PD CEN/TR 16816:2015

BSI Standards Publication

End use performance of wood products — Utilisation and improvement of existing methods to estimate service life

National foreword

This Published Document is the UK implementation of CEN/TR 16816:2015.

The UK participation in its preparation was entrusted to Technical Committee B/515, Wood preservation.

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

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

ISBN 978 0 580 88431 3

ICS 79.080

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2015.

Amendments issued since publication

Date	Text affected

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 16816

April 2015

ICS 79.080

English Version

End use performance of wood products - Utilisation and improvement of existing methods to estimate service life

Performances des produits en bois dans leur emploi - Utilisation et amélioration des méthodes existantes pour estimer la durée de vie

Leistungseigenschaften von Holzprodukten

This Technical Report was approved by CEN on 21 March 2015. It has been drawn up by the Technical Committee CEN/TC 38.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. CEN/TR 16816:2015 E

Contents

Page

Foreword

This document (CEN/TR 16816:2015) has been prepared by Technical Committee CEN/TC 38 “Durability of wood and wood-based products”, the secretariat of which is held by AFNOR.

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

1 Scope

The scope of WG28 Performance Classification is expressed in this Technical Report:

Guidance on the determination of end use performance of wood products: utilization and improvement of existing test methods to estimate service life, in order to give input to the harmonized product standards dealing with the durability requirement of the CPD and future Regulation (EU) No 305/2011 (The Construction Products Regulation CPR).

This Technical Report brings together the evaluations and discussions to date that have occurred within CEN/TC38/WG28 Performance Classification.

This technical report does not address panel products specifically.

2 Background

2.1 General

The development of performance-based design methods for durability requires that models are available to predict performance in a quantitative and probabilistic format. The relationship between performance during testing and in service needs to be quantified in statistical terms and the resulting predictive models need to be calibrated to provide a realistic measure of service life, including a defined acceptable risk of non-conformity.

Service-life prediction or planning is a process for ensuring that, as far as possible, the service life of a building will equal or exceed its design life, while taking into account (and preferably optimising) its life-cycle costs (ISO 15686 [1]). For a long time, the international organizations CIB and RILEM have been leading this development, which has had an impact on standardization work nationally, regionally, and globally through ISO.

Service-life prediction should be integrated into the design process for constructions, but it is also applicable to existing buildings and other construction works.

Drivers for establishing service-life planning methodology and routines include the need for building owners to be able to forecast and control costs throughout the design life of a building or construction. It also influences the reliability of constructed assets, and hence the health and safety of users.

The construction sector is under pressure to improve its cost effectiveness, quality, energy efficiency and environmental performance and to reduce the use of non-renewable resources. A key issue for the competitiveness of wood is the delivery of reliable components of controlled durability with minimum maintenance needs and life-cycle costs.

The importance of service-life issues is reflected in the Construction Products Directive (CPD) with its six essential requirements, which should be fulfilled by construction products during a ‘reasonable service life’.

2.2 ISO/TC 59/SC14 “Design life”

The development of performance-based design methods for durability requires that models are available to predict performance in a quantitative and probabilistic format. The relationship between performance during testing and in service needs to be quantified in statistical terms and the resulting predictive models need to be calibrated to provide a realistic measure of service life, including a defined acceptable risk of non-conformity.

Service-life prediction or planning is a process for ensuring that, as far as possible, the service life of a building will equal or exceed its design life, while taking into account (and preferably optimising) its life-cycle costs (ISO 15686 [1]). For a long time, the international organisations CIB and RILEM have been leading this development, which has had an impact on standardization work nationally, regionally, and globally through ISO.

Service-life prediction should be integrated into the design process for constructions, but it is also applicable to existing buildings and other construction works.

Drivers for establishing service-life planning methodology and routines include the need for building owners to be able to forecast and control costs throughout the design life of a building or construction. It also influences the reliability of constructed assets, and hence the health and safety of users.

The construction sector is under pressure to improve its cost effectiveness, quality, energy efficiency and environmental performance and to reduce the use of non-renewable resources. A key issue for the competitiveness of wood is the delivery of reliable components of controlled durability with minimum maintenance needs and life-cycle costs.

The importance of service-life issues is reflected in the Construction Products Directive (CPD) with its six essential requirements, which should be fulfilled by construction products during a ‘reasonable service life’.

2.3 CEN/TC 350 Sustainability of Construction Words

CEN/TC 350 is responsible for the development of voluntary horizontal standardized methods for the assessment of the sustainability aspects of new and existing construction works and for standards for the environmental product declaration of construction products.

The objective is to ensure that LCA-based data for environmental product declarations are consistent, comparable, verifiable and scientifically based. Since the life cycle has to be defined, it is essential to include information on service lives, including reference service lives.

Methods for sustainability assessments should be based on a performance-based approach, and should cover environmental, social and economic performance.

2.4 CEN/TC 351 Construction Products: Assessment of release of dangerous substances

The work of CEN/TC 351 is directed to the area covered by the Biocidal Products Directive and REACH. Indicators, criteria and developed standards will have significant influence in the future on the materials available for construction products and on service-life design options.

2.5 COST Action E37 sustainability through new technologies for enhanced wood durability

The Task Force Performance Classification (TFPC) was established at the COST Action E37 workshop in Ljubljana in 2004 [2]. Its aim was to outline principles for a performance-based classification of wood durability, in particular in using the natural durability of untreated wood and for modified wood products, traditional and non-traditional treatments and non-biocidal measures for wood protection.

The COST Action ended in September 2008, and the TFPC submitted a final report for inclusion in the overall documentation of the Action [3]. Standards for durability of wood and wood-based products, not least those produced by CEN/TC 38 Durability of wood and wood-based materials, were of primary interest to the TFPC. They considered that the present standards could not deliver adequate performance-based data. One goal of the Task Force was therefore to address the way durability is treated in standardization. It was conceived that well-founded proposals on amalgamating modern, material-independent methods of service-life prediction and design with traditional wood assessment methods would be of direct use, e.g. to CEN/TC 38 and the construction industry.

The TFPC recognized the use of Reference Service Life (RSL) as a basis for estimations of Estimated Service Life (ESL). The estimates are not necessarily reached by use of the Factor Method as in ISO 15686, but the basic principle is useful. To develop a range of performance classes, the scientific community must connect better and cooperate with user groups and stakeholders and define reference products that can be evaluated under reference service conditions. Test results on any commodities, products and components will then be compared with agreed RSLs, and this can form the foundation for a range of performance classes. During this development, existing use classes have to be taken into account and, if necessary, adapted to suit a forthcoming system for performance classification. As an input to Factor A (Quality of components) in the Factor Method, it will be necessary to define a range of Resistance Classes to feed into the assessments. This work is carried forward in CEN/TC 38 WG28 and the WoodExter project.

2.6 WoodExter project

The WoodExter project [4] (2007 – 2010) was a collaborative pan-European-funded research project supported by WoodWisdom-Net and the Building with Wood industry initiative. Its objective was to take the first steps towards introducing performance-based engineering design for wood and wood-based building components in outdoor above-ground situations. This enables capture of the benefits of 'design for durability' and has delivered a practical engineering tool for service-life estimation based on a novel methodology. The project focused on cladding and decking as two test case products to rigorously assess this methodology.

The project aims were to:

— characterize climatic influence on performance of timber cladding;

— characterize new and existing techniques as in-service indicators of performance prediction;

— combine the above in an engineering-based model;

— calibrate and rigorously test the model for the selected Use Class 3 products, cladding and decking;

— transfer knowledge to enable confident specification of timber cladding and decking.

A pilot model has been developed in the WoodExter project incorporating key input data and the interactions between them that influence performance of cladding www.kstr.lth.se/guideline. The consequence class depends on the severity of consequences in case of non-performance and is described by the factor γ_d.

The exposure index I_{sk} is conceived as a 'characteristic (safe) value' accounting for uncertainties. The exposure index is assumed to depend on:

— geographical location determining global climate;

— local climate conditions;

— the degree of sheltering;

— distance from the ground;

— detailed design of the wood component;

— use and maintenance of coatings.

2.7 Design value I_{Rd} for resistance factor depending on material

The design resistance index I_{Rd} for selected wood materials is determined on the basis of resistance class according to Table 1. This is a simplified first step for a material resistance classification based on a balanced expert judgment of moisture dynamics and durability class. The resistance class term is based on a combination of durability class data according to EN 350-2, test data, experience of treatability and permeability for wood species as well as experience from practice.

Biological durability is the key factor determining performance for wood in different use classes. The robust laboratory and field test methods that exist make it possible to assign a durability rating to timber linked to the intended use class according to EN 335, assuming a worst case scenario. Other factors determine the likelihood of the worst case scenario occurring in practice.

The natural durability of wood is classified into durability classes as described in EN 350-1 and presented as durability classes for heartwood of timber species in EN 350-2. Durability class is a classification on five levels from non-durable to very durable. This is based on decades of data from ground contact field trials for use class 4. The natural durability for a wood species can vary widely.

Table 1 — Resistance classification of selected wood materials and corresponding design resistance index

Material resistance class	Examples of wood materials[a]	I_{Rd}
A	Heartwood of very durable tropical hardwoods, e.g. afzelia, robinia (durability class 1) Preservative-treated sapwood, industrially processed to meet requirements of use class 3.	10,0
B	Heartwood of durable wood species e.g. sweet chestnut (durability class 2)	5,0
C	Heartwood of moderately and slightly durable wood species e.g. Larch and Scots pine (durability class 3 and 4,)	2,0
D	Slightly durable wood species having low water permeability (e.g. Norway Spruce)	1,0
E	Sapwood of all wood species (and where sapwood content in the untreated product is high)	0,7

[a] For the majority of wood materials there is variability in material resistance. The material resistance classification should defer to local knowledge based on experience of performance of cladding and decking and where this is not available field test data and then laboratory test data. It is possible that a classification with different design resistance indices may need to be adopted for specific regions or countries, based on practical experience e.g. from the use of a material in that region.

For out of ground contact (e.g. exterior wood cladding) the challenge is to translate durability class from use class 4 to use class 3. In EN 350-1 the term “markedly different” is used to describe the additional benefits of low permeability on the performance of wood out of ground contact. Expert advice is recommended for assigning the material resistance class for wood materials such as:

Preservative treated wood is often a combination of mixed treated heartwood and sapwood. The treated sapwood should be thoroughly treated and enhanced to durability class 1. The heartwood is more resistant to treatment and the enhancement of the heartwood can be considered to be slightly higher than the natural durability class of the heartwood for the species (EN 350-2). Therefore, for preservative treated decking it may be more sensible to take a mid-point between the resistance class of the treated sapwood and the treated heartwood. E.g. for pine heartwood treated (resistance class C) and pine sapwood treated (resistance class A) the overall batch of preservative treated wood should then be classified as resistance class B.

For untreated wood if there is a mixture of heartwood and sapwood present in the wood species then the material resistance can either be classified as the mid-point between the class of the heartwood (resistance class A to D) and the sapwood (resistance class E). If this risk is not acceptable then the material resistance class should be taken as the worst case (E), the least resistant competent of the overall material.

The durability of modified wood, e.g. acetylated, furfurylated and thermally modified, is specific to the technologies employed and may vary between specifications for the different materials. Expert advice is recommended for assigning the material resistance class for modified wood.

The input data are described by Thelandersson et al. [5] (2011) and the design of a detail is made in the following steps:

1) Choose consequence class to determine $\gamma_{d;}$

2) Determine a base value I_{S0} for the exposure index depending on the geographic location of interest;

3) Find a correction factor for the exposure index to account for the local climate conditions (meso- or micro-climate). Factors of importance are orientation, overall geometry of the structure, nature of the surroundings;

4) Find appropriate correction factors for:

   — Sheltering conditions;

   — Distance from ground;

   — Detailed design of the wood component considered.

   Steps 2–4 give a characteristic value I_{Sk} for the exposure index.

5) 5Choose material to determine a design value I_{Rd} for the resistance index;

6) Check performance by the condition:

$$I_{Sd} = \gamma_d \cdot I_{Sk} \leq I_{Rd}$$

   Where:

   I_{Sd} is performance

   γ_d is consequence class

   I_{Sk} is characteristic value for the exposure index;

   I_{Rd} is design value for the resistance index

7) If non-performance, change inputs in some or all of steps 2, 3, 4 and 5.

3 Work in this area continued in the Swedish led project WoodBuild 2008-2013.CEN/TC38 Standards: requirements for efficacy

3.1 Preservative treated wood

The majority of CEN/TC38 efficacy tests are relevant to preservative treated wood. The CEN/TC38 system involves a framework in which specifications for preservation can be made on a country-by country basis depending on the requirements of any given country, yet using the same set of efficacy tests. This framework for specification is laid down in European standards EN 351-1 and EN 599-1. Of these it is EN 599-1 which governs the choice of appropriate test methods depending on the use class in which the treated wood is to be used.

EN 599-1 ensures the appropriate efficacy tests are performed for each use class (including the correct choice of artificial aging procedure). Some efficacy tests are considered “minimum requirements” while others are considered to be “additional / local tests”, which are not necessarily required in all European countries. Tests differ if the preservative is a penetrating preservative or a superficial preservative. Table 2 summarizes the requirements for the testing of a penetrating preservative in accordance with EN 599-1.

Table 2

Minimum and additional test requirements for penetrating preservatives according to Use Class, as specified in EN 599–1			
Use Class	**Pre-conditioning requirement**	**Minimum requirements**	**Additional / local tests**
1	EN 73	EN 47 and/or EN 49–2 and/or EN 20–2	EN 117
2	EN 73	EN 113 (brown rot fungi only)	UC1 tests EN 152
3	EN 73 EN 84 (EN 84 not required if EN 330 conducted)	EN 113 (brown rot fungi only)	UC1 tests EN 152 EN 113 (on *C versicolour*) EN 330
4	EN 73 EN 84	EN 113 (brown rot fungi and *C. versicolour*) ENV 807	UC1 tests EN 152 EN 252
5	EN 73 EN 84	As UC4 plus EN 275	UC1 tests EN 152

The vast majority of the efficacy tests are conducted on small blocks of pine sapwood that are defect-free. They are mainly conducted in conditions where the test organism is the only organism present (e.g. in the case of basidiomycetes pure cultures are used) and in conditions conducive to the wood degrading activity of that organism.

All the minimum requirement tests are laboratory efficacy tests, with the exception of EN 275 for UC5. It is not possible to conduct efficacy tests against all organisms which may attack wood in practice. Test organisms have been chosen to be representative of the types of organism that are encountered in the relevant use class.

The results from each of the relevant efficacy tests are assessed using guidelines given in EN 599-1 and a “biological reference value” (brv) is calculated for each test in terms of the application of preservative required to pass the test. The highest of the brv’s from the tests required for a particular use class is known as the “Critical Value” (CV) of that preservative for the given use class.

The CV is not necessarily the retention requirement. In order to calculate the retention requirement for a preservative the CV can be adjusted. This adjustment is done within a given country to take account of local conditions and expectations.

3.2 Naturally durable wood

The natural durability classes of timber species commonly traded in Europe are given in EN 350-2. These durability classes are based on long term experience and on field performance in UC4 exposure. EN 350-1 describes assessment methods for naturally durable species for which the same experience is not necessarily available and that are not listed in EN 350-2. The assessment of these species is based on EN 252 (ground contact field test), though a laboratory test based on EN 113 (basidiomycete fungi) is permitted to derive a provisional natural durability class which can be used until the field test results become available. Two further technical specifications have been developed by CEN/TC 38 to test natural durability. CEN/TS 15083-1 is a laboratory test against basidiomycete fungi, and CEN/TS 15083 is a laboratory test against soft rot fungi.

4 Guidance on the determination of end use performance of wood products

Certain aspects peculiar to wood products should be taken into account when estimating the service life of construction products and planning the service life of buildings and constructions. These include:

— biological durability: a key factor for wood products in service;

— service conditions: period of wetness of the substrate, and what influences this, is the main factor in determining risk of decay. ISO 21887:2007 [6] defines a system of 'service classes' for wood products called Use Classes;

— insect hazard: damage by wood-boring insects and termites is affected more by whether the insects are present in the geographical region than by the service conditions;

— assessment procedures: standard tests for the biological durability of wood, especially of treated wood products, already exist (EN 599);

— natural variability: as wood is a natural material with large inherent variations, it is more realistic to define broad service classes than precise service life in years.

Broadly, for each Use Class the expected service life is determined by a combination of the biological durability of the timber and the physico-chemical factors that put the products at risk of biological degradation. The intended or designed service life can be met by selecting a timber of suitable biological durability or by reducing or eliminating the factors that put wood at risk of degradation. In practice, service life is usually met by a combination of the two.

By assigning values to these two characteristics it is possible to derive a value equivalent to a service class. This approach is in keeping with the aims of the factor method and compatible with it.

Considering two unique features of wood products more closely:

— Biological durability is the key factor determining performance in different use classes. Existing laboratory and field test methods make it possible to assign a durability rating to any timber product linked to the intended Use Class, assuming a worst-case scenario. Other factors determine the likelihood of the scenario. In assessing the biological durability the principle is to determine performance against reference service products for each use class and service-life period;

— Period of wetness of the substrate is key for the development of timber decay. This is affected by environmental parameters (including design, building physics, exposure, and maintenance) which have a marked effect on performance and vary greatly across Europe. No internationally agreed methods for assessing these parameters exist, but various national approaches based on experience take them into account. Any one of these parameters or a combination thereof can have an over-riding influence on performance.

At present, a single value for each factor should be allocated at a national approval level. This allows national experience for certain products to play a key role. For example, untreated spruce, a non-durable timber, is known to achieve the desired service life when used as painted exterior cladding in the Nordic countries, but this is not always the case in other European countries. Therefore in that region, a high rating can be allocated to the product making it unnecessary to invoke enhanced durability. The national schemes may well follow the ISO methods in detail.

Notwithstanding the above, if factors outside the control of moisture risk exist, such as the risk of wood-destroying beetles or termites, then this invokes the need for enhanced durability or protective design measures to eliminate the risk.

This information concentrates on the biological performance of wood-based products. Although this is a most important aspect, other factors in ISO 15686 also need to be taken into account.

A significant, if not the most significant, challenge is to be able to predict the performance of **products** (e.g. window, woodpole, timber deck, structural beam) from tests that by their very nature do not consider the primary influences of service life such as design, exposure and maintenance. CEN/TC38 tests almost exclusively consider only the **material**, and an idealised material (e.g. preservative treated sapwood), and the primary influence of material resistance not the moisture risk. Termites and insects might present a special case. They have to be present so there is a need to consider the product use location (e.g. South France) and insects and termites as an ‘add on’ to service life prediction. Beyond that we may just accept that the reliable material resistance (durability + permeability) data are the only influence CEN/TC 38 may have over performance classification and service life prediction. In which case our insect and termite tests should have a high predictive ability and be good at classifying the performance of wood and wood-based materials.

The primary two means of delivering performance for a UC3 wood product are design of the product (and its execution in the real building) and the exposure aspects (meso, macro, micro). Design and exposure can be controlled to deliver a wood product that meets a desired service life through elimination of moisture risk. However, it can be difficult to achieve and risks are high of non-conformities (e.g. poor workmanship on installation of the window) which will compromise performance. The third means is the material resistance. For most of our tests we classify the performance of preservative treated wood (the material) not the product. The more complex the construction product the further away from the prediction we are with our tests. The material resistance is a hugely important part of service life modelling so perhaps we can accept that this is all we will achieve – but then we must be sure that how we measure material resistance, against which reference products is appropriate for our needs. We must think of the end user of wood products. The distinction between efficacy and performance is complex and yet subtle. The users understand performance and a helpful structure could be if Tier 1 is efficacy and Tier 2 is the claim for performance.

For SLP models the need is for ranking of resistance and estimate of variability. Our existing methods do not deliver this. An ideal test to inform on service life would be applicable to all wood based materials (preservative treated, naturally durable, modified wood) and be **practical, realistic and fast.**

5 Guidance on utilization and improvement of existing methods to estimate service life

5.1 General

The core work item of WG28 is to consider existing methods and their ability to estimate service life. Are there fundamental changes needed concerning reference products, the methods and time series data, changes to data handling, analysis and interpretation. Ultimately to identify the key gaps and challenges or weaknesses in using existing standards for estimating service life.

5.2 Gap analysis of existing standards in TC38 to inform on service life

Before progressing to review the core test standards a helpful schematic (courtesy of Prof Joris van Acker) shows the structure of what we have and what might be needed.

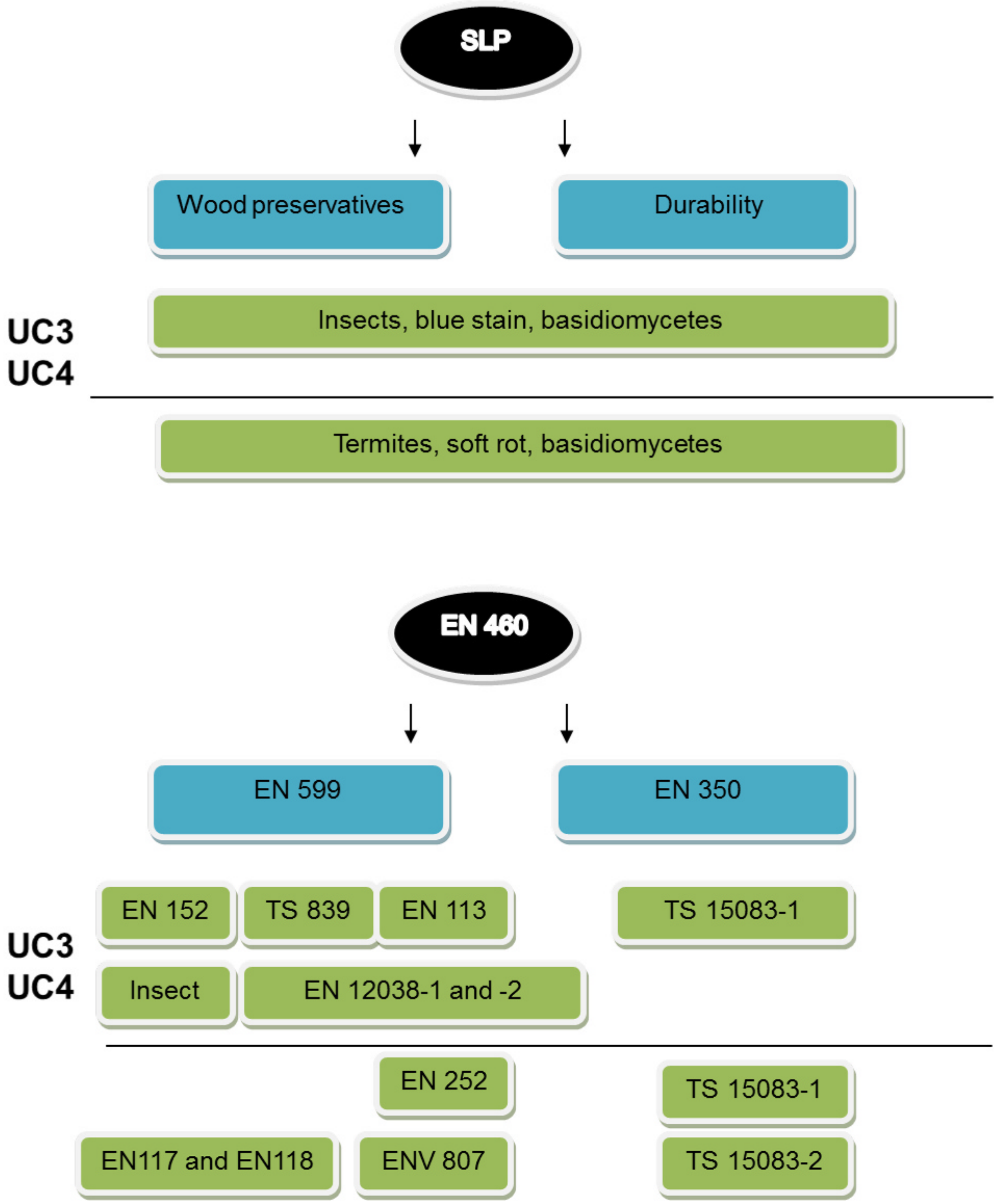

Figure 1

WG28 recommends that EN 460 becomes the primary user interface and is where performance and service life information may be brought together. EN 599 and EN 350 are where the data from the suite of test methods is manipulated to yield service life information. The test methods in green boxes need to produce good quality useful data.

CEN/TC38 tests that mainly focus on efficacy seem to offer little in their present form to inform on performance.

Summary issues recorded when discussing the individual standards in WG28 meetings:

The suite of existing standards has poor fit for:

- modified wood, innovative products;
- wood based panel products (glue line additives);
- insect Growth Regulators;
- wood Polymer Composites;
- systems e.g. in-line preservation and coating.

Other issues are:

- they are not dose response related;
- mixed heartwood and sapwood preservative treated wood in product;
- maintenance and moisture risk not well understood;
- look at real product performance and test data?;
- focus on quick wins in existing suite;
- focus on UC3 and decay (mould, insects, termites);
- recent and on-going research activity (e.g. WoodExter, Woodbuild) has been summarized and exchanged at WG28 meetings;
- CEN/TC38 WGs need access to research findings and WG28 can assist;
- ramifications for environmental performance have to be considered;
- requirements of CPR and input needed.

Specific comments and notes are now presented for key test methods (as identified by WG28):

EN 350

CEN/TS 15083

EN 599

EN 113

CEN/TS 839

ENV 807

EN 152

EN 252

EN 330

EN 46

EN 47

EN 117

EN 118

EN 12038

<table>
<tr>
<td>Standard
EN 350
CEN/TS 15083 etc.</td>
<td>Predictive ability
High? Variability</td>
<td>Materials
Heartwood
(Modified wood?)</td>
<td>CEN TC38
WG21</td>
</tr>
<tr>
<td colspan="2">Reference product
Reference to compare?
Low deviation regional species?
Worst case scenario tests when classifying.</td>
<td colspan="2">Questions? Method change, time series, replicates?
Internal reference linked to UC or product?
Benchmark with well know species (Scots pine heartwood in the Nordics). Regional ref species in Europe that must be compared. Nothing at the moment. One species oak – high variability can be contained but it is difficult – also query relevance to construction industry. Select wood from one forest as reference?
Do we need more wood references? Test different Scots pine? Collect data on variability? And also for products?
EN 350–1 uses Scots pine sapwood and beech as references. 30 %–60 % variation in mass loss. Ref for virulence. Does not use beech in calculations see WG23 doc as it is shown high virulence differences?</td>
</tr>
<tr>
<td colspan="2">Data handling and analysis
Framework for bringing together all durability data for predictive ability.
Statistical analysis needed against a range of properties (distribution and variability)</td>
<td>Weaknesses
Sapwood?
High variability with nat. durability</td>
<td>Questions to WG21
Use condition as sub-sets of UC
Different classification systems why not one?
One species – differing resistance when sourced from different regions (Scots pine + termites)
High variability of tropical species
Conduct faster test with regional species as internal ref.?
Use treated timber sapwood as internal ref.?
Ref could have a distribution of properties to characterize not just one to capture variability and build confidence limits associated with data.
Task Group in WG28 to look at statistics and confidence limits.
EN 350 revision of data underway asking for capture of variability information.
Wood material is part of the product</td>
</tr>
</table>

EN 350

- It could be one document with above ground and in ground sub-sections. It should include surface deterioration of wood rather than just mass loss. The limit state in use for UC3 material in construction is more often the loss of surface character or aesthetic appeal;
- It should pick up the effect of coatings and provide a distribution of performance;
- A round robin test of fungi showed they were good choices. If used to test modified wood products the fungi selection should be verified;
- Reference material of medium durability is needed with high reliability and a standard distribution. The distribution of performance and the reference product chosen would be linked to the use class;
- Probabilistic data for species would provide good benchmark data and connect to the market for wood products;
- Could we use a synthetic wood as our benchmark? Likely to have lower EMC as well which is a problem;
- The data ranking should be different for hardwoods and softwoods.

CEN/TS 15083-1, CEN/TS 15083-2

- Variability and its management is key;
- Statistically more valid to consider the median and issue percentile data with the test results.

<table>
<tr><td>Standard
EN 599–1</td><td>Predictive ability
Indifferent</td><td>Materials
Wood preservatives</td><td>CEN TC38
WG21</td></tr>
<tr><td colspan="2">Reference product</td><td colspan="2">Questions? Method change, time series, replicates?
Includes UV and other physical and chemical deterioration. This is important.
UC 1 and 2 – building model at point of use or during service – risks that are clear and accepted or not. Where is the demand for SLP coming from? Is it structural timber UC2 or cladding UC3?</td></tr>
<tr><td colspan="2">Data handling and analysis</td><td>Weaknesses</td><td>Need? Questions to WG</td></tr>
</table>

<table>
<tr>
<td>Standard
EN 113</td>
<td>Predictive ability
Indifferent
BS 8417 [7] CVs</td>
<td>Materials
M
Preservative treated wood</td>
<td>CEN TC38
WG23</td>
</tr>
<tr>
<td colspan="2">Reference product
Tunnelling bacteria important.
Maybe we keep EN 113 as efficacy std?</td>
<td colspan="2">Questions? Method change, time series, replicates?
Fungal strains OK? How do we know they are relevant to the current situation experienced in construction? They were selected as they could grow in the presence low levels of preservative, meaningful in practice. Woodpole project yielded no single additional fungi.
Cu tolerance – on going think tank in WG23.
More than single point of assessment?
Could be a performance std if we add more replicates? Yes it is possible if collected from industry treated material in a systematic and statistical valid way. Would need to be whole piece – not possible in jar!
University of Gent modified EN 113</td>
</tr>
<tr>
<td colspan="2">Data handling and analysis
Point of failure. Could be more than pass/fail. Grade 1–10 cf. internal controls
Assess classification in CEN/TS 15083.</td>
<td>Weaknesses
WPCs (EN 12038) little experience?
Penetration patterns
Treated heartwood and sapwood mix
Low number of replicates close to toxic limit.
Modified wood
Panel products</td>
<td>Need? Questions to WG
Dose response – indicate efficacy levels. Used to define durability is incorrect. Anything that is not dose response we need something else. CEN/TS 15083 being used to assess modified wood.
Compare all with ASTM, JPI etc.?</td>
</tr>
</table>

EN 113

The fungal strains were considered to present a suitable challenge for the wood treatment. Isolates could be collected from failed stakes and products – EH illustrated the example of ground contact posts in France.

EN 113 in two parts e.g. Part 1 Efficacy test – verify the claim Part 2 Performance deviation test

Can we just say we are certain to a point and beyond that we need to accept that there will be failures? Provide a spectrum of efficacy for the claim?

— Market facing – accept that it will never be 100 % and this will be acceptable. This is normal for building engineering, to apply consequence factors and acceptance criteria as part of the risk management;

— Half way tests – screening Bravery test. The establishment of fungi and getting moisture in to the specimen is highly variable which is largely avoided by running the test for 16 weeks;

— Limited number of replicates to reject if something goes wrong. Some laboratories add more;

— Additional information such as the median (statistically weak in this case). Better to have more replicates to drive confidence in the outcome. This has to be balanced with costs effectiveness of the test;

— Not helpful to have a time series for EN 113 as earlier withdrawal the variability of moisture uptake is high, after 16 weeks the test dries out;

— Could we look at treated material and the untreated reference to gain a percentage improvement in durability in the test? It was considered to be too variable to do this and mass loss criteria could not be translated into percentage improvement;

— Reference materials – ideally there would be lots of reference materials but this would be too onerous to test. WG – could we create a European reference performance database of materials tested in different laboratories that is continuously updated?

— Could a standard reference material be created – a modified wood?

Standard CEN/TS 839	**Predictive ability** Indifferent	**Materials** Preservative treated wood Ready to use products	**CEN TC38** WG23
Reference product Tunnelling bacteria important. Maybe we keep EN 113 as efficacy std?		**Questions? Method change, time series, replicates?** Fungal strains - How do we know they are relevant to the current situation experienced in construction? They were selected as they could grow in the presence low levels of preservative, meaningful in practice. For example, the Woodpole project yielded no single additional fungi. Cu tolerance – on going think tank in WG23. Do we need more than a single point of assessment? Could be a performance std if we add more replicates? Yes it is possible if collected from treated material industry in a systematic and statistical valid way. Would need to be whole piece – not possible in jar!	
Data handling and analysis Point of failure. Could be more than pass/fail. Grade 1–10 compared to internal controls Assess classification in CEN/TS 15083.		**Weaknesses** WPCs (EN 12038) little experience? Penetration patterns Treated heartwood and sapwood mix Low number of replicates close to toxic limit. Modified wood Very little experience Modified RAL EN 113 method It is difficult method	**Questions to WG23** Dose response – indicate efficacy levels. Used to define durability is incorrect. Anything that is not dose response we need something else. CEN/TS 15083 being used to assess modified wood. Compare all with ASTM, JPI Extra experience is needed so kept as TS at the moment. More and more difficult to have round robin trials and independent input. Does not give the same result as EN 113 to give the same efficacy. Paper from UK on cf. std products. Method changed!

— Questions that WG28 would like to be considered by WG23 concerning CEN/TS 839:

  — CV is higher than for EN 113;

  — It works in France – can be difficult to find the decay fungi but a suggestion that coloration works for visualizing fungi;

  — Can we get a shorter test?;

  — It links to end use but over estimates requirements in many cases – works well for window frames;

  — Not easy to translate to SLP information as we would need more efficacy and final product assessment to pick up the moisture risk aspect.

Standard ENV 807	**Predictive ability** Indifferent Limited	**Materials** Preservative treated wood Sub toxic levels used.	**CEN TC38** WG23
Reference product Copper Chrome		**Questions? Method change, time series, replicates?** Good time series could be prolonged to create fast EN 252? Insufficiently exploited time series. Looking for a level being reached at a certain time. 40weeks could be added if 32 weeks insufficient	
Data handling and analysis Accommodate all evaluations in an informative annex. Allowing EN 599 to set brv requirements for ENV 807.		**Weaknesses** Significant assumptions in sub toxic and what might work in practice Unable to cope with link between laboratory and field Excludes basidiomycetes so links with reality difficulty. Panel products	**Questions to WG23** Review of data alongside TMC, BAM fungal cellar? How could be better exploit the time series?

— ENV 807:

— A well designed test method with data available in a time series - but complicated;

— Issues around the size performance ratio of stakes. Small stakes mean that not enough arrive at pH balance that would occur in large stakes and posts – copper would precipitate;

— Larger specimens would have very low mass losses which is problem;

— ENV 807 should consider having MoE measurement included as for natural durability;

— Efficacy in soft rot ENV 807 should be compared to TMC and BAM fungus cellar.

<table>
<tr><td>Standard
EN 152</td><td>Predictive ability
Indifferent</td><td>Materials
Preservative treated wood</td><td>CEN TC38
WG23</td></tr>
<tr><td colspan="2">Reference product</td><td colspan="2">Questions? Method change, time series, replicates?
Staining is a critical limit state for UC3
Mould – important limit state (include in EN 350?) for exterior wood. Not captured at the moment.
Woodbuild mould and limit states on spruce (Lund) and H. Viitanen’s thesis.</td></tr>
<tr><td colspan="2">Data handling and analysis</td><td>Weaknesses
Efficacy of product on SPS. Determine efficacy and transfer.
Panel products</td><td>Questions to WG23
Not performance predictive critical, for whole product.</td></tr>
</table>

— EN 152

  — A good test method focusing on blue stain with a pass/fail criteria;

  — An equivalent is needed for uncoated wood and EN 350;

  — There is a RAL field test of product underway that would be helpful here;

  — A good test as it includes weathering and UV and has recently been updated;

  — It should be connected to the EN 927 wood coatings test series.

<table>
<tr><td>Standard
EN 252</td><td>Predictive ability
High (Fence posts, vineyard stakes, wood poles)</td><td>Materials
Preservative treated wood</td><td>CEN TC38
WG25</td></tr>
<tr><td colspan="2">Reference product
Scots pine sap
CCA 2 and 9kg
Outdated – any suggestions?</td><td colspan="2">Questions? Method change, time series, replicates?
Time series good
Covers naturally present organisms</td></tr>
<tr><td colspan="2">Data handling and analysis
Data analysis not time series focused single point. Interpretation of early signs (Pia in Woodexter) looked at time series.
‘Tap and prod’ subjective assessment
Other means (mechanical, qPCR)</td><td>Weaknesses
Field site significant and mode of failure differences
Slow
Single point
Panel products</td><td>Questions to WG25
Consider a time series data analysis
Early indication of decay or early limit states
Way of interpreting it that doesn’t involve expert judgement?
Need something practical</td></tr>
</table>

— EN 252

  — The standard for material durability;

  — Not many tests on hardwoods;

  — Reliance on natural durability laboratory tests there is an imbalance;

  — Ranked performance;

  — Work in Finland on woodpoles inspected at 25 years for their first check– to be linked to EN 252;

  — Pia Larson’s (SP) work on early signs and statistics and evaluation of points to median rating of 2 needs further consideration;

  — Purslow’s IRG paper on predicting ultimate service life from number of failed stakes data;

- Statistics critical to capture variability in fields;
- Must verify decay organisms in fields and need to assess the aggressiveness of the test field;
- References of CC and CCA and treated wood;
- Natural durability of wood species ranked performance.

<table>
<tr><td>Standard
EN 330</td><td>Predictive ability
High (Window joinery)</td><td>Materials
Preservative treated wood</td><td>CEN TC38
WG25</td></tr>
<tr><td colspan="2">Reference product
TBTO
Outdated?
Relevance?
Chemically stable preservative</td><td colspan="2">Questions? Method change, time series, replicates?
‘Real situation’ coated joints – stop egress of water
Artificial
Ability of industry to put products on market – what is the worst case? UC 3 uncoated test
Lack of uncoated UC3 field test is an inadequacy. What about UC3 field – lap-joint, double layer?</td></tr>
<tr><td colspan="2">Data handling and analysis
Time series</td><td>Weaknesses
Very slow</td><td>Questions to WG25
Reference method not just preservative.
Relative protective effect.
UC3 uncoated is major use and we have nothing of reliable experience test method. Use of coating protection in BPD applications?</td></tr>
</table>

- EN 330
  - The wetting and control of moisture ingress is key;
  - Local climate is reflected in ground proximity tests;
  - EN 330 not widely used;
  - Needs to allow a range of test methods for UC3;
  - Need for benchmarking;
  - Dose (function of T, MC and daily values) response of fungi (Brischke);
  - 0-4 mean decay rating;
  - Service life in different regions – combine to building physics;

- Complex and costly but better quality data;
- Could we have a database of geographic impacts?;
- Leaching of extractives is significant for natural durability – we test raw material not pre-weathered material as we do in the lab efficacy tests. Limited experience of whether this is significant an effect.

<table>
<tr><td>Standard
EN 46–1
EN 47</td><td>Predictive ability
High</td><td>Materials
Preservative treated wood</td><td>CEN TC38
WG24</td></tr>
<tr><td colspan="2">Reference product</td><td colspan="2">Questions? Method change, time series, replicates?
Insects and termites are present or not.
It needs to be an add on factor for the performance classification or SLP model not an inherent driver for performance</td></tr>
<tr><td colspan="2">Data handling and analysis</td><td>Weaknesses
Panel products</td><td>Questions to WG24</td></tr>
</table>

— EN 46-1 and EN 47

  — UC1 and UC2 – some in cladding UC3;

  — Not a big problem outdoors EN 599 defers such that if termites then wood boring insects will be OK.

<table>
<tr><td>Standard
EN 117</td><td>Predictive ability
High</td><td>Materials
Products of preservative pre-treated wood at risk from termites</td><td>CEN TC38
WG24</td></tr>
<tr><td colspan="2">Reference product</td><td colspan="2">Questions? Method change, time series, replicates?
Termites are there or not.
It needs to be an add on factor for the performance classification or SLP model not an inherent driver for performance.
Geographical
Species variability</td></tr>
<tr><td colspan="2">Data handling and analysis</td><td>Weaknesses
IGRs
Panel products</td><td>Questions to WG24
Repellency impact of treatments
Did As repel or Cr harden wood
Cu organics termites now tunnel though it?</td></tr>
</table>

<table>
<tr><td>Standard
EN 118</td><td>Predictive ability
High</td><td>Materials
Products of superficially treated wood at risk from termites</td><td>CEN TC38
WG24</td></tr>
<tr><td colspan="2">Reference product</td><td colspan="2">Questions? Method change, time series, replicates?
Termites are there or not. It needs to be an add on factor for the performance classification or SLP model not an inherent driver for performance
Geographical
Species variability</td></tr>
<tr><td colspan="2">Data handling and analysis</td><td>Weaknesses
IGRs
Panel products</td><td>Questions to WG24
Repellency impact of treatments
Did As repel or Cr harden wood
Cu organics termites now tunnel though it?
Round robin on choice tests</td></tr>
</table>

— EN 117 and EN 118

  — Big differences between choice and no choice tests?;

  — Species differences - should we stick with flavipes/grassei?;

  — Introduce a mass loss measure for homogeneous materials;

  — Difficult subject. Example of Reunion study classification that showed none of the species were resistant to termites – grazed to a rating of 3. Yet some of the species work in the field!;

  — Mass loss is commonly used in other standards;

  — Link to EN 252 field test;

  — No field test – depends where test site is…;

  — Repellent effect of pine until terpenes evaporate (2 years) and *Pinus sylvestris* – Nordic sourced is attacked and French sourced is attacked later in service in France.

  — Many vagaries to manage!

— EN 12038

  — 3.1 moisture performance and character focus for wood based panels;

  — Could be prEN 113-2 vermiculite overlay could be preconditioned – weathering to get rid of phenolics and extractives;

  — Critical performance of the edges of panels and need to edge seal;

  — The installation quality and coatings make this a joinery type product. Glue line additives are critical and WPCs need to be accommodated.

6 Actions

6.1 General

Work Items should be initiated in WG21, WG23, WG24, WG25 to consider the questions raised in this document. The work items will be extracted for ease of assimilation by working groups.

Suggestions are as follows:

6.2 WG21

EN 350, CEN/TS 15083, EN 599.

Consider your test methods in the light of SLP models needing a ranking of material resistance and an estimate of variability.

Consider alternative benchmark species to include in natural durability testing and their link to UC and possible regions in Europe.

Gather information on variability of data to improve the statistical analysis of data. Include a measure in the ranking of the material resistance and degree of variability. This might be median and percentile data for example.

Consider including surface deterioration and other effects in tests to link to real end use.

6.3 WG23

EN 113, CEN/TS 839, ENV 807, EN 152.

Consider your test methods in the light of SLP models needing a ranking of material resistance and an estimate of variability.

Can the existing standards be modified to have better fit for modified wood, innovative products, Wood based panel products (glue line additives), Wood Polymer Composites?

Could EN 113 be more of a performance standard with introduction of time series assessments and more replicates?

Could we have reference materials for different UC?

How can we better exploit the time series of ENV 807 and review alongside EN 252 are there studies that compare ENV 807 with BAM fungal cellar, terrestrial microcosm (TMC) and real life?

Can EN 152 be modified to give a test for uncoated wood – surface aesthetic and mould very important for UC3.

EN 12038 could be a vermiculite overlay of EN 113 (e.g. prEN 113-2?).

6.4 WG25

EN 252, EN 330.

Consider your test methods in the light of SLP models needing a ranking of material resistance and an estimate of variability.

Are there more appropriate regional reference materials.

Continue work on analysing data to reach certain points (not just single point failure) and look at median and percentile values.

Early indications of performance would be most beneficial.

Need to allow a range of test methods for UC3 – critically inadequacy in what we have. Should the lap-joint continue? Should EN 330 continue? What of the double layer test is it UC3?

6.5 WG24

EN 46, EN 47, CEN/TS 1187, EN 118.

Consider your test methods in the light of SLP models needing a ranking of material resistance and an estimate of variability.

Insects and termites are either present or not so it needs to be an add on factor not a driver of performance. Consider how a factor for insect might be included.

Do we need a field test for termites?

Other issues for all to consider are:

— Is material resistance all we can deliver?;

— Do we understand variability in our data?;

— Can CEN/TC 38 tests become dose response related;

— Mixed heartwood and sapwood preservative treated wood in product;

— Maintenance and moisture risk not well understood;

— Look at real product performance and test data to bridge our knowledge;

— Focus on quick wins in existing suite;

— Focus on UC3 and decay (mould, insects, termites) – field test deficiency;

— CEN /C 38 WGs need access to research findings - WG28 can assist;

— Ramifications for environmental performance have to be considered;

— Requirements of CPR and input needed.

Responses considered by the CEN/TC38 working groups should be presented back to Plenary in 2012.

7 Acknowledgements

Thank you to the following for providing text:

— Finn Englund (SP, Sweden) - Simon Forster (Arch, UK) - Joris Van Acker (UniGent, Belgium).

Thank you to WG28 delegates for contributing to the debate and discussion to date in the true spirit of CEN TC38.

Dr Ed Suttie

WG28 Convenor

11 November 2011

Bibliography

a) References in the text;

[1] ISO 15686, *Buildings and constructed assets — Service life planning*

[2] ACTION C.O.S.T. E37. Sustainability through new technologies for enhanced wood durability. TFPC http://www.cost.eu/COST_Actions/fps/Actions/E37

[3] FINAL REPORT T.F.P.C. 29-12-2009 F. Englund, SP Trätek. http://www.cost.eu/COST_Actions/fps/Actions/E37

[4] WoodExter website www.woodwisdom.net/mm_files/do_849/WoodExter_ProjectOverview.pdf

[5] Thelandersson S et al (2011). Quantitative design guideline for wood in outdoor above ground applications. International Research Group on Wood Protection, IRG Doc. 11-20465

[6] ISO 21887:2007, *Durability of wood and wood-based products — Use classes*

[7] BS 8417:2011, *Preservation of timber — Recommendations*

b) CEN/TC38 Standards referred to in the text:

[8] EN 20-2, *Wood preservatives - Determination of the protective effectiveness against Lyctus brunneus (Stephens) - Part 2: Application by impregnation (Laboratory method)*

[9] EN 47 *Wood preservatives - Determination of the toxic values against larvae of Hylotrupes bajulus (Linnaeus) - (Laboratory method)*

[10] EN 49-2, *Wood preservatives - Determination of the protective effectiveness against Anobium punctatum (De Geer) by egg-laying and larval survival - Part 2: Application by impregnation (Laboratory method)*

[11] EN 73, *Wood preservatives - Accelerated ageing of treated wood prior to biological testing - Evaporative ageing procedure*

[12] EN 84, *Wood preservatives - Accelerated ageing of treated wood prior to biological testing - Leaching procedure*

[13] EN 113, *Wood preservatives - Test method for determining the protective effectiveness against wood destroying basidiomycetes - Determination of the toxic values*

[14] EN 117, *Wood preservatives - Determination of toxic values against Reticulitermes species (European termites) (Laboratory method)*

[15] EN 152-2, *Wood preservatives — Laboratory method for determining the protective effectiveness of a preservative treatment against blue stain in service — Application by methods other than brushing*

[16] EN 252, *Field test method for determining the relative protective effectiveness of a wood preservative in ground contact*

[17] EN 275, *Wood preservatives - Determination of the protective effectiveness against marine borers*

[18] EN 330, *Wood preservatives - Determination of the relative protective effectiveness of a wood preservative for use under a coating and exposed out-of-ground contact - Field test: L-joint method*

[19] EN 350-1, *Durability of wood and wood-based products - Natural durability of solid wood - Part 1: Guide to the principles of testing and classification of the natural durability of wood*

[20] EN 350-2, *Durability of wood and wood-based products - Natural durability of solid wood - Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe*

[21] EN 351-1, *Durability of wood and wood-based products - Preservative-treated solid wood - Part 1: Classification of preservative penetration and retention*

[22] EN 599-1, *Durability of wood and wood-based products — Efficacy of preventive wood preservatives as determined by biological tests — Specification according to use class*

[23] ENV 807, *Wood preservatives - Determination of the effectiveness against soft rotting micro-fungi and other soil inhabiting micro-organisms*

[24] EN 12038, *Durability of wood and wood-based products — Wood-based panels — Method of test for determining the resistance against wood-destroying basidiomycetes*

[25] CEN/TS 15083-1, *Durability of wood and wood-based products - Determination of the natural durability of solid wood against wood-destroying fungi, test methods - Part 1: Basidiomycetes*

[26] CEN/TS 15083-2, *Durability of wood and wood-based products - Determination of the natural durability of solid wood against wood-destroying fungi, test methods - Part 2: Soft rotting micro-fungi*

c) Other references

[27] AARSETH L.-I., HOVDE P.J. (1999). A stochastic approach to the factor method for estimating service life. 8th International Conference on Durability of Building Materials and Components, Vancouver, Canada

[28] BOURKE K., DAVIES H. *Factors affecting service life predictions of buildings. BRE Report 320.* Garston. BRE Bookshop, 1997

[29] BRISCHKE C., FRÜHWALD HANSSON E. (2011): Modeling biodegradation of timber - Dose-response models for above-ground decay and its climate-dependent variability, International Conference on Structural Health Assessment of Timber Structures, SHATIS '11, June 16-17, 2011, Lisbon, Portugal. Document No. 032

[30] Brischke, C.; Frühwald Hansson, E.; Kavurmaci, D.; Thelandersson, S. (2011): Decay hazard mapping for Europe, Stockholm: The International Research Group on Wood Protection, IRG/WP/11-20463

[31] Brischke, C.; Welzbacher, C.R.; Meyer, L.; Bornemann, T.; Larsson-Brelid, P.; Pilgård, A.; Frühwald Hansson, E.; Westin, M.; Rapp, A.O.; Thelandersson, S.; Jermer, J. (2011): Service life prediction of wooden components – Part 3: Approaching a comprehensive test methodology, Stockholm: The International Research Group on Wood Protection, IRG/WP/11-20464

[32] CPD Levels and classes in the Construction Products Directive: Guidance Paper E, 2002

[33] [Derbyshire H., Carey J. Evaluating joinery preservatives – performance prediction using EN 330 L-joints. BRE IP 2/01. Garston. BRE Bookshop, 2001

[34] Durability and the Construction Products Directive: Guidance Paper F, 2004

[35] FRANCIS L., SWAIN A., MORRELL J. *Predicting the decay resistance of timber above-ground: 2. When can reliable field data be obtained? IRG Doc 07-20368*. International Research Group on Wood Protection, Stockholm, Sweden, 2007

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™