriptive, but merely to define the minimum level of auditing required to comply with this part of ISO 15686. For certain types of project with known high risks, it is likely that the list of core audit activities will be extended to include other audits. For example, with complex mechanical or electrical plant, the assessment of commissioning and handover activities is of key importance and is likely to form a core audit activity.

In practice the detailed design audit is generally more onerous than other audits, and is not likely to be fully effective unless preceded by pre-briefing and briefing audits. Similarly if no detailed design audit has been prepared, the completeness of audits of construction, commissioning, operation, refurbishment and disposal may be limited because relevant information from the design stage has not been made available. Therefore the following requirements apply:

— pre-briefing and briefing audits shall always precede detailed design audits (see 5.4.1 on the timing of audits);

— a detailed design audit shall be carried out whenever conformance with this part of ISO 5686 is required prior to construction;

— when construction, commissioning, operation and life care, refurbishment or disposal audits are carried out without a preceding detailed design audit, this shall be stated in the audit report.

5.3 Roles

5.3.1 Introduction to the parties

The audit process described in this part of ISO 15686 involves three principal parties: the client, the auditor and the auditee. The client could be the occupier, or could have a financial interest in the constructed asset (e.g. as owner, leaseholder, lender or insurer), and is responsible for initiating the audit. The auditor shall be an individual or organization that is independent of the specific project activities being audited, and is responsible for carrying out the audit activities and reporting the findings. The auditee is generally the designer but may also be the project manager, constructor or supplier, and is responsible for providing the auditor with the necessary project information and, in conjunction with the client, for addressing any nonconformities identified in the audit process.

NOTE In practice the audit can be carried out as a second- or third-party function. A second-party audit is carried out by a person from within the same organization or within the project team, but independent of the activity being audited. A third-party audit is carried out by a person or organization wholly independent of the activity being audited.

5.3.2 Client

The client's (or client's nominated project manager or agents) responsibilities and tasks are

— to determine the need for the audit,

— to contact the auditee to obtain its full cooperation and to initiate the process,

— to appoint the auditor and, if applicable, approve the composition of the audit team,

— to consult with the auditor and define the scope, extent and objectives of the audit, including which of the audit stages listed in Table 1 shall be carried out and which parts of the project shall be included or excluded from the audits,

— to identify the anticipated uses(s) to which the audit will be put, including any specific legal, insurance or other requirements,

— to provide appropriate authority and resources to enable the audit to be carried out,

— to approve the audit plan,

— to provide information on pre-briefing decisions and the design brief that are relevant to service life,

— to receive the audit reports and determine their distribution, and

— to determine/initiate the audit response (in conjunction with the auditee), including any corrective action arising from nonconformities raised.

5.3.3 Auditee

The responsibilities and tasks of the auditee are

— to inform employees about the objectives and scope of the audit as necessary,

— to provide access to the reference documents and other information required by the auditor in order to ensure an effective and efficient audit process,

— to cooperate with the auditor to permit the audit objectives to be achieved,

— to receive a copy of the audit report unless specifically excluded by the client,

— to respond to nonconformities, queries and comments in the audit report, if required to do so by the client.

5.3.4 Auditor

The auditor's responsibilities and tasks are

— to consult with the client and the auditee (if appropriate), in determining the criteria and scope of the audit,

— to obtain relevant information necessary to meet the objectives of the audit,

— to determine whether sufficient information has been provided by the client/auditee to enable the audit to proceed,

— to form the audit team and agree its composition with the client, giving consideration to potential conflicts of interest and any need for specialist input from outside organizations,

— to prepare the audit plan in consultation with the client and auditee, and to communicate the agreed plan to all parties,

— to carry out the audit in accordance with the agreed audit plan,

— to collect and analyse relevant and sufficient audit evidence to determine audit findings and reach audit conclusions,

— to document individual audit findings and the reasoning and steps taken in reaching those findings,

— to safeguard documents pertaining to the audit and return such documents as required,

— to notify the client and/or auditee without delay of audit findings of critical nonconformities,

— to pass on significant comments and observations relating to the information provided and the options for addressing any nonconformities,

— to report to the client on the audit clearly and conclusively within the time agreed in the audit plan, and

— where instructed by the client, to agree a programme for "closing out" all nonconformities and reviewing information/activities to check that nonconformities have been addressed.

Wherever two or more auditors are engaged in auditing a project, a lead auditor shall be nominated. The lead auditor shall be responsible for ensuring the efficient and effective conduct and completion of the audit within the audit scope and plan approved by the client.

NOTE A description of the specific duties of a lead auditor is provided in ISO 19011.

5.3.5 Defining responsibilities

Whilst most of the above tasks will be clearly identifiable as those of the client, auditee or auditor, responsibility for some tasks will be less clear and may vary according to the specific project and the parties involved. The client and the auditor shall be jointly responsible for ensuring that the specific roles are clearly defined and that all of the above tasks are assigned.

5.4 Auditor appointment

5.4.1 Timing

The auditor shall be appointed at or before the start of the asset life cycle stage(s) to be audited unless a later appointment is agreed with the client. Later appointments may be justified by

— the need to audit pre-briefing and briefing decisions before undertaking a detailed design audit, or

— the need to audit life care activities when a constructed asset has been in operation for some time.

5.4.2 Qualifications

Auditors (or audit teams) shall possess an appropriate combination of knowledge, skills and experience to carry out service life performance audits. The lead auditor and those involved in the audit function shall be suitably qualified and experienced professionals skilled in the major design and management disciplines included in the project. Auditors shall

— demonstrate familiarity with projects of a similar size, complexity and function(s) as the constructed asset (or parts) being audited,

— provide details of qualifications, expertise and experience of the individual audit team members, including experience of service life assessment and auditing principles,

— provide a declaration that there is no potential conflict of interest between audit team members and the auditee,

— meet specific requirements of clients, certification or accreditation bodies, or insurers (e.g. the need for professional qualifications or technical expertise in a particular discipline),

— be independent of the activities they audit and be able to assure the client of their independence and freedom from bias and conflict of interest throughout the auditing period, and

— arrange for the provision of additional input from external specialists where specific expertise is not available within the audit team. However, overall responsibility for the audit should remain with the appointed auditor and not the external specialist.

5.4.3 Resources

Auditors shall have ready access to any relevant published reference information, such as local building regulations, standards, codes of practice or other industry or client in-house guidance that is necessary to meet the objectives of the audit.

NOTE 1 In addition to general guidance on the design, construction, operation and life care of the constructed asset type in question, access can also be required to more specialist reference information, such as geological maps or climatic information on the location in question.

Auditors shall establish procedures for ensuring that published reference information used in the audit is kept updated, and for ensuring, where necessary, that information is current at the time of use.

Auditors shall take steps to preserve future access to any published reference information used in an audit, but which is subsequently superseded or becomes obsolete.

NOTE 2 Such information could be required at a later date to verify the criteria against which the project was audited, for example in the case of future disputes or deficiencies in the service life performance of the constructed asset.

The lead auditor shall ensure that the audit team has adequate time available to carry out the audit and prepare the audit report in accordance with the audit plan.

5.5 Audit quality control

5.5.1 Performance evaluation and consistency of auditors

The performance of individual auditors shall be monitored by the auditing organization, either through observation of audits or through other means. Such information shall be used to improve auditor selection and performance and to identify unsuitable performance.

Audit procedures shall be designed to arrive at similar conclusions when the same audit evidence is evaluated against the same audit criteria by different auditors. Audit quality control procedures shall be established to enable auditor performance to be measured and compared to achieve consistency among auditors. Such procedures may include the following (where relevant):

— auditor training workshops;

— auditor performance comparisons;

— supervision of audit activities and review of audit reports by experienced audit supervisors;

— performance appraisals;

— rotation of auditors between audit teams.

Revisions could be required to any existing quality control procedures (such as ISO 9000 quality systems) within the auditing organization, to account for the additional role of auditing service life performance.

5.5.2 Reliability of audit findings and conclusions

The auditing procedures (and any associated quality control procedures) shall be designed to provide the client and the auditee with the desired level of confidence in the reliability of the audit findings and any audit conclusions.

The evidence collected during the audit will inevitably be only a sample of that available, since the audit is conducted over a limited period of time and with limited resources. There is therefore an element of uncertainty inherent in all service life performance audits. This uncertainty shall be notified to users of the audit findings and shall be taken into account by auditors when planning and conducting the audit.

6 Implementing the audit

6.1 Audit plan

At the time of appointment, the lead auditor shall prepare an auditing plan in consultation with the client and the auditee. The plan shall include the following:

— the objectives and scope of the audit;

— identification of individuals and, where relevant, external organizations, with significant responsibilities regarding the objectives and scope;

— identification of essential reference documents;

— the proposed timing and duration of the agreed audit activities (including specific dates where appropriate);

— the key dates for provision of audit information;

— the required timing and frequency of audit reports;

— information relating to the future retention and legal status of the reference documents and other information used or generated during the course of the audit;

— the agreed schedule of meetings to be held with the client and/or auditee.

The auditing plan is required to reflect the programming of the design and construction activities and to allow for any necessary action to be taken in response to the audit findings. Such action may include

— the commissioning of tests to verify specific service life assumptions made by the auditee, or

— the implementation of design changes where the requirements of the service life brief have not been met.

Any changes made to the audit plan as the project proceeds shall be communicated by the auditor to the client and auditee.

NOTE The optimum timing of the specific audit stages will depend upon the nature of the project and the chosen procurement route. With large or complex projects, it can be necessary to audit and report on different work packages or parts of the constructed asset at different times to reflect the progress of the design and construction activities and the development of the operating and life care plans.

6.2 Documentation

The auditor shall be given access to all relevant documentation relating to the project brief and the auditees' responses thereto, together with any other documented evidence in support of service life performance claims made in the project documentation. Depending on the project stage being audited, these "reference documents" may include (but are not restricted to) the following:

— layout and detail drawings;

— surveys, including ground, climate and condition surveys;

— specifications and/or schedules of the work to be carried out;

— installation, commissioning, operating and/or life care instructions;

— life cycle cost plans;

— operating and maintenance records;

— instructions or proposals for refurbishment, adaptation, alteration, change of use, disposal, decommissioning, disassembly, recovery;

— any relevant information (such as manufacturer's literature, guarantees, warranties, third-party certification, or test data) in support of service life forecasts made in the project documentation;

— any relevant outputs from service life performance assessments or risk analysis exercises carried out by the project team [e.g. failure mode effect analyses (FMEA), fault tree analyses, stochastic models, reliability assessments];

— copies of any reports from previous service life performance audits or reviews, including any relevant supporting evidence.

Auditees' records of relevant design decisions and the reasons behind those decisions should also be kept available for auditors.

Further guidance on specific information required at each audit stage is provided in 6.6.1 to 6.6.9.

6.3 Changes to project information

The auditor shall be provided with all relevant new information or amendments to existing information produced during the course of the project. Appropriate steps shall be taken to ensure that the audit findings and conclusions are amended to reflect such information.

Where significant new information or amendments are issued after circulation of an audit report, it may be necessary to issue an addendum or a revised report. In some cases the required changes may be incorporated into audit reports for subsequent stages of the project

6.4 Audit records

The auditor shall maintain records of all reference documents and other information received from the client and/or auditee and used in arriving at the audit findings, including the date of receipt, and the date(s) and reference(s) of any revisions notified.

The auditor shall establish procedures for recording the steps taken in arriving at the audit findings (including issues considered and reference information consulted), and the reasoning and justification for the findings. This documented audit trail shall be retained for future inspection for a suitable period to be agreed with the client or determined by third-party quality assurance requirements.

Recording of the audit trail enables quality checks to be made of the audit process and audit activities to be revisited at a later date if the need arises. All reference and working documents used during the course of the audit shall be retained for a period to be agreed between the auditor and the client, and in any case until completion of all audit stages. The auditor shall identify and make provisions for any specific third-party requirements (e.g. quality assurance, legal or insurance) relating to the long-term retention of audit documentation. Those documents involving confidential or proprietary information shall be suitably safeguarded by the auditor.

6.5 Audit reports

On completion of an audit (or an audit stage) and where required by the client, the audit findings shall be communicated to the client in a written report. Unless specifically excluded by the client, the auditee shall also receive a copy of the report.

The audit report shall contain the audit findings or a summary thereof, with reference to the supporting evidence (subject to agreement between the auditor and the client).

The auditor shall identify and report as a nonconformity information that is

— incorrect,

— missing or incomplete,

— contradictory,

— impractical or ill defined,

— unsupported by reliable data, or

— still uncorrected, i.e. where a nonconformity identified in a previous audit remains uncorrected.

The audit report may include observations, supported by factual data, that are relevant to service life planning, for example: "Only two makes of boiler will meet the specified design life requirement."

The audit report shall also contain the following information:

— details of the project, the auditee and the client;

— the agreed terms of reference and scope (including parts specifically included/excluded from the audit), objectives and programme for the audit;

— a record of any targeting of the audit, for example to specific components or assemblies (see annex A);

— a list of reference documents provided by the client and/or auditee and used in arriving at the audit findings (including date of receipt, dates of amendments, supplemental information received);

— a list of published or other reference information (other than that provided by the client and/or auditee) used in the audit;

— the period of time covered by the audit (if relevant) and the date(s) the audit was conducted;

— the identity of the audit team members, including any external specialists;

— a statement of the confidential nature of the contents;

— the distribution list for the audit report;

— a summary of the audit process including any obstacles encountered;

— photographs and/or drawings of identified nonconformities (e.g. in installation or life care activities);

— a summary of the findings of any previous audit reports for the project and of any corrective action taken.

Standard proformas shall be used to record audit findings where appropriate (see annex C).

Guidance on specific reporting requirements for the various stages of the audit process is provided in 6.6.1 to 6.6.9.

NOTE It is not usually the responsibility of the auditor to determine any corrective action required in response to the audit findings, unless, by agreement between the auditor and the client, provision of recommendations or guidance relating to remedial measures is a part of the auditors' appointment. The reason for excluding advice on remedial measures is to avoid unintentional transfer of liability from the auditee to the auditor.

6.6 Executing audits at each stage

6.6.1 Pre-briefing audit

Status: The pre-briefing audit is a core element of the performance audit and shall precede the detailed design audit. If not undertaken before a site is selected, the pre-briefing audit may be carried out at the same time as the briefing audit.

Purpose: The pre-briefing audit is undertaken to record and examine decisions taken while the project is in gestation so that conflicting aims are brought to light and initial objectives are not lost sight of at later stages.

Inputs: The following information (as applicable) shall be collected, recorded and examined:

— information relevant to the long-term plans for the site(s);

— information on the need for constructed works and alternatives considered (e.g. option appraisals, proposals for adaptation/re-use of existing facilities);

— plans for construction, operation and management of the facility;

— plans for future refurbishment, adaptation and alteration of the facility;

— plans for disposal, deconstruction, and recovery management;

— plans for site reinstatement;

— previous relevant proposals and management decisions (e.g. feasibility studies, value management workshops, option appraisals);

— statements of limiting factors (e.g. availability of projected fuel, material or manpower resources; ground-bearing capacity of site, risk of flooding or earthquake).

Outputs: Observations of the auditor shall be discussed with the client (or client's nominated agent) and auditee (if appointed). Nonconformities shall be identified and reported. Examples of nonconformities are the following:

— contradiction between long-term and short-term aims, e.g. no opportunities for projected future expansion on a restricted site;

— business need for the project not verified, e.g. no investigation of availability of alternative facilities in existing premises; option appraisal not carried out;

— no plans for reuse of materials, components or site, e.g. reinstatement of site compromised by hard-to-remove structure and ground works;

— implications of future refurbishment, adaptation and alteration not properly considered, e.g. major plant to be built-in rather than movable; future alterations or changes of use restricted by structural configuration or loadbearing capacity;

— design life of the project undefined or poorly defined, e.g. "life to be as traditional masonry construction".

6.6.2 Briefing audit

Status: The briefing audit is a core element of the performance audit and shall precede the detailed design audit.

Purpose: The briefing audit is undertaken to ensure that the project brief provides an adequate basis for service life planning at the initial and detailed design stages. The client's stated and implied requirements for service life performance are examined to see whether they provide the briefing information needed by the designer.

Inputs: The following information (as applicable) shall be collected, recorded and examined:

— the report on the pre-briefing audit and records of discussion of auditor's observations at the pre-briefing stage;

— information in any formal brief that is relevant to the service life performance of the constructed asset, e.g. client design lives for components and assemblies that form part of the works (see Note 1 below);

— relevant information derived from discussions, statements, future plans, agreed proposals and model designs, e.g. availability and/or reliability of mechanical and electrical plant or systems; plans for future operation, life care, deconstruction and disposal of the works; location and accessibility of specific components and assemblies;

— information on safety and other issues related to the failure of components used in the works, e.g. need for special cleaning equipment for luminaires above a specific height; cost and/or environmental impact of future disposal;

— details of external and required internal environments, including anticipated temperature extremes, use of aggressive chemicals;

— the intended procurement method and time programme proposed;

— test data and reference service lives for specified components, assemblies or plant items that are a requirement of the brief;

— site details and survey information relevant to the service life of the constructed works.

Outputs: Observations of the auditor shall be discussed with the client and auditee. Nonconformities shall be identified and reported. Examples of nonconformities are as follows:

— incompatibility between anticipated use and life care, e.g. daily public use and weekly cleaning;

— inadequate or unreliable design data, e.g. “water table thought to be about 3 m below ground level”;

— lack of information on intensity of specific degradation agents, e.g. no information provided on the use of main spaces for specific sports activities;

— service life performance requirements that are not achievable within the project context, e.g. glazed claddings to be maintenance free;

— nonconformities reported in the pre-briefing audit that remain uncorrected, e.g. no consideration of reuse of materials and components.

NOTE 1 To avoid the need for unnecessarily bulky documentation, it will usually be possible to refer to the suggested minimum design life values in Table 1 of ISO 15686-1:2000 and only to depart from these values where warranted by special conditions. However, use of the table requires a prior decision to have been made as to the design life of the constructed works.

NOTE 2 It is common for the project brief to evolve over a period while requirements for the works are identified and considered in more and more detail. The briefing audit will need to be amended to keep pace with the development of the brief.

NOTE 3 The use of standard proforma for recording service life performance requirements in the project brief can be advantageous as a means of ensuring that all relevant issues have been included. An example of such a proforma, together with a proforma for recording the findings of the briefing audit, is provided in annex C (informative).

6.6.3 Initial design audit

Status: The initial design audit is a secondary audit that may be carried out during the early stages of design development to help reduce nonconformities in the detailed design.

Purpose: The purpose of the audit is to assess the service life implications of initial concept designs and to report on their adequacy in relation to the service life requirements of the project brief. Where more than one initial design has been prepared, auditing enables the service life implications of alternative designs to be compared. It may also help to clarify the project brief (see Note 2 in 6.6.2).

Inputs: The auditor shall examine the information describing the initial design (i.e. drawings, schedules, outline specifications), together with the information provided in the brief and the auditor’s reports on the briefing and pre-briefing stages.

Outputs: Observations of the auditor shall be discussed with the client and the auditee. Clarification of the brief may be required. Nonconformities with the brief shall be identified and reported. Examples of nonconformities are as follows:

— aspects of the design not conforming with the design life requirements of the brief, e.g. roof profile and coverings with a reference service life that is shorter than required when modified by relevant factors (see ISO 15686-1:2000, clause 9);

— lack of evidence in support of design decisions, e.g. use of projecting canvas blinds proposed but site exposure unknown;

— missing or incomplete information that could seriously affect service life, e.g. no information on access for maintenance of high level cladding;

— unsuitable or impractical design, e.g. undrained grass area proposed for regular overflow parking;

— continuing nonconformity of items reported on at the pre-briefing or briefing stages, e.g. future reinstatement of site compromized by hard-to-remove structure and ground works.

To avoid unnecessary paperwork, the initial design audit should be targeted to those items that have a major effect on service life and to aspects of design that differ between alternative initial designs (see annex A). The auditee may find observations by the auditor helpful when developing the detailed design.

6.6.4 Detailed design audit

Status: The detailed design audit is a core element of the performance audit and shall be undertaken whenever conformity with the auditing clauses (clauses 5 and 6) of this part of ISO 15686 is required. The detailed design audit shall be preceded by pre-briefing and briefing audits.

Purpose: The aim of this audit is to ensure the detailed design

— conforms with the relevant service life performance requirements of the project brief,

— addresses nonconformities identified in the pre-briefing, briefing and initial design audits, and

— provides adequate information on installation and commissioning for those involved in the construction process.

Inputs: The auditor shall examine the information describing the detailed design (i.e. drawings, calculations, schedules, specifications, safety requirements, instructions for commissioning, operation and life care of the works, other evidence relevant to the assessment of service lives such as test results, performance assessments and certificates, manufacturer's records), together with the information provided in the brief and the auditor's reports on the briefing, pre-briefing and initial design stages.

Outputs: Observations of the auditor shall be discussed with the client and auditee. Clarification of the information provided may be required. Nonconformities with the brief and with previous audit reports shall be identified and reported, together with reference to relevant supporting evidence (such as good practice guidance, test data, performance assessments and certificates). Examples of nonconformities are as follows:

— failure to meet the service life performance requirements stated in the project brief, e.g. components, materials or assemblies with an estimated service life of less than the design life, or with maintenance requirements in excess of those specified;

— incompatibilities in the service lives of related components, e.g. roof tiles secured with fixings of a lesser service life; inaccessible sealants of a lesser service life than the claddings behind which they are installed;

— information that is contradictory or inadequate, e.g. mismatch between stated exposure conditions and selected design options or component specifications;

— design details or specifications that are impractical or unrealistic, e.g. fixing tolerances that are unlikely to be achievable, workmanship standards that conflict with available skills level;

— information that is missing or incomplete, e.g. important weathering detail or fixing specification not provided;

— assumptions that are unsubstantiated by reliable data, e.g. unsubstantiated manufacturer's sales statement accepted as evidence of reference service life;

— continuing nonconformity of items reported in previous audits, e.g. no information on access for maintenance of high level cladding.

To avoid unnecessary paperwork, the detailed design audit should be targeted to those items that have a major effect on service life performance (see annex A).

NOTE Further guidance on carrying out detailed design audits, including checklists of issues to be considered, is provided in informative annexes A and C. Guidance on specific audit issues relating to civil engineering works and mechanical and electrical plant is provided in annex A.

6.6.5 Construction audit

Status: The construction audit is a secondary element of the performance audit that may be carried out after the pre-briefing, briefing and detailed design audits.

Purpose: The purpose of this audit is to ensure that the service life performance required by the brief and the information in the detailed design relevant to the service life are not compromised by work on site or by materials and components delivered to the site.

Inputs: The auditor shall examine information relating to the implementation of the works, such as site inspection reports, delivery notes, test reports on materials, information on changes to specifications and drawings, weather reports during construction, information on site quality control procedures, information on inspections by independent bodies. Where required by the client, the auditor may also carry out checks on specific areas of construction.

Outputs: Observations of the auditor shall be discussed with the client and auditees; there will be more than one auditee if the constructor is involved in deficiencies of workmanship and designers have approved specification changes. Nonconformities with provisions of the detailed design relevant to the service life and with previous audit reports shall be identified and reported. Examples of nonconformities are as follows:

— design or specification changes made on site, e.g. substitution of alternative components, materials or suppliers for which service life test data is not available;

— unreliable control of materials, e.g. haphazard batching of materials for site-mixed mortar;

— failure to achieve the specified standards of workmanship, e.g. surfaces inadequately prepared prior to painting;

— inappropriate site alterations to components or assemblies, e.g. alterations to timber roof trusses;

— lack of relevant quality control records, e.g. no daily record of temperatures on site during critical operations such as sealant application, lack of concrete test records;

— inadequate storage or protection of materials on or off site;

— installation of damaged or defective components or materials;

— failure to install components or materials in accordance with manufacturer’s instructions or good industry practice;

— continuing nonconformity of items reported in previous audits, e.g. no revision of incorrect design or detailing issues identified in detailed design audit.

NOTE The use of standard checklists of issues to be included in the construction stage audit is encouraged. A sample checklist is provided, by way of example, in C.4.

6.6.6 Commissioning and handover audit

Status: The commissioning and handover audit is a secondary audit that may be carried out following construction to help ensure the satisfactory operation and service life performance of the completed works.

Purpose: The purpose of this audit is to ensure that the service life performance required by the project brief is not compromised by the commissioning and handover procedures, and to ensure that adequate instructions are provided for those responsible for the future operation and life care of the completed works.

Inputs: The auditor shall examine the information provided on commissioning, handover and life care in the initial brief and detailed design, together with handover records, inspectors' reports, management log sheets, final clearance certificates, operating and life care instructions and building handbooks or manuals. Where required by the client, the auditor may also carry out spot checks to ensure that commissioning activities are being properly implemented.

Outputs: Observations of the auditor shall be discussed with the client/asset manager and auditees. Non-conformities with the project brief, detailed design and with previous audit reports shall be identified and reported. Examples of nonconformities are as follows:

— inspection or test records missing, incomplete or inadequate, e.g. fuel consumption during run-in period not recorded;

— manufacturer's commissioning instructions not followed, e.g. heating system inadequately flushed out prior to use;

— operating and/or life care instructions missing, incomplete or inadequate, e.g. no instructions provided for extending and retracting bleacher seating, maintenance requirements for patent glazing not specified, excessive maintenance intervals specified for external timber components;

— impractical operating or life care instructions, e.g. inadequate space for servicing of heating plant, no provision for access to high level cladding;

— continuing nonconformity of items identified in previous audits, e.g. test data still not available for resin floor finish.

NOTE Further guidance on the assessment of operating and life care instructions is provided in A.4.

6.6.7 Operation and life care audit

Status*:* The operation and life care audit is a secondary audit that may be undertaken during the operational life of the constructed asset to help safeguard the service life performance.

Purpose*:* The purpose of this audit is to ensure that the operation and life care activities are being carried out in accordance with the brief, detailed design and commissioning and handover instructions, and that such activites are appropriate with regard to the service life performance (or agreed performance levels) of the constructed asset.

Inputs: The auditor shall examine information provided on operation and life care in the initial brief, detailed design and commissioning and handover instructions, together with activity timetables, attendance records, condition survey reports, maintenance instructions, schedules and records. The auditor may also carry out checks on maintenance and cleaning procedures where required by the client.

Outputs: Observations of the auditor shall be discussed with the client and asset manager (in this case the auditee). Nonconformities with the operating and life care plans/handbook or with the requirements of the project brief shall be identified and reported. Examples of nonconformities are as follows:

— failure to properly implement operating and/or life care instructions, e.g. specified cleaning intervals and methods not adhered to; plant not operated in accordance with manufacturer's instructions;

— specified life care regime inadequate or inappropriate, e.g. maintenance intervals inappropriate (see note below);

— specified life care regime infeasible, e.g. no provision for maintenance access to inaccessible components; inability to replace components incorporated within the construction;

— lack of evidence of life care activities, e.g. missing or incomplete inspection or testing records, log books, attendance records and reports;

— continuing nonconformity of items identified in previous audits, e.g. maintenance intervals still inadequate, life care instructions still not provided.

NOTE In some cases the original life care requirements defined at the briefing, detailed design, commissioning or handover stages of a project can require amendment to account for changes in the type or intensity of use of the facility, or to reflect the actual patterns of degradation observed. For example, it can be necessary to increase (or decrease) maintenance intervals, specify alternative protective measures, or to substitute certain components or assemblies with those more suited to the actual in-service conditions.

6.6.8 Refurbishment/adaptation/alteration/change of use audits

Status: Refurbishment/adaptation/alteration/change of use audits are secondary audits that may be carried out during the life of the constructed asset.

Purpose*:* The purpose of these audits is to ensure that refurbishment, adaptation, alteration or change of use activities carried out during the life of the constructed asset are not detrimental to the service life performance of components and assemblies, or of the asset as a whole.

The audit described here relates to limited refurbishment, adaptation, alteration or change of use. works only. Where significant alteration or a complete refurbishment is proposed, the full performance auditing procedures described in this clause should be implemented, including appraisal of the service life of parts to be retained.

Inputs: The auditor shall examine information provided on future refurbishment, adaptation, alteration or change of use in the initial project brief and detailed design, together with condition survey reports, the brief, detailed design and specifications for the proposed works, details of components to be demolished or removed, manufacturers' information and test results for materials and components to be used in the works.

Outputs: Observations of the auditor shall be discussed with the client, funder, designer and/or asset manager. Nonconformities with the original project brief (updated as necessary to reflect current needs) and with information provided with the detailed design shall be identified and reported. The audit is undertaken when detailed plans for the proposed works have been prepared but before the start of the work. Examples of nonconformities are as follows:

— incompatibility between the service lives of new and existing components or assemblies, e.g. long-life cladding attached to short-life structure;

— inappropriate specification or detailing of new components and materials, e.g. inadequate protection of existing components, use of components or materials that are detrimental to the service life performance of existing components and materials (such as those due to bimetallic corrosion);

— inappropriate change of use, or change of use that may impact on the service life performance of components and materials, e.g. accelerated deterioration of floor finishes due to increased foot traffic or loadings;

— failure to conform to service life performance requirements of the original brief (as updated and/or amended by the refurbishment brief), e.g. specification of short-life components or components requiring excessive maintenance;

— impractical or ill-defined alterations, e.g. periodic replacement of existing components compromised by alterations (such as insufficient space to replace escalator once partition and ceiling layouts are altered);

— continuing nonconformity of items identified in previous audits, e.g. failure to address accessibility problems to high level cladding.

6.6.9 Disposal/decommissioning/deconstruction/recovery/site reinstatement audits

Status: Disposal/decommissioning/deconstruction/recovery/site reinstatement audits are secondary audits that may be carried out at the end of the asset life cycle.

Purpose: The purpose of this audit is to ensure that the means for disposal, decommissioning, deconstruction, material recovery and/or site reinstatement envisaged in the original project brief and detailed design (as updated during the life of the constructed asset) are considered when these activities are undertaken. The audit shall verify that a plan for these activities has been produced and that the work carried out meets the plan in terms of material recovery and site reinstatement. The audit shall also verify that information on features remaining on the site has been provided for the benefit of subsequent users of the land.

The audit is undertaken when detailed plans for disposal, etc., have been prepared before the start of the work. The audit may be extended to include a second report on the implementation of the disposal, etc., plans.

Inputs: The auditor shall examine information provided on future disposal, etc., in the original project brief and detailed design (as updated during the life of the constructed asset), together with the proposals for deconstruction, disposal of recoverable material and waste, inventories of recoverable materials, plant and equipment, details of site contamination including foundations, underground services and storage tanks.

Outputs: Observations of the audit team shall be discussed with the client and asset manager (in this case the auditee). Nonconformities with the disposal, etc., requirements of the original project brief and information provided with the detailed design shall be identified and reported. Where required, a second audit report should identify non-conformities in the implementation of the disposal, etc., plans. Examples of nonconformities are as follows:

— failure to adhere to disposal, etc., requirements of the project brief, e.g. quantity of material to be recovered for re-use, methods of deconstruction or disposal, procedures for site reinstatement;

— missing or incomplete information on disposal, etc., e.g. no details of how specific components or materials to be recovered, no provision for making safe underground services;

— instructions that are impractical or ill-defined, e.g. inadequate access for necessary plant, inability to remove large items of mechanical plant;

— failure to obtain or confirm necessary permissions, e.g. waste burning on site may not be allowed;

— failure to conform to disposal, etc., instructions, e.g. reduction in quantity of recovered material due to changes in method of deconstruction.

7 Service life performance reviews

7.1 Internal review procedures

The audit principles and procedures set out in clauses 5 and 6 are directed towards formal audits carried out by organizations or individuals which are independent from the project activites being audited. However, much of the guidance is equally applicable to less formal service life performance reviews carried out alongside existing internal project and design management procedures. Internal review procedures may include design reviews (e.g. as part of ISO 9000 quality control procedures), value management exercises, checks for compliance with health and safety, local building codes and other legislation, and monitoring or inspection of installation works. Internal reviews may be undertaken at the request of the project client, as a requirement of formal quality control procedures, or to satisfy the project team that adequate regard has been paid to service life performance issues.

NOTE ISO 9004 provides detailed guidance on the implementation of structured in-house design reviews at the conclusion of each phase of design development.

The choice between formal independent audits and internal performance reviews will depend upon a number of factors, including the particular requirements of the client, requirements of third parties such as funders or insurers, and the resources available. A summary of the main advantages and disadvantages of internal reviews is provided in informative annex B. A third option of internal reviews followed by external audits may also be adopted, whereby the documented outcomes of the review process form the inputs into the audit process. In this case the review becomes the primary means of ensuring effective service life planning and the audit function is limited to that of verifying the outcomes of the review.

7.2 Planning the review

A service life performance review can only be effective if

— the review is undertaken by a suitably qualified reviewer, and

— the relevant information and/or site access is made available to the reviewer.

Reviewers or review teams shall therefore include at least one member with several years' experience of design (or of other relevant activities such as operation and maintenance, depending on the project stage under review) of projects of a similar type, size and complexity to that being reviewed. Reviews shall only be carried out when relevant information and/or site access is available.

7.3 Implementing the review

The review stages shall be planned to mirror the audit stages set out in Table 1 and clause 6. The purpose of each review is the same as for the audit at that stage of a project. As with performance audits, the pre-briefing, briefing and detailed design reviews are core review functions and shall be undertaken whenever compliance with the review clause 7 is required prior to construction.

Whereas performance audits are concerned only with identifying nonconformities with the clients' service life performance requirements, the scope of reviews shall also include the identification and initiation of corrective actions to ensure that those requirements are met.

A checklist of items to be considered as part of a design review is provided in for information in annex B.

7.4 Recording the review

The reviewer or review team shall take appropriate steps to formally record the review process and findings in order

— to form the basis for action to correct nonconformities and answer outstanding queries,

— to provide a documented trail for future inspection and verification, and (where appropriate)

— to provide the formal inputs, or reference documents, for subsequent service life performance audits.

Records of the review process and findings shall be maintained for an appropriate period of time to be agreed with the client or determined by legal, insurance or third-party quality assurance requirements. Further guidance on the need for and control of quality records is provided in ISO 9004.

Internal reviews may focus simultaneously on a wide range of functional and/or performance based requirements (e.g. structural, fire, acoustic, environmental, safety, energy consumption, accessibility and buildability requirements). However, to conform with this part of ISO 15686, observations and nonconformities that apply specifically to service life performance shall be clearly identified in a separate statement.

The statement shall include the following information:

— the date and circumstances of the review;

— details of the project;

— identification of the reviewer/review team;

— the review criteria, scope and objectives, including relevant client requirements for conformity with this part of ISO 15686;

— a list (including issue numbers and dates) of the reference documents provided for review, including identification of drawings, surveys, calculations, specifications and other data;

— a summary of the findings of any previous reviews for the project and of any corrective action taken;

— the review findings, including the reasoning and steps taken to reach those findings;

— corrective action recommended as a result of the review;

— the distribution list for the review statement.

Annex A
(informative)

Audit guidance

A.1 Audit targeting

A.1.1 Introduction

A fully comprehensive audit of service life performance is rarely likely to be justified because of the expense and time required to carry it out. A comprehensive audit would have to examine the evidence on service life performance for every system or component in a building or constructed asset, even for minor components used in only one or two places and for components that are known to be exceptionally long lasting. By careful targeting of the detailed design and implementation audits on critical and sensitive items (that is, on those components, assemblies and systems where deterioration presents the greatest threats to the service life performance of the asset), it should be possible to ensure that the design conforms broadly with the design life brief and that major problems caused by deterioration are avoided.

The key to audit targeting is the selection of components, assemblies and systems which are most likely to suffer significant deterioration. How this is assessed will depend on the specific circumstances of the case. One method, covering each element of the constructed asset in turn, is briefly described below. However, it may be more relevant to select components that are subject to specific environmental conditions or whose failure would have disastrous consequences. Selection may be based on more than one of the following:

— items that could cause major problems, for example process shutdown, security, health and safety or environmental hazard, or high-cost repair;

— permanent items intended to have a service life in excess of the constructed asset's design life (or the period to first refurbishment);

— items exposed to specific hazards on a particular site, for example where a standard garage canopy is to be built in an exposed marine environment;

— untried items, for example a new formulation for a protective coating;

— the need to limit maintenance and repair to the resources (finance or manpower) available;

— experience of the deterioration of similar constructed assets in similar circumstances, for example from examination of feedback and cost in use records.

Table 2 of ISO 15686-1:2000 sets out a hierarchy of failure consequences (e.g. danger to life, interruption of asset use) that may be useful in selecting components for audit.

Whatever the selection approach adopted, it is essential that the auditor considers the constructed asset as a whole and pays particular attention to site and use conditions and to any unusual or innovative features.

A.1.2 Risk assessment

Risk management involves identification, analysis and response. Both the identification and analysis of risks (i.e. potential causes or types of failure) are relevant to the selection of components for audit. The example below is intended to illustrate how identification and analysis of risks can help in the selection of components, assemblies and systems for which performance over time is critical. Other forms of identification and analysis may be equally helpful or better suited to specific circumstances.

Table A.1 shows as an example the hazards identified for individual components in six building elements. The hazards may be identified from the auditor's, designer's or client's experience, from published material or from feedback data from buildings in use.

NOTE In the context of this annex, the term "hazard" relates only to an adverse or undesired event. It does not relate to the probability or consequences of that event.

Table A.1 — Hazard identification

Element	Component	Hazard reference	Hazard description
External wall	Facing bricks	a	Deterioration of appearance
		b	Water penetration
	Stone cladding	a	Fracture and detachment
Pitched roof	Insulation	a	Reduced thermal insulation
Internal subdivision	Door ironmongery	a	Failure in normal use
		b	Failure to provide security
		c	Failure to provide fire safety
Heating installations	Radiators	a	Leaks
Drainage	Soil pipes	a	Leaks
		b	Blockages
Lift installation	Access doors	a	Failure of operating gear

Risk analysis criteria can be applied to target the audit on specific hazards. The analysis will identify hazards that have the greatest influence on the service life performance of the constructed asset. The four relevant criteria are the following:

— incidence (how likely is the occurrence of a specific hazard?);

— extent (how widespread could the potential hazards be?);

— consequences (what would the effects be?);

— costs (how expensive would failures be to rectify?).

Using the auditor's experience and feedback from repair and maintenance records a rating (high, medium or low) is allocated to each criterion as it applies to a specific item. Comparison of the combined ratings enables critical items to be identified, on which to focus the audit. Table A.2 illustrates this method and how it relates to a decision whether or not to select a component for auditing.

Table A.2 — Risk analysis

Element	Component (hazard reference from Table A.1)	Incidence [a]	Extent [a]	Consequences [a]	Cost [a]	Audit
External wall	Facing bricks: a	M	H	H	H	Yes
	b	L	M	H	M	
	Stone cladding: a	L	H	H	H	Yes
Pitched roof	Insulation: a	L	M	L	L	No
Internal subdivision	Door ironmongery: a	M	H	L	L	Yes
	b	L	M	H	L	
	c	L	M	H	L	
Heating installation	Radiators: a	M	M	H	L	No
Drainage	Soil pipes: a	L	L	H	L	No
	b	M	L	L	L	
Lift installation	Access doors: a	L	M	H	L	No

[a] H = high; M = medium; L = low.

A.2 Assessment of service lives

As part of the initial design and detailed design audits, the auditor should assess the service lives of selected components, assemblies and systems in order to establish whether the design satisfies the design life requirements set out in the project brief.

ISO 15686-1 provides detailed guidance on issues affecting component longevity and describes two approaches to forecasting the service lives of specific components, assemblies and systems. The first approach is based on test data and the second is based on the factoring of a reference service life to account for specific conditions of use. A systematic framework for performance testing is provided in ISO 15686-2.

Where practicable, a service life assessment based on the appropriate, complete test data assembled in accordance with the methodology described in ISO 15686-2 and summarized in ISO 15686-1 should be used in preference to a forecast based on the less accurate factor method. However, in practice, comprehensive test data that fully matches the anticipated conditions of use is often not available and time and/or cost constraints often prohibit its collection. Consequently, the use of the factor method or some other structured means of assessing service lives is likely to be necessary.

Whatever method of service life forecasting is used, the auditor should ensure that full account is taken of the project specific issues (such as the location, exposure and intended operational use of the constructed asset) identified in the project brief. An assessment should be made of all relevant agents of degradation (mechanical, electromagnetic, thermal, chemical and biological) to which the selected components, assemblies or systems will be exposed, and of the possible degradation mechanisms that those agents might initiate. ISO 6241 and ISO 15686-1 provide further guidance on agents and mechanisms of degradation.

In evaluating the service lives of specific components, assemblies and systems, the auditor should consider any relevant evidence provided by the auditee or readily obtainable by the auditor, such as:

— data provided by a manufacturer, a test house or an assessment regime (for innovative products or materials, this will normally be based on the manufacturer's or supplier's exposure results); this may be a single figure or a distribution of typical performance;

— previous experience or observations of similar construction or materials in similar conditions;

— service life performance assessments made by members of the European Union of Agrement and the World Federation of Technical Assessment Organisations in their technical assessments;

— publications that include schedules of typical service lives;

— local building codes or standards that in certain cases may give a typical service life for components, assemblies and systems.

In certain cases, where specifically required by the client, the auditor may commission or undertake additional tests on specific components, assemblies or systems to verify the forecast service life performance.

A.3 Assessment of installation instructions

As part of the detailed design audit, the auditor is required to assess the adequacy of the installation instructions to ensure that the constructed asset as constructed conforms with the service life performance requirements set out in the project brief. The auditor should focus on those aspects of the detailing and construction activities that are most likely to influence the service life performance of the constructed asset and its constituent parts.

Specific detailing issues that should be considered as part of a detailed design audit include the following:

— interfaces and abutments between components, e.g. wall-roof junctions;

— coordination and interaction of building services, structure and other components, assemblies and systems;

— joints and jointing, including, where relevant, the provision of expansion joints;

— fixings and support, including number and type of fixings, support centres;

— protective measures/features, e.g. cathodic protection, overload circuits;

— layout and adequacy of space, e.g. provision of access for plant maintenance;

— incompatibilities and the need for isolation of incompatible materials, e.g. bimetallic corrosion between dissimilar metals, acidic rainwater run-off from certain materials;

— any other known problem areas (i.e. relating to specific construction types, materials or components) which might affect the ability of the constructed asset or its component parts to achieve the requirements of the design life brief.

Those aspects of the detailing that provide a positive contribution to service life performance should be noted in addition to those that may detract from performance.

Since the design responsibility for different elements or components is often split between different designers/specialists, particular attention should be paid to interfaces and interactions between different elements and components.

Specific construction issues that should be considered as part of the detailed design audit include the following:

— storage, protection and handling of materials on and off site;

— any special requirements for temporary protection during or following installation, e.g. protection of cementitious products during the curing period;

— conditioning requirements for moisture- or temperature-sensitive components, such as timber-based boards;

— minimum curing periods for cementitious materials;

— any special conditions of temperature or humidity to be maintained for the proper application or installation of a product or component;

— reference to manufacturers' instructions and/or approved installer schemes (where relevant);

— requirements relating to alterations (dimensional, structural, etc.) made to components or materials on site, e.g. whether alterations are permitted, the need for additional protective measures following site alterations;

— instructions for any site batching or mixing/preparation;

— any other known problem areas (i.e. relating to specific construction types, materials or components) which might affect the ability of the constructed asset or its constituent parts to achieve the requirements of the design life brief.

When auditing the installation instructions, the auditor should refer to any relevant information provided by the auditee or readily obtainable by the auditor, such as:

— instructions or guidance provided by a manufacturer or a supplier;

— requirements of any relevant guarantees, warranties or registered installer schemes;

— installation information provided in local standards, codes or other good practice guidance;

— previous experience or observations of similar construction or materials in similar conditions;

— members of the European Union of Agreement and the World Federation of Technical Assessment Organisations may provide guidance on installation in their technical assessments.

Any nonconformities should be listed in the audit report, along with any relevant supporting evidence (such as specific references to the above information sources).

A.4 Assessment of operating and life care instructions

As part of the commissioning and handover audit, the auditor is required to assess the adequacy of the operating and life care instructions for the completed facility.

In some cases, a broad assessment of operating and life care requirements for the constructed asset based on historical evidence for assets of a similar type may be sufficient for the purpose of the audit. However, in most cases it will be necessary for the auditor to assess the operating and life care requirements of specific components, assemblies and systems in order to determine whether the instructions provided by the project team are adequate. In doing so, the auditor should consider any relevant information provided by the auditee or readily obtainable by the auditor, such as:

— instructions or guidance on operating and life care regimes provided by a manufacturer, a supplier or a test house;

— minimum operating and life care requirements specified by any relevant guarantees or warranties;

— operating and life care information provided in local standards or codes;

— previous experience or observations of similar construction or materials in similar conditions;

— guidance on operating and life care requirements provided by members of the European Union of Agreement and the World Federation of Technical Assessment Organisations in their technical assessments;

— books which are available that include typical life care intervals.

A.5 Life cycle costs and environmental impact

In addition to the issues discussed above, the project brief may also include requirements for life cycle costs, or sustainability and environmental impact, that are related to service life performance, and that fall within the scope of an audit. Specific issues that may require auditing include the following:

— service life, maintenance and cost assumptions within life cycle cost models;

— life cycle assessments of the constructed asset and/or specific components, assemblies and systems;

— definition and assessment of waste streams, recycling and recovery capacity;

— assessment of embodied energy, carbon dioxide, environmental labelling of components.

Further guidance on life cycle costing and life cycle assessment will be provided in ISO 15686-5 and ISO 15686-6, respectively. ISO 14010, ISO 14011 and ISO 14012 provide detailed guidance on environmental auditing. Life cycle assessment is covered in detail in ISO 14040.

A.6 Auditing civil engineering works

It is important that auditing procedures for civil engineering works recognize the significant differences between these and other forms of constructed works. Key differences that should be accounted for in the audit typically include the following:

— the large-scale nature of many civil engineering projects;

— the different construction methods employed, e.g. use of high-strength pretensioned concrete, cantilevered bridge construction;

— the different design approaches used, e.g. limit state design, greater use of probabilistic modelling, simulation and prediction of degradation rates and mechanisms;

— greater use of prototypes, trial constructions and computer models to test proposed construction;

— the need to incorporate safety factors and spare capacity, e.g. to allow for future increased loadings;

— the often catastrophic effects of failure, e.g. loss of life, national economic consequences;

— onerous design life requirements, e.g. typically 120 years or more for major infrastructure works;

— onerous life-care requirements, e.g. maintenance at 5-year cycles only, no access from underside of bridge.

A.7 Auditing mechanical and electrical plant

Specific issues relating to mechanical and electrical plant and systems that should be taken into account in the audit include the following:

— the complexity and interdependence of many plant items and systems;

— the importance of protective measures within systems, such as thermal cut-out circuits, chemical dosing of water, and cathodic protection of corrosive metals;

— the need to assess the subcomponents and subsystems within complex items of the plant, and the determinants of long-term performance;

— the influence of operation and use on service life performance, e.g. hours of use, number of starts/stops, extent of operating periods;

— the importance of correct specification, and suitability for the intended application;

— the importance of adequate commissioning and adjustment of plant prior to use;

— the significance of timely and appropriate maintenance, including the use of condition-based maintenance and remote performance monitoring;

— the expression of service life performance requirements in terms of design life, mean time to failure, availability and/or reliability criteria (e.g. minimum periods of uninterrupted use), minimum acceptable levels of performance;

— the common use of techniques such as failure mode effect analysis and fault tree analysis to assess failure modes and risks;

— the dynamic nature of many plant items and the significance of lubrication, wear and metallurgy;

— the effect of variations in operating temperature and conditions, e.g. failure due to overheating of pumps and motors;

— the ability of the plant or system to accommodate changing requirements over time, e.g. regulatory, user-defined (output, frequency of use, energy consumption, etc.).

Annex B
(informative)

Review guidance

B.1 Advantages and disadvantages of service life performance reviews

Reviews that are integrated with other internal project review procedures may be undertaken at the request of the project client, or to satisfy the project team that adequate regard has been paid to service life performance issues.

Advantages of service life reviews being carried out as part of project review procedures can include the following:

— familiarity with the project details, constraints, special features, and with local climate, construction methods and materials;

— detailed understanding of the reasons behind key decisions;

— detailed understanding of client requirements;

— ease of access to project information and documentation;

— ability to directly address audit queries and findings quickly in order to minimize delays in the project;

— potential to integrate audit procedures with other project review procedures such as designers' quality management system checks.

NOTE There will inevitably be some areas of overlap between designers' internal quality assurance checks and service life performance review activities. It can be beneficial to coordinate the two review activities in order to avoid duplication of effort.

Disadvantages of service life reviews carried out as part of project review procedures can include the following:

— a risk of over-familiarity with the project, leading to failure to identify deficiencies or shortcomings;

— a reluctance to question key assumptions or decisions due to personal involvement in such decisions;

— a risk of impaired objectivity, e.g. due to team loyalties, reluctance to criticize peers;

— inferior knowledge and experience of service life performance auditing compared with that of external specialists;

— inferior auditing resources and access to auditing information compared with that of external specialists;

— a reluctance to sacrifice conflicting performance targets, e.g. security, aesthetic aspects.

B.2 Checklist of items to be considered as part of a design review

The following checklist gives items that should (where appropriate to the design phase and project) be included in an internal design review. Note that some items may not be directly relevant to service life performance and may fall outside the scope of a particular performance review.

a) Items pertaining to customer needs and satisfaction:

1) comparison of customer needs expressed in the product specification with technical specifications for materials, products and processes;

2) validation of the design through prototype tests;

3) ability to perform under expected conditions of use and environment;

4) unintended uses and misuses;

5) safety and environmental compatibility;

6) compliance with regulatory requirements, national and International Standards, and organizational practices;

7) comparison with competitive designs;

8) comparison with similar designs, especially analysis of the history of internal and external problems to avoid repeating problems.

b) Items pertaining to product specification:

1) dependability and serviceability requirements;

2) permissible tolerances and comparison with process capabilities;

3) product acceptance criteria;

4) instability, ease of assembly, storage needs, shelf-life and disposability;

5) benign failure and fail-safe characteristics;

6) aesthetic specifications and acceptance criteria;

7) failure mode and effect analysis, and fault tree analysis;

8) ability to diagnose and correct problems;

9) labelling, warnings, identification, traceability requirements and user instructions;

10) review and use of standard parts.

c) Items pertaining to process specification:

1) ability to produce product conforming to the design, including special process needs, mechanization, automation, assembly and installation of components;

2) capability to inspect and test the design, including special inspection and test requirements;

3) specification of materials, components and sub-assemblies, including approved suppliers and subcontractors, as well as availability;

4) packaging, handling, storage and shelf-life requirements, especially safety factors relating to incoming and outgoing items.

Annex C
(informative)

Checklists and proformas

C.1 Statement of service life requirements in the project brief

Table C.1 provides examples of service life performance requirements that may be included in the project brief for a domestic dwelling and a school in Western Europe. Reference should be made to 6.6.2, which also lists the information that should accompany the brief. It should be noted that the examples are intended only to illustrate the general approach. Specific service life requirements should be defined for each individual project.

Table C.1 — Sample statements of service life performance requirements

Issue	Information/requirements	
	Dwelling	**School**
Description/usage of building		
Description and intended use of building	Development of two and three bedroom dwellings for leasing.	School for 1 000 children aged 10 to 16 years. Accommodation to include teaching accommodation, staff offices, dining hall and kitchens, gymnasium, indoor swimming pool.
Anticipated patterns of use	Continual use apart from short periods of vacancy between tenancies.	Teaching use from 09:00 to 16:30 hours. Evening and weekend use for community activities. Infrequent use during school holidays.
Site and building environment		
Site issues (e.g. ground conditions, previous use(s) of site)	Shrinkable clay soil. Some ground contamination from previous industrial use (see site investigation/soil report).	Former playing field/parking area. See site investigation/soil report.
External local environment/ exposure	Sheltered suburban location in south of England.	Exposed coastal location (rural) in north of England.
Internal environment	Occupation by the elderly, therefore high level of heating.	Humid and corrosive environment in swimming pool enclosure. High occupancy live loads.
Client design lives		
Design life of building	100 years	60 years
Inaccessible and difficult to replace components – generally	100 years	60 years
Major replaceable components – generally	30 years	30 years
Service installations and external works – generally	30 years	20 years
Specific components	Central heating boiler: 15 years Hot water cylinder and pipework: 60 years Roof covering: 60 years	Floor coverings: 15 years Boiler plant: 25 years Kitchen fittings: 20 years
Reliability/availability requirements	Heating breakdowns and down time to be minimized.	No heating plant breakdowns/downtime during teaching hours. No teaching room to be unavailable for more than two days per school term.

Table C.1 (*continued*)

Issue	Information/requirements	
	Dwelling	**School**
Client life care/maintenance requirements		
Maintenance requirements – generally (e.g. anticipated maintenance/replacement regimes, timing of works)	External cyclical maintenance (e.g. repainting): 6 years. Other external planned maintenance works to coincide with repainting cycles (where possible).	Low maintenance required generally. Internal redecoration: 5 years. Maintenance/replacement regimes in accordance with planned preventive life care/maintenance schedule. Maintenance work to be limited to evenings, weekends and school holidays.
Specific components	Annual servicing/maintenance of central heating equipment. Internal doors to be self finished/ maintenance free.	Condition monitoring of heating plant. Low maintenance claddings, doors and windows. Impact- and graffiti-resistant internal wall finishes and doors.
Anticipated future refurbishment/extension/ change of use/disposal	Kitchen and bathroom refurbishment at 30-year intervals.	Internal refurbishment at years 20 and 40. Anticipated demolition and rebuilding at year 60.
Specific accessibility requirements	Windows to be cleanable from inside the dwelling. All external elements requiring maintenance to be accessible by ladder or from inside the dwelling.	Provision for future removal/replacement of heating plant. Provision of hard-standing at perimeter of building for maintenance access equipment.
Safety issues relating to component failure		
General	Design/specification to be suitable for occupancy by the elderly.	Risk of injury to occupants from defective components to be minimized.
Component specific	Electrical systems to be protected by residual current circuit breakers.	Roof-lights to have laminated/shatter-resistant glazing.

C.2 Briefing audit

Table C.2 comprises a completed example of a proforma for recording the findings of a briefing audit. The purpose of the audit is to ensure that the project brief provides an adequate basis for service life planning at initial and detailed design stages. It should be noted that the sample audit findings included in the following table are for illustrative purposes only. Specific audit clauses should be prepared for each individual project.

Table C.2 — Sample proforma for recording findings of briefing audit

Issue	Audit findings [a]
Description/usage of building	Information should be provided on the specific types of teaching accommodation to be provided, e.g. general classrooms, science laboratories, craft workshops. The specific uses of the classrooms will influence the design and specification of components such as floor and wall finishes.
Building environment	The specific location and exposure of the site is unclear. It is unclear whether site investigation and soil reports are available for the site.
Design lives	Specific design lives have been stated for some components, assemblies and systems, but no general statements have been made regarding the remaining components, assemblies and systems. The client should confirm whether the use of suggested minimum design lives taken from Table 1 of ISO 15686-1:2000 is acceptable. The client should clarify whether the stated design life for the roof relates to the structure and finish, or the structure only.
Maintenance/life care requirements	No specific requirements have been included for internal floor finishes. The client should clarify the anticipated level of maintenance, e.g. daily washing/vacuuming.
Adaptability/flexibility/future use(s)	The client should confirm whether there are any requirements for flexibility of spatial provision, e.g. ease of relocation of internal partitions, ability to subdivide spaces, structural grid.
Safety issues relating to component/system failure	The client should clarify the safety implications and requirements relating to the reliability of extract fans in the laboratory areas.
Documentation	Copies of the following documents should be made available to the designer if available: Site plan showing relationship between new building and existing; Site investigation and soil analysis reports.
[a] Note that only deficiencies/nonconformities have been commented upon.	
NOTE Additional columns may be added to the above proforma to provide space for client responses to the specific audit issues identified, and to enable subsequent audit responses to be made.	

Table C.3 — Sample component assessment matrix

Data from design life brief				Data from detailed design audit			
Element	**Component**	**Design life**	**Life care/other requirements**	**Specification**	**Forecast service life**	**Forecast maintenance/life care/requirements**	**Other comments**
Ground floor	Covering	15	Daily sweeping/ vacuuming, weekly washing	PVC sheet	10	Regular polishing will prolong life.	Life may be reduced in circulation areas (e.g. corridors, stairs).
External walls/ cladding	Structure	60		Zinc-coated steel frame	60+	—	Zinc coating thickness should be checked.
	External claddings/ finishes	30	Minimal maintenance/life care	Profiled metal coil, zinc-coated steel	25	Coating may require maintenance after 20 years. Manufacturers recommend 6 monthly washing down.	Zinc coating thickness should be checked. Cut ends should be treated against corrosion.
	Windows	30	Minimal maintenance/life care	Powder-coated aluminium	30+	Periodic washing as recommended by manufacturer. Annual lubrication of ironmongery.	
Internal fittings	Partitions	30	Demountable	Painted fair faced blockwork	60+	Periodic repainting.	Non-structural, therefore demountable. However, not readily relocated.
	Ceilings	30	Access to building services required	Suspended ceilings – metal grid, mineral fibre infill panels	30+ (grid) 20* (panel)	Partial replacement of infill panels may be required within 30 year service life of grid.	* Service life of infill panels dependent upon frequency of removal/replacement for access purposes.
Mechanical and electrical plant/ equipment	Boiler plant	25	Design for maximum reliability. Out of hours maintenance only.	Gas fired boiler, cast iron heat exchanger	25	Annual servicing in accordance with manufacturer's instructions.	
	Calorifiers	25		Copper calorifiers	25	—	

C.3 Detailed design audit

C.3.1 Assessment of component service lives and life care requirements

Table C.3 provides a completed example of a proforma for summarizing the auditor's assessments of component service lives and required life care. The specific service life and life care forecasts recorded in the proforma will be derived from the auditor's detailed assessments of, for example, likely failure modes, anticipated usage and environmental exposure. Details of such assessments, and of the information used in the assessment process, should also be formally recorded by the auditor, and may be included in the audit report.

It should be noted that the sample audit findings in Table C.3 are for illustrative purposes only, and relate only to a small selection of building elements and components. Specific audit clauses should be prepared for each individual project.

C.3.2 Sample audit statements

This section provides typical examples of standard audit statements for use in audit reports. The statements are grouped according to the different types of audit nonconformity. The statements are provided for illustrative purposes only and should not be regarded as definitive.

Table C.4 — Sample audit statements

Statement type	Examples
Noncompliance with design life brief	The forecast service life of *(insert component/assembly system*) is less than the design life stated in the design life brief. The life care requirements of *(insert component/assembly/system*) exceed those specified in the design life brief. The design/specification of *(insert component/assembly system)* does not conform to the design life brief because *(insert reason, e.g. inadequate access has been provided for future life care or removal)*.
Missing/incomplete information	Insufficient information has been received for the audit of *(insert component/assembly/ system)* to proceed. *(insert component/assembly/system)* has not been audited because insufficient information/no information has been provided on *(insert details of missing information)*.
Unclear/ambiguous information	It is not clear how *(insert issue)* is to be addressed. It is not clear what provisions have been made for *(insert issue).* Instructions on *(insert issue)* are ambiguous/unclear.
Inaccurate/incorrect information	Adequate provision does not appear to have been made for *(insert issue*). *(insert issue)* is not/does not appear to be in accordance with *(insert reference to National/International Standard/other good practice guidance).* *(insert issue)* is not suitable for the intended location/environment/use.
NOTE 1 *Italics* means to be completed by the auditor. NOTE 2 Wherever possible, audit statements should be backed up by references to supporting information such as the source of the service life or maintenance assessment, or to appropriate standards, codes of practice or other good practice guidance.	

C.3.3 Sample checklists of issues to consider in detailed design audit

The use of standard audit checklists as a means of ensuring that all relevant issues are considered by the auditor, should be encouraged. Tables C.5 and C.6 provide sample checklists of typical issues for consideration in a detailed design audit of profiled metal cladding and boiler plant. The checklists are intended for use in assessing the adequacy of the installation instructions prepared by the project team and for identifying potential causes of defects and deterioration. It should be noted that the checklists are intended to illustrate the type and range of issues that should be considered as part of a detailed design audit, and are not intended to be definitive.

Table C.5 — Sample audit checklist — Boiler plant

Subject	Specific audit issues
Materials	Interaction, possible incompatibilities, isolation of dissimilar metals or incompatible materials, protective treatments
System design/interaction	Design and interaction of heating/hot water system, including pumps, water circuits, ventilation, control systems
Boiler support	Adequacy of support base/framework
Controls	Suitability, adequacy of safety systems (e.g. “fail safe” overheating cut-out)
Fabrication/assembly	Jointing and sealing of boiler shell sections
Pressure regulation	Adequacy of provisions
Sizing	Evidence of over/under sizing for intended use/demand
Ventilation	Adequacy of ventilation around plant (to prevent heat build-up), location/adequacy of flues and air intakes, provisions for control of flue condensate
Water treatment	Water hardness/corrosivity, provisions for treatment
Provision/access for maintenance	Location and accessibility of plant, provisions for future removal and replacement, provisions for drain-off, isolation, service valves
Ability to accommodate changing requirements over time	System flexibility, spare capacity, provision for future adaptation or extension/expansion
Common failure modes	Identification, assessment of risks, adequacy of protective measures, suitability for environment

Table C.6 — Sample audit checklist — Profiled metal cladding

Subject	Specific audit issues
Materials	Interaction, possible incompatibilities (e.g. between cladding and fixing), provisions for isolation of dissimilar metals or incompatible materials; protective/ decorative treatments
Surface protection/coatings	Composition, thickness and adequacy of corrosion protection (e.g. hot dip galvanizing, zinc-sprayed coating); composition, thickness and adequacy of surface finish (e.g. organic coating, anodizing)
Strength and deflection	Evidence of structural calculations for underlying support structure, supporting framework and cladding materials
Thermal movement	Provisions for thermal movement (e.g. at junctions, connections); provision of movement joints
Condensation control	Evidence of dew-point calculations, risk of interstitial condensation, provision of vapour barriers/seals, thermal bridging, ventilation of voids
Rainwater control	Detailing of joints, flashings, provisions for rainwater drainage, roof/wall penetrations
Fixings	Adequacy, strength, tolerances, provision for thermal movement
Joints and jointing	Provision of joint seals/gaskets, details of fasteners and seals
Performance of cladding system	Evidence of performance test data (e.g. for water tightness, air permeability, wind resistance)
Common failure modes	Identification, assessment of risks, adequacy of protective measures, suitability for external local environment and internal environment

C.4 Construction audit

C.4.1 Sample checklist of issues to consider in construction audit

The use of standard audit checklists as a means of ensuring that all relevant issues are considered by the auditor, should be encouraged. Table C.7 provides a sample checklist of typical issues for consideration in a construction audit of timber-framed walls. It should be noted that the checklist is intended to illustrate the type and range of issues that should be considered as part of a construction stage, and is not intended to be definitive.

Table C.7 — Sample construction audit checklist — Timber-framed walls

Subject	Specific audit issues
Storage on site	Storage to avoid warping, weather protection
Panel erection	Stabilization of panels during erection, bedding of sole plate, holding down devices, verticality of panels, site alterations to panels, notching/holes through studs
Cavity (fire) barriers	Provision of, continuity, fixing, provision of damp proof course (where required)
Breather membranes	Type, fixing, horizontal/vertical laps
Vapour checks	Type, location, fixing, joint support, laps, continuity, service penetrations
Sheathing	Fixing
Insulation	Continuity, restraint against slumping, contact with electric cables
Wall ties	Horizontal/vertical spacing, fixing to studs, alignment, vertical flexibility
Damp proof courses	Provision below sole plate, laps, sealing of joints, support/fixing of cavity trays, provision of weep holes to brickwork
Lintels	Support, fixing of multiple timber members

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