

Implementation Of The European Construction Products Directive Via The Iso 15686 Standards

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Summary: In 1993, on a significant European initiative, a working group aimed at developing standards for design life was established in ISO/TC59, Building Construction. This was identified as a guiding concept regarding durability of building products that should be of help in implementing the European Construction Products Directive, CPD. The establishment was based on the Vienna Agreement on co-operation between CEN and ISO. Subsequently, the working group was elevated to ISO/TC59/SC14.

The scope of the activity is to document steps to be taken at various stages of the building cycle to ensure that the resulting building, or other constructed facility, will last for its intended life without incurring large unexpected expenditures. The activity has progressed to the stage where the first two parts of the developing standard, ISO 15686 Buildings and Constructed Assets – Service Life Planning, are approved, i.e. Part 1, General principles and Part 2, Service life prediction procedures. Part 3, Performance audits and reviews, is soon expected to be approved. Additional parts are being drafted or have been proposed.

In Europe, the members of the European Organisation for Technical Approvals, EOTA, are now starting to issue European Technical Approvals for products as one of the two possible routes for CE marking them. This is done on the basis of an assessment of the product that includes the evaluation of its durability in order to obtain a reasonable economical working life, as required by the CPD. The durability evaluation is performed according to general EOTA guidance developed on the basis of the service life prediction concepts as expressed in ISO 15686-2.

For product standards – the other possible route for CE marking – this durability evaluation process is not yet so advanced, although attempts of implementation are starting in the concrete area. However, a similar development for other groups of materials in general is not equally straightforward. To facilitate for writers of product standards to implement service life issues in accordance with ISO 15686, a general guidance document is badly needed.

The development of ISO product standards addressing service life issues will not only be beneficial on the European level for the implementation of the CPD, but also on the world-wide level to obtain useful and recognised tools for communication of building products' service life characteristics.

Keywords: Construction Products, Service Life, Technical Approvals, Standards.

1 INTRODUCTION

In 1993, the standardisation work in the field of service life planning started when ISO/TC59/SC14/WG9, Design Life of Buildings, was launched at a meeting in Atlanta. The purpose of the activity is to document steps to be taken at various stages of the building cycle to ensure that the resulting building, or other constructed facility, will last for its intended life, the design life, without incurring large unexpected expenditures. It is needed to facilitate the making of objective estimates of the service lives of buildings and facilities.

There was a significant European initiative to establishing the standardisation group. The EUREKA umbrella project Eurocare has as its strategic goal to increase the service life of the built environment and to decrease yearly life-cycle costs for its conservation, restoration and maintenance. Eurocare, therefore, early adopted the Service Life Methodology established by CIB and RILEM (Masters and Brandt 1989). Together the three organisations in 1991 took the initiative to a dialogue with the Commission of the European Communities and the European standardisation body CEN regarding standardisation of the Service Life Methodology.

This was identified as a guiding concept regarding durability of building products that should be of help in implementing the European Construction Products Directive, CPD (The Council of the European Communities 1988), (Caluwaerts et al. 1993). ISO/TC59/SC14/WG9 was the result of a CEN/BTS-1 request and based on the Vienna Agreement on co-operation between CEN and ISO. Subsequently, as the scope and work broadened, in 1998 the working group was elevated to the subcommittee level, obtaining the designation ISO/TC59/SC14.

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For product standards, the other possible route for CE marking, this durability evaluation process is not yet so advanced, although attempts of implementation are starting in the concrete area. However, a similar development for other groups of materials in general is not equally straightforward. To facilitate for writers of product standards to implement service life issues in accordance with ISO 15686, a general guidance document is badly needed.

Of course, the development of ISO product standards addressing service life issues will not only be beneficial on the European level for the implementation of the CPD, but also on the world-wide level to obtain useful and recognised tools for communication of building products' service life characteristics.

2 STATE OF WORK OF ISO/TC59/SC14, DESIGN LIFE

The activity has progressed to the stage where the first two parts of the developing standard, ISO 15686 Buildings and Constructed Assets – Service Life Planning, are approved, i.e. Part 1, General principles (ISO 2000a) and Part 2, Service life prediction procedures (ISO 2001). Part 3, Performance audits and reviews (ISO 2000b) is soon expected to be approved.

Part 1 describes the principles and procedures that apply to design, when planning the service life of buildings and constructed assets. It is important that the design stage includes systematic consideration of local conditions to ensure, with a high degree of probability, that the service life will be no less than the design life. The standard is applicable to both new constructions and the refurbishment of existing structures. However, additional considerations may apply to existing buildings.

Part 2 of the standard series is mainly based on the Service Life Methodology (Masters and Brandt 1989). It describes a procedure that facilitates service life predictions of building components. The general framework, principles, and requirements for conducting and reporting such studies are given. It should be emphasised that the standard does not describe the techniques of service life prediction of building components in detail.

Part 3 has reached the DIS status and is intended to become a fully approved standard in June 2000. This part 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. However, the cost implications of service life planning and the broader issues of sustainability (e.g. embodied energy, land use) are not addressed here.

Other parts on which work has commenced are on "Data requirements", "Life cycle costing" and "Guidelines for considering environmental impacts". The first of these is intended to describe requirements of data in order to estimate the service life of a structure, building system, or building. However, at least in a first step, this part will be developed as a technical report rather than a standard. The second work item, "Life-cycle costing", is to enable comparative assessment of the cost performance of buildings and constructed assets over an agreed period of time. The last work item is to provide guidance on assessing the relative environmental impacts of alternate service life designs, and to identify the interface between environmental LCA and service life planning.

Another recently approved work item is "Maintenance and condition assessment protocols for buildings", with the objective to develop guidance for improving the quality of durability and service life data derived from condition assessment of the existing building stock. Still another work item, "Reference service life", aiming to provide guidance on the provision of reference service life for use in the application of ISO 15686-1, is currently a subject of balloting.

Moreover, proposals for new work items on maintenance and on characterisation of degradation environments are likely to be drafted.

Finally, a new work item proposal on service life design of concrete structures is under way. Originally initiated via discussions at a workshop arranged amongst others by CEN/TC104, Concrete, this work item was brought to consideration by SC14 and is now formally transferred to ISO/TC71, Concrete, Reinforced Concrete and Pre-Stressed Concrete. Thus, the

recently established ISO/TC71/SC7, Service Life Design of Concrete Structures has, in liaison with *fib*, started to prepare the work item proposal with the aim of developing a Code of practice on service life design of concrete structures. This would become the first international product standard addressing service life planning issues explicitly, simultaneously serving as an example or a template how to cope with other building products in this context.

Figure 1 gives an overview of the ISO 15686 series of standards produced and in process. The M1 and P1 levels in the figure depict the generic standards on service life planning: Service life prediction procedures and general principles, respectively. The levels P2 and M2 represent semi-generic support standards while the M3 level illustrates the manifold of product standards that in time should be complemented with descriptions of service life assessment procedures. The proposed work item on service life design of concrete structures is intended to serve as an example of such a product standard.

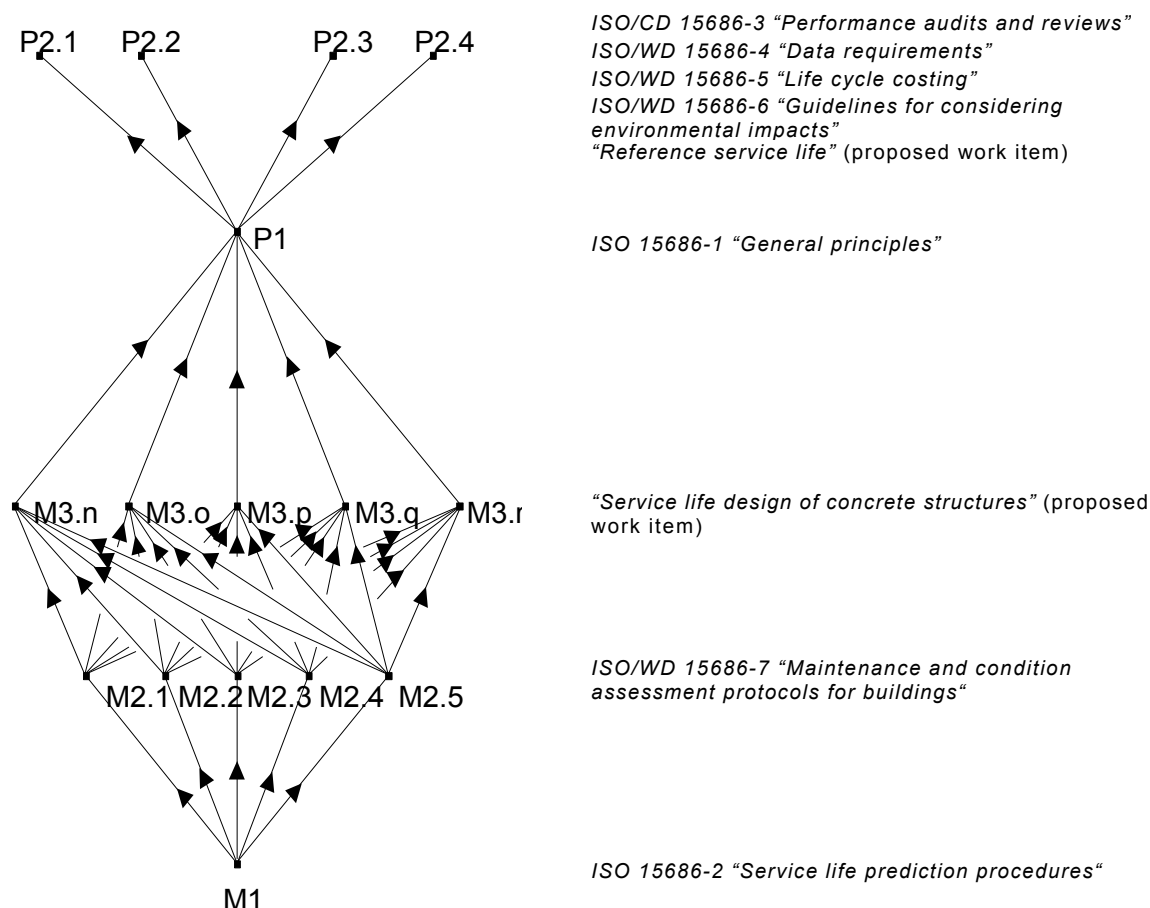


Figure 1. Relationship among standards for service life design and planning of buildings and constructed assets – ISO 15686 series.

The major work and challenge in this standardisation area lies in completing existing product standards with sub-parts describing methods for assessment and declaration of service life data. Another vital work area is methods for exposure/testing and evaluation. The major parts of this work do not lie within the scope of SC14, but they ought to meet the requirements of, and be developed in accordance with the framework of the SC14 standards.

3 THE EUROPEAN CONSTRUCTION PRODUCTS (CPD) DIRECTIVE

In 1988 the EU Council adopted the Construction Products Directive (The Council of the European Communities 1988) with the aim of removing the barriers to trade in this specific area following the white paper on the internal market approved by the Council in June 1985. The CPD is different from other similar so-called “New Approach” directives, such as the ones on toys or machines, in as far as it tries to accommodate with the specificity and complexity of the construction sector.

Indeed the CPD fixes the essential requirements for the construction works (both buildings and civil engineering works). There are six essential requirements which apply to the works as set out in annex I of the directive:

- Mechanical resistance and stability;
- Safety in case of fire;
- Hygiene, health and the environment;

- Safety in use;
- Protection against noise;
- Energy economy and heat retention, and;
- Such requirements must, subject to normal maintenance, be satisfied for an economically reasonable working life.

The CPD has, however, not the aim of harmonising the regulations on works of the Member States but rather of bridging the "works" and the construction products put on the European market and used in these works. It therefore specifies the level of performances of these products: the products "have such characteristics that the works in which they are to be incorporated, assembled, applied or installed, can, if properly designed and built, satisfy the essential requirements...". This is the notion of "fitness for the intended use" of a construction product.

The link between the essential requirements of the works and the product characteristics to be assessed is fixed in Interpretative Documents (The European Commission 1994). The Interpretative Documents (IDs) have been drafted on the basis of existing regulatory requirements of the Member States, each ID containing necessarily one chapter on the requirements of the works and one on the characteristics of the products, in principle allowing to accommodate the requirements for the works.

Since the essential requirements of the works may present differences according to climate, geographical location or regulations from a country or a region, so may also product characteristics, if needed, be expressed in classes and levels.

The CPD specifies further that a construction product is fitted for its intended use if it conforms to:

- a harmonised European standard (drafted by CEN/CENELEC);
- a European Technical Approval (issued by an EOTA member), or;
- a non-harmonised technical specification (e.g. a national technical specification) recognised at Community level,
- all three being denoted technical specifications.

Finally the CPD specifies that, before getting a CE marking, the conformity to these technical specifications must be attested. This will be carried out via certification by a third party or self-declared by the manufacturer. It involves anyhow factory production control procedures to be applied by the manufacturer. Details are described in the systems of attestation of conformity (AC) as laid down in Annex III of the CPD. For each family of products, the AC system is fixed in a Commission Decision, after consultation of the Standing Committee on Construction (representatives of the Member States). With respect to the assumption of the working life of construction products in harmonised technical specifications, reference is made to the following provisions of the CPD and the IDs, fixing the working context both for CEN and EOTA:

- According to the CPD "the products must be suitable for construction works which (as a whole and in their separate parts) are fit for their intended use, account being taken of economy, and in this connection satisfy the following essential requirements where the works are subject to regulations containing such requirements. Such requirements must, subject to normal maintenance, be satisfied for an economically reasonable working life".
- *Maintenance* is defined in the IDs as "a set of preventive and other measures that are applied to the works in order to enable the works to fulfil all its functions during its working life".
- *Normal maintenance* according to the IDs "includes inspections and occurs at a time when the costs of the intervention which has to be made are not disproportionate to the value of the part of the works concerned, consequential costs being taken into account".
- The *Working life* is defined in the IDs as "the period of time during which the performance of the works will be maintained at a level compatible with the fulfilment of the Essential Requirements".
- *Economically reasonable working life* according to the IDs "presumes that all relevant aspects are taken into account such as: costs of design, construction and use; costs arising from hindrance of use; risks and consequences of failure of the works during its working life and costs of insurance covering these risks; planned partial renewal; costs of inspections, maintenance, care and repair; costs of operation and administration; disposal; environmental aspects".
- The IDs provide that it is up to the Member States "when and where they feel it necessary, to take measures concerning the working life which can be reasonable for each type of works, or for some of them, or for parts of the works, in relation to the satisfaction of the essential requirements".
- Furthermore, the IDs provide that category B specifications (product standards) and Guidelines for European Technical Approval (ETAGs) "should include indications concerning the working life of the products in relation to the intended uses and the methods for its assessment".

4 EUROPEAN TECHNICAL APPROVALS

As described above harmonised European (product) standards and European Technical Approvals are both technical specifications in the sense specified by the CPD. For most products, performance will be described via product standards

supported by test standards or horizontal standards. The CPD, therefore, recognises this route via standardisation as the main route for the European harmonisation and to CE marking for construction products. Harmonised European (product) standards are developed by CEN/CENELEC under mandate of the EC and EFTA. The CPD, however, recognises also that for other products this route is not applicable:

For all those products where the state of the art does not or not yet permit to produce a product standard, the CPD has envisaged an alternative route to allow also these products to come to the market and to overcome their barriers to trade: this route is the ETA. Products for which an ETA can be granted are specified in Article 8 of the CPD.

An ETA is a favourable assessment of the fitness of a product for an intended use, based on the fulfilment of the essential requirements for building works for which the product is used. An ETA is placed at the same level as a harmonised European standard: it must be followed by an attestation of conformity under a given system before the CE marking can be affixed to the product. An ETA for a product of a manufacturer can be granted on the basis of an ETA Guideline for a product family drafted by EOTA after having received a mandate from the Commission and the EFTA Secretariat (Article 11 of the CPD) or on the basis of an internal EOTA procedure for "isolated" products (Article 9.2).

Having to fulfil the principles of the CPD in the drafting of ETAGs and in the issuing of ETAs, EOTA has worked out a number of guidance rules for the handling of the above mentioned concepts on working life of construction products in ETAGs and related ETAs *and for the assessment of their durability*.

Firstly and based on the work of ISO, a table (refer to Table 1) has been drafted indicating the working life of construction products to be assumed in ETAGs and ETAs depending on assumed working lives of the works (e.g. given by national regulations). It should be noted that, according to the IDs, the working life of a product "cannot be interpreted as a guarantee given by the producer, but regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works". By EOTA the assumed working life of a product should be understood as a basic assumption and reference to be considered when laying down the type and severeness of verification methods (e.g. number of freeze-thaw cycles) and provisions relating to durability *in the ETAGs and related ETAs*. When allocating given products to working life categories, the presumptions of the IDs concerning the "economically reasonable working life" should be taken into account.

Table 1. Relation between assumed working life of construction works and of products

Assumed working life of works (years)		Working life of construction products to be assumed in ETAGs, ETAs and hENs (years)		
Category	Years	Repairable or easily replaceable ¹	Repairable or replaceable with some more efforts	Lifelong ²
Short	10	10	10	10
Medium	25	10	25	25
Normal	50	10	25	50
Long	100	10	25	100

¹ In exceptional and justified cases, e.g. for certain repair products, a working life of 3 to 6 years may be envisaged (when agreed by EOTA TB or CEN respectively).

² When not repairable or replaceable "easily" or "with some more efforts".

Secondly general guidance has been produced to ETAG writers on the approach that should be taken in the development of *these ETAGs* on the subject of Assessment and/or Prediction of Working Life of products, in order to achieve a consistent and harmonised technical approach between different *ETAGs*, and to limit the amount of long term ageing to be performed during assessments *of products leading to their CE marking*.

The approach taken is based on the methodology of (ISO 2001), see Figure 2, and briefly described in clause 8 of (ISO 2001), but adapted to the specificity of technical approval work, in particular for the *quick* assessment of innovative products:

- 1) In the *Definition* stage, use is made of assumptions as to the "normal" worst conditions that the product will see in use. These conditions are not usually the absolute worse conditions but are chosen so that the majority of the product population will be at or below these conditions. As many individual products will be at conditions less severe than the "normal" it is obvious that many products will achieve working lives longer than that predicted, in some instances by factors of 2 or 3.

The term "User needs" relates, essentially, to the definition of what is expected of the product and relates to the product's fitness for use. In the context of the work of EOTA this will be defined, within limits set by the EOTA Working Group and its Mandate, by the applicant for an ETA by his claims made for the product. Assessments should be limited to user needs only in so far they relate to the Essential Requirements of the CPD.

The "Building Context" relates to aspects such as the climate and/or site in which the building will be located, the effects of its occupancy and use, incorporation into the works etc. Where the precise building context is not known, or where more than one context is anticipated by the applicant, a "worst case" situation should be assumed. Alternatively, each context should be considered separately. Further guidance is given on possible building context sub-divisions:

- climatic sub-divisions of Europe
- other external sub-divisions such as orientation of the product in structures and positions of the building
- internal environment sub-division
- other internal sub-divisions (orientation and use of the building or compartments of buildings)
- subterranean

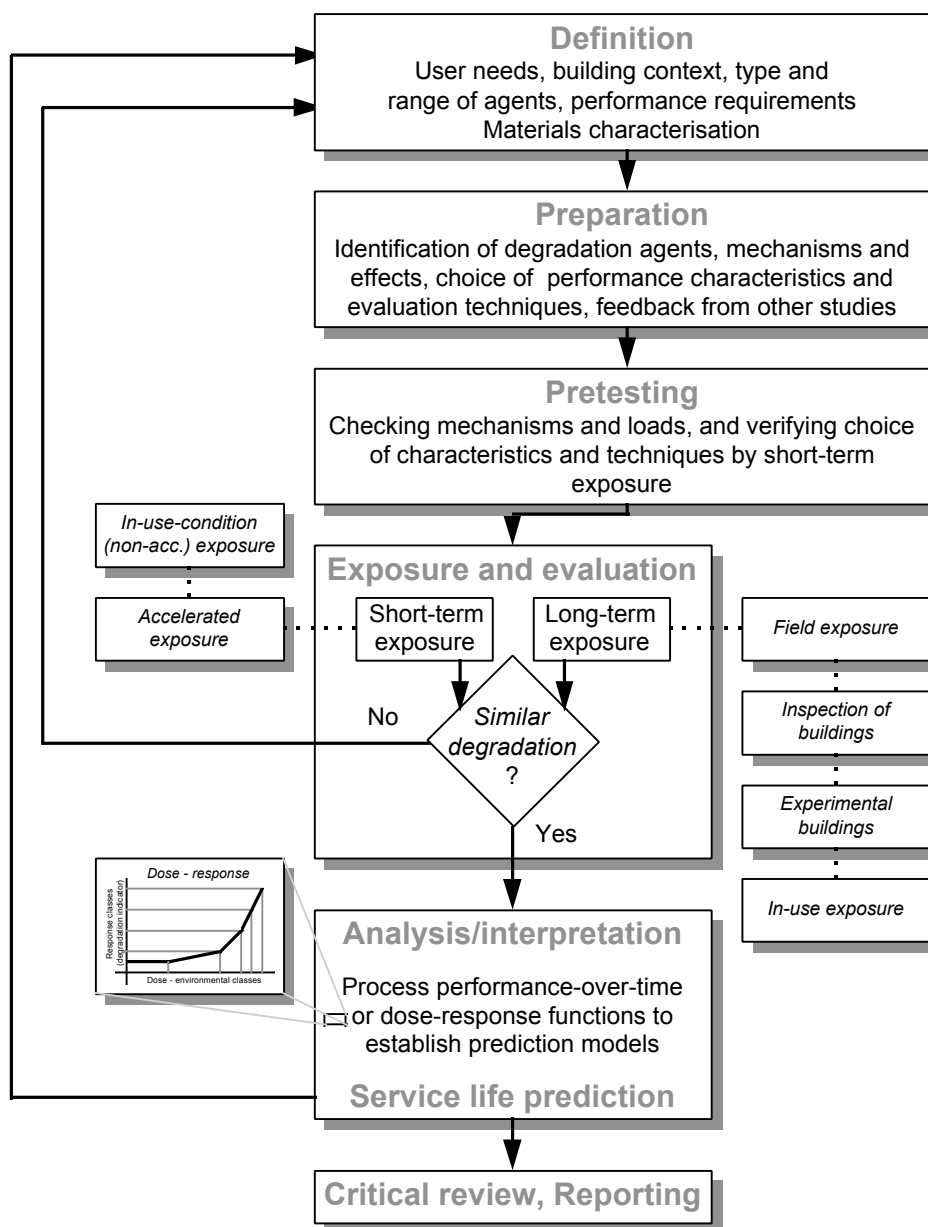


Figure 2. Systematic methodology for service life predictions of building materials and components (ISO 2001)

Performance requirements for particular products or components are defined by the Essential Requirements of the CPD, expanded upon by the Interpretative Documents and laid down in the EC mandates, based upon the regulatory requirements applicable in the Member States. The appropriate performance requirements, performance criteria and methods of verification to be used in the assessment of working life are elaborated upon in the ETA Guideline.

Finally and in order to ensure that a predicted working life relates to the product on the market it is essential that all products are adequately characterised in terms of structure, chemical composition and performance values corresponding to the selected performance criteria.

- 2) The *Preparation* stage is the most critical stage when drafting the ETAG. It involves the identification of the possible degradation factors (e.g. weathering, biological, incompatibility, use etc), identification of the degradation mechanisms and the effects of degradation on the product. The result will be the proposal or selection of the most appropriate approach (including ageing tests).

Therefore, possible degradation factors and their effects in relation to building context are listed (see examples in Tables 2 and 3). This list is not meant to be exhaustive and relates mainly to the effects of degradation factors on materials. Also other factors, such as use-related factors, the possible effects of interaction between the product and other parts of the building (e.g. due to dimensional changes) as well as the possibility of synergistic effects between two or more factors which may cause a greater than predicted change (e.g. UV radiation + moisture) should be taken into account.

**Table 2. Example of degradation factors that have to be taken into account:
(exposure situation internal- 1st part)**

Degradation factor	Actions	Reactions	Materials possibly at risk (examples)	Sub-division of factor
Solar radiation U.V.	<i>Products are generally protected from UV radiation</i>			
Thermal	Solar heat gain causing rise in temperature ^{1,2}	Thermal expansion - bowing or twisting) temporary) permanent - loss of bond Cyclic expansion/contraction - fatigue damage	Metals Plastics Thin sheet materials Multilayer materials Concrete Mechanically fixed product Bonded products	Climatic zones Orientation of building or building compartment
Differential temperatures	Thermal	Mechanical	Thin panels	Climatic zones
Internal/external ³	expansion/contraction	- bowing - twisting - delamination	Multilayer materials	Internal conditions
Internal/internal ⁴	Thermal	Mechanical	Thin panels	Internal conditions
	expansion/contraction	- bowing - twisting - delamination	Multilayer materials	
Localised heating ⁵	Localised chemical/physical degradation	Chemical	Plastics	
	Localised thermal expansion contraction	- embrittlement - change in appearance Physical - embrittlement - change in appearance - loss of thermal properties Mechanical - bowing - distortion - delamination	Thin panels Multilayer materials	Temperature of heat source Continuous/intermittent
Depressed temperatures ⁶	Thermal contraction	Mechanical - shrinkage	Materials generally	

¹ Only significant for unventilated buildings or building compartments

² Most significant in uninsulated lightweight structures

³ Refrigerated buildings – special case⁴ Separation of heated/unheated rooms

⁵ Materials behind radiators etc or special cases such as factories with elevated process temperatures

⁶ As for external in refrigerated buildings and unheated buildings or parts of buildings – minimum temperatures may be different

Table 3. Risks related to degradation factor and orientation (internal)

Orientation of internal degr. factor	Horizontal surfaces	Vertical surfaces	Ceilings
Water	High risk of liquid water Risk of condensation	Low risk of liquid water Risk of condensation	Low risk of liquid water Risk of condensation
Chemical spillage	High risk	Low risk	Low risk
Wear	High risk - pedestrians	Low risk different form of wear - people brushing against	No risk
Impacts	High risk - dropping impacts	Horizontal impacts from people, vehicles etc	Small risk, special cases e.g. sports arenas

For developing a programme for the assessment of working life, technical specification writers will have to make use of many sources of information used to identify and select the most appropriate assessment procedure taking into account the nature of the product and its intended use: knowledge and experience (the chemistry and physical make up of the material and a knowledge of the proposed use), natural exposure data of construction products either under service conditions or under defined exposure conditions, testing following accelerated ageing (falling into three main groups: direct, indirect and torture tests) taking into account specific accelerated ageing conditions and extrapolation rules.

- 3) In the methodology envisaged by (ISO 2001), *Pretesting* is designed to validate the proposed ageing test. In the context of ETA work (unique and quick assessment of a product of a manufacturer wishing to bring his product as soon as possible to the market) this stage will generally not be possible. It is therefore essential that full use is made of all existing knowledge and data held by Approval Bodies and others when drafting the ETAGs and having to evaluate the products.
- 4) As far as the testing step is concerned, ETAGs describe fully any ageing test proposed, including conditions, periods, performance criteria etc. Tests should be as short term as possible and should generally be related to a fixed period of exposure, with the overriding requirement that it allows the prediction of working life with an acceptable degree of confidence.

The ISO methodology anticipates the comparison of the results of relatively short-term tests to those of long term tests under in-service conditions and a dose effect loop. This will not be possible in the case of assessments for ETAs and consequently ETAG writers should, wherever possible, utilise existing and generally accepted tests. However, the review procedures envisaged for ETAGs and ETAs, and the associated increase in knowledge and experience of a product, will give them the opportunity to re-assess the methods of verification selected for the determination of working life.

5 CONCLUSIONS/FUTURE WORK

The international standardisation on the design life of buildings essentially sprung out from a European initiative to support the implementation of the Construction Products Directive. Similar motives and needs were apparent in most parts of the world, encompassing performance based building and construction issues, the need for standards and tools for the service life planning and design of buildings, and in general environmental and resource conservation concerns.

The major parts of the future standardisation work lie in amending the various product standards with guides on the assessment and evaluation of durability and service life of products when in normal use in constructed assets. This is a long term perspective and work. The European standardisation organisation CEN has not reached too far in this process. CEN's prime and immediate objective for durability assessment so far is to use the present state-of-the-art in each product family (The European Commission 2001). This results in standards addressing durability and working lives of products at very unequal levels: some are or will be very detailed, whilst others will give nothing or only basic points without details.

In future generations of harmonised product standards, a more systematic approach following the ideas developed in this paper ought to be introduced. ISO/TC59/SC14 is discussing to process a generic standard giving guidance on how service life assessment and declaration of service life data ought to be addressed in product standards to meet the requirements of the already established standards, and hence the Construction Products Directive. Furthermore, the initiative of TC59/SC14 to start a standardisation action in the field of service life design of concrete structures, should be seen as a first example of an implementation, setting the level of ambition for others.

A promising new approach that might be appointed in future product standards for complementing the classical approach of durability studies was the presented at the 8DBMC Conference, and subsequently improved (Lair et al. 2001). This approach suggests two steps in the process of service life prediction. One is aimed of taking benefit from all information available, from

experts' judgements to durability test results. In order to anticipate premature failure or degradation, the predicted service life thus obtained may then be corrected by an FMEA (failure mode and effects analysis) exercise.

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