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Durability of wood and wood-based products — Recommendations for measurement of emissions to the environment from treated wood in service

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National foreword

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Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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Durability of wood and wood-based products - Recommendations for measurement of emissions to the environment from treated wood in service

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

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Contents

Foreword

This document has been prepared by CEN /TC 38, "Durability of wood and wood-based products", the secretariat of which is held by AFNOR.

The status of this document as CEN Report has been chosen because the most of its content is a review of methods of measurement of emissions from preservative treated wood in order to stimulate the discussion of the test parameters and the test methods for emissions to be retained.

Introduction

The regulatory control of biocides and biocidal products (as defined under the UE Directive 98/8/EC, including wood preservatives, requires increasing amounts of environmentally related information on which to base decisions.

In the case of wood preservatives (product type 8) this includes the provision of data concerning wood preservative treated articles.

This data is used to assess whether there is an unacceptable environmental impact likely to arise from the use of the treated timber product.

Such a risk assessment has to consider potential releases to all environmental compartments, namely air, soil, surface water, groundwater and sediment.

Many uses of wood preservative products are intended to extend the natural durability based expectation of service life, sometimes in the order of several decades.

It is therefore necessary to have a means of determining not only absolute values for potential emissions to the environment but perhaps more importantly the fluxes, or rates of emission during the course of time. They should be representative.

That is to say they should represent the emissions from in service sized pieces of treated wood.

Flux rates and profiles can then be inserted into mathematical models usually based on defined scenarios .

Such determinations of emission rates will also be invaluable in the development of new products because they will enable the researcher to identify early in the development of the product whether there are potential problems with the product in its areas of intended use.

It is quite impractical to mimic all of the biotic and abiotic factors present the natural environment in the laboratory. It has to be decided if a means can be found which will take into account as many as possible of these factors together with the large variation in climate and socio-economic factors present in Europe. Is it possible to conceive of a “surrogate” environment into which to determine emissions?

If it is believed that there is a potential for creating EN standards in this area it is vital that the methods can be reproduced in any suitably equipped laboratory, whether government, institute or industry. The methods should also not be costly, but must be cost effective.

Having produced an emission this should then be characterised. This might be through chemical analysis of the active substances, substances of concern and relevant metabolites; or by some other tests which can indicate ecotoxicological effects, for example so-called “soup testing”. The next steps would be to identify the environment ‘belonging’ to the treated component and to characterise the physical-chemical behaviour of the active substances, substances of concern and relevant metabolites in order give an answer about their bioavailability in a given environment.

These aspects are being considered by other expert groups in the EU and the OECD and should not be considered part of the remit for CEN/TC 38 to produce standards.

Any proposed standards should also take into consideration of the Technical Guidance Documents (currently being revised) in place for the Biocidal products Directive (98/8/EC), and the New and Existing Substances Regulations

1 Scope

This CEN Report is intended to stimulate discussion of the test parameters and the test methodologies to achieve a consensus of opinion. This should allow test methods for emissions from preservative treated wood to be prepared and tested before they become standards. The standards will allow competent authorities and manufacturers of wood preservatives to comply with the requirements of the Biocide Products Directive(BPD.)

2 Framework of cases for determination of needs for emission test methods

The following matrix has been established taking into account different documents and works (see [2] to [7] included).

The aim is to try to link the different end-use categories for treated timber in service, with the Biological Hazard Classes on one hand and the exposed environmental compartment on the other hand; through this, it is possible to list the specific cases of emissions from treated timber to the environment (see Table 1).

Table 1 — Specific cases of emissions from treated timber to the environment

Targets	Biological Hazard Classes	Use categories and typical scenarios	Exposed Environmental Compartment	Emission data needed	First Exposed Non targets
Insects	HC 1	Internal non structural Bedroom floor	Indoor Air	**Emission to indoor Air**	**Human**
Insects + Fungi	HC 2	Internal structural Roofing timber	Indoor Air	**Emission to indoor Air**	**Human Environment** Indoor air organisms (Bats)
Insects + Fungi	HC 3	External above ground and above fresh-water House cladding Fence rails Jetty planks	Soil by run-off rain water Fresh water by run-off rain water	**Leaching by rain water** **Leachate migration into soil /surface water**	**Environment** Soil organisms Fresh water organisms
Insects + Fungi	HC 4 a	External in ground contact Transmission Pole Fence post	Soil by run-off rain water Soil by direct contact	**Leaching by rain water + Leachate migration into soil + Direct emission into soil**	**Environment** Soil organisms
	b	External in freshwater contact Jetty in a lake Poles Sheet Pilings	Fresh water by run-off rain water Fresh water by direct contact	**Leaching by rain water + Direct emission into water**	**Environment** Fresh water organisms Ground water
Insects + Fungi + Marine borers	HC 5	External in seawater contact	Sea water by run-off rain water Sea water by direct contact	**Leaching by rain water + Direct emission into sea water**	**Environment** Sea Water organisms

There are two ways to approach the question of the need for emission data to feed in the exposure assessment calculations in the different scenarios.

The first approach would be to consider globally the emission from the commodity to the environment without any differentiation of all the mechanisms. This would mean to have one test method for each of the commodities listed in the reference scenarios ; or, if it is possible to define a worst case scenario for each use category or a model case, then one test method would be needed for each of the use categories where the conditions are strongly different ; only may be the cases of HC 1 and HC 2 could be combined (emissions from wood to indoor air) , as well as HC 4 b and HC 5 where the difference is only the kind of water. This approach looks rather difficult to handle in a systematic way of producing emission data, as the list of tests needed might change if scenarios are revised.

The second approach would be to consider each possible mechanism of emission to obtain elementary emission data, and then to combine these (sum up) to calculate the global emission of one commodity to a given environmental compartment in a scenario.

In this second approach, the list of types of emission data needed is the following :

- emission from treated wood to indoor air ;
- leaching from treated wood by rain water ;
- rain water leachate migration into soil/water ;
- direct emission from wood into soil/ground water ;
- direct emission from wood into water (fresh water or sea water).

3 Review of methods of measurement of emissions from preservative treated wood

3.1 General

Methods are required for the measurement of emissions from preservative treated wood in service. This document reviews a number of methods which have been used to measure emissions from preservative treated wood under laboratory conditions. These methods do not include tests using small specimens or sawdust, or for measuring emissions from wood during drying after treatment.

The methods are for wood in service in biological HC 2 to HC 5, with exposure to the environmental compartments of air, soil, ground water beneath soil, fresh water and sea water.

3.2 Air

It is possible that treated wood used in a building could affect air, indoor air, and treated wood outside buildings could affect outdoor air. The Existing Substances Directive uses a value of 0,01 Pa as the vapour pressure threshold. Below this vapour pressure a substance is not considered to be volatile and emissions to air are not considered in the risk assessment. If the substance has a vapour pressure greater then 0,01 Pa, the substance is considered sufficiently volatile to evaporate and produce a concentration in air. The effect of that concentration should be considered in a risk assessment. The concentration is used in an equation which predicts deposition on to surface water and the resulting concentration in the surface water (Predicted Environmental Concentration) assessed for the risk to aquatic organisms by dividing the PEC by the PNEC (Predicted No Effect Concentration) from an ecotoxicological test organism (e.g LD_{50} *Daphnia*).

If the PEC / PNEC ratio is greater than 1, there is a potential environmental risk and the tiered approach allows the PEC to be measured, rather than calculated. As it is not possible to measure the concentration in surface water which is solely emitted from treated wood, and the emissions from treated wood are likely to be affected by many parameters, the actual emission from treated wood could be measured.

The ‘Metre cube box’ method has been used for the measurement of formaldehyde emission from wood. The principle of the test is realistic in that treated wood could be placed in the chamber at a defined temperature and air at a defined flow rate can be passed over it. Any volatile materials at the temperature of the test will evaporate and pass out of the chamber. The air will then have to be tested for its environmental effects. If the active ingredient can be analysed, then it will have to be extracted from the air and chemically analysed. The result can be converted to an amount of active ingredient emitted in $mg/m^2/day$.

If the active ingredient cannot be analysed, or all of the substances emitted from the wood need to be assessed for their environmental effect, and not just the active ingredient of the wood preservative, then the outlet air will have to be used in a test which measures the environmental effect of air. It is probably outside the scope of CEN TC/38 Working Group 25 to suggest a suitable test. The OECD Biocides programme is considering methods of ecotoxicological testing and are considering this issue.

Note that the vapour pressure of 0,01 Pa is the vapour pressure of the components *in the dry wood* and not of the components in the treating solution. It is unlikely that any of the components of current wood preservatives used indoors have components which have a vapour pressure in dry wood of greater than 0,01 Pa, so this test is unlikely to be required in support of a wood preservative to comply with the data requirements of the BPD.

Meyer and Boehme (1997) (see |13]) determined formaldehyde emission from solid wood using a specially designed chamber of 1 m^3. During testing, the temperature was (23 ± 1) °C and the relative humidity was (45 ± 5) %. The air exchange rate was fixed at 1 h^{-1}. The chamber was loaded with four solid wood samples measuring 500 mm by 250 mm by 20 mm, giving a total surface area capable of emission of 1 m^2 (neglecting the edges). Thus, the ratio of air exchange rate to loading was 1. These test conditions were in accordance with specific provisions (Chemikalien –Verbotsverordnung, 1993) (see [9]). The sampling period was 50 min and the test ran for 15 days. Concentrations of 2µg/kg to-9 µg/kg formaldehyde were measured.

Van Eetvelde and Stevens (1993) (see [18]) used a 7,9 l column containing a specimen of meranti 55cm x 6cm x 1 cm, coated with preservative, and exposed for 48 h or 96 h to an air flow rate of 2 l/min. The ratio of wood volume to air volume is 1:24 and the wood surface area to air volume is 1: 10. Air changes are 16 changes per hour. The emission rate for dichlorofluanid applied in a primer-type formulation at 80 g/m^2 after 48 h drying, emitted 2,6 µg/m^2/h over the first 24 h at 40 °C. This is equivalent to an emission rate of 0,06 mg/m^2/day.

Wu and Milota (1999) (see [20]) used a 1m^3 laboratory kiln connected to two sets of condensers to cool the exhaust air and to collect water. The quantity of wood (Douglas fir) was 20 boards, 17,.3 cm long, 42mm x 147 mm cross section. The temperature and humidity were chosen to simulate kilning schedules at temperatures from 71,1 °C to 93,3 °C using air at ambient temperature and humidity flowing at 2l/min for 48 h. Emissions were 0,70 to 0,84 g/kg oven dry wood, equivalent to 0,00024 mg/m^2/day. The ratio of wood volume to air volume is 1:46, and the wood surface area to air volume is 1: 63. Air changes are 0,12 changes per hour.

The European Wood Preservative Manufacturers Group (EWPMG)has proposed a test using a 1 m^3 box . The method uses (23 ± 1) °C and a relative humidity of (45 ± 5) %. The air exchange rate is 1 h^{-1}. The chamber is loaded with wood having a surface area of 1 m^2 so the ratio of air exchange rate to loading is 1. The rate of emission in mg/m^2/day should be determined over 0 day to 10 days, and 10 days to 100 days.

In the Organisation for Economic Co-operation and Development (OECD) emission scenario the ratio of wood surface area (205 m^2) to receiving compartment volume in the roof (227 m^3) is 1:1,1. If the 1 m^3 box is acceptable, the test parameters to be decided are wood dimension and surface area, air temperature and humidity, air changes per hour, duration of test and sampling times.

A research report in the context has been published in "UBA-Texte (51-99)" as "BAM-Forschungsbericht : Entwicklung eines standardisierbaren Prüfverfahrens zur Bestimmung des Eintrages von Holzschutzmittel-Wirkstoffen aus behandeltem Holz, Altholz und daraus hergestellten Holzwerkstoffen in die Luft". The report includes the results of emission measurements with regard to Lindan, Furmecyclox, Dichlofluanid, Permethrin, Tebuconazol, Propiconazol taking into account also different types of emission test chambers. Extracts of this report are also published in [23], [24] and [25].

3.3 Above Ground

The environmental risk of preservative treated wood in service out of ground contact is considered to be soil or surface water. For example the components of a fence or deck which are above soil but not in contact with the soil, and the components of a jetty or fisher cabin which are above water, but not in contact with it.

Stilwell and Gorny (1997) (see[16]) measured the amount of Cu ,Cr and As beneath seven treated decks in service and compared the concentrations with soils samples not beneath the deck. The decks ranged in age from 4 months to 15 years. The average contents (mg/kg) in soil beneath decks were Cu 75 mg/kg , Cr 43 mg/kg, As 76 mg/kg, and the control soils were Cu 17 mg/kg, Cr 20 mg/kg and As 4 mg/kg. The Cu, Cr and As emissions can be calculated from the data in the paper (Table 2). The emission is higher in the first four months, and decreases with time so that the Cu, Cr and As levels beneath the 15 years deck are close to background levels. The level of emission is less than 4 mg/m^2/day.

Table 2 — Cu, Cr and As emissions calculated from Stilwell and Gorny (1997), (see [16])

Years in service	Minimum : Minimum in soil beneath deck minus minimum in control soil (mg/m²/day)			Maximum : Maximum in soil beneath deck minus maximum in control soil (mg/m²/day)		
	Cu	Cr	As	Cu	Cr	As
0,3	2,,05	0,68	0,18	9,82	1,60	3,54
2	0,38	0,10	0,12	1,64	1,85	2,94
5	0,27	0,03	0,43	1,58	0,52	1,24
7	0,23	0,09	0,41	1,08	0,90	3,18
7	0,16	0,09	0,54	2,55	1,17	2,07
8	0,39	0,10	0,40	3,28	1,12	2,95
15	0,03	0,02	0,02	0,15	0,06	0,35

Cooper and Ung (1997) (see [10]) measured Cu ,Cr and As in the water collected from fence and deck units. The 6” x 1” fence boards and 2” x 6” decking were treated with 2% CCA-C, fixed at 21 °C or at 60 °C with high humidity. The boards were leached for 12 cycles of accelerated spray exposure with recirculating water. The concentration of Cu, Cr and As was measured in the water. The boards were then made up into fence or deck units and exposed outdoors and above ground to natural weathering. Water running off the units was collected and analysed after 4 months exposure and 2 years exposure. See Table 3. The highest concentration was 2,40 mg/kg Cu from 21 °C fixed fence boards. After 4 months the highest concentration was 4,91 mg/kg Cu , and after 2 years, the highest concentration was 3,74 mg/kg Cu from the same fence boards. After 2 years, copper was 0,38 mg/kg to 3,74 mg/kg, Cr 0,2 mg/kg to 1,89 mg/kg and As 0,17 mg/kg to 3,06 mg/kg.

Table 3 — Concentration of Cu, Cr As in spray water and run-off water from CCA treated fence and deck components and units

	Fixation at 21 °C			Fixation at 60 °C .High humidity		
	Cu mg/kg	Cr mg/kg	As mg/kg	Cu mg/kg	Cr mg/kg	As mg/kg
Fence						
Spray water Concentration	2,40	0,90	1,95	1,38	0,23	1,05
Average Concentration 0 month to 4 months	4,91	1,16	2,79	5	1,11	2,58
Average Concentration 4 months to 2 years	3,74	1,89	3,06	3,51	1,89	2,80
Deck						
Spray water Concentration	1,61	1,37	1,90	1,22	0,64	1,35
Average Concentration 0 month to 4 months	1,92	,63	1,68	1,63	0,63	1,51
Average Concentration 4 months to 2 years	0,81	0,47	1,66	0,38	0,2	0,17

The EWPMG have proposed a test using a 5 cm x 5 cm test specimen, 15 cm long. One face is sprayed with water (75 ml per day, 5 days per week) to simulate rainfall equivalent to 1400 mm rain per year. The run-off water is collected and analysed, or could be used in ecotoxicological testing.

The effect of light on wood exposed out of ground contact can be important in determining emission rate, and should be simulated in a laboratory test. These tests did not use artificial light.

The author has used preservative treated panels, 400 mm x 97 mm wide, 20 mm thick, exposed to natural weathering outdoors. They are exposed vertically, with only the front face open to exposure. A collector beneath the panel collects run-off water. This experimental set up allows the rate of emission in mg/m^2/day to be determined over 0 day to 10 days and at intervals. The test ran for 66 weeks. The emission rate appeared to decline with longer exposure times but there were peaks of emission in periods of high rainfall, several months after exposure.

The weatherometer is a standardised test for wood exposed out of ground contact and could be adapted to enable to collection of emissions from treated wood. The important requirement is for a natural and realistic exposure regime, not an accelerated test which is likely to be more severe than experienced by wood in service.

The test parameters which would need to be decide are the dimensions of the test specimen, how realistic rainfall would be applied to it, defining what is realistic rainfall in terms of droplet size, frequency and duration. Also the need for drying periods and the duration of wetting and drying periods, and how light can be simulated realistically. The rate of emission in mg/m^2/day should be determined over 0 day to 10 days, and 10 days to 100 days.

Note the variability of the results in the published papers. The test protocol should allow a means of calibrating the test method and allowing for variability in test results. Alternatively, a range would have to be used in subsequent risk assessments. The use of ranges of values (mean, median, 90th percentile etc) as emission values, rather than one value in mg/m^2/day still needs to be addressed, although not as part of these methods.

3.4 Soil Columns

Once an emission has been clected from wood above ground, its effect on soil can be determined. Although this is a major requirement of the BPD, it may be outside of the scope of these methods to standardise the testing of emissions in soil. Perhaps reference could be made to existing standards (e.g. OECD 106 for measuring soil absorption, or ecotoxicological test using earthworms). However, the effect of wood preservatives in soil have been investigated, usually using soil columns or lysimeters.

Peek, Klipp and Brandt (1993) (see [14]) used soil which had passed through a 2mm sieve, in a soil column 25 mm diameter, 250 mm deep, wetted daily with 50 ml of demineralised water.

Holland and Orsler describe two techniques for determining the absorption of wood preservatives in soil. The method described in OECD guidelines uses 3 g of soil and 15 ml of preservative agitated gently and sampled after 1 h, 2 h, 3 h, 24 h and 96 h. The 1 ml liquid samples were analysed to determine the amount in solution and by difference, the amount absorbed by the soil. The Thin-Layer Chromatography (TLC) plate technique uses glass slides coated with a slurry of soil and water and allowed to dry. One end is dipped in the preservative solution and the plate removed after the liquid front had moved 165 mm. The soil on the slide at different positions could be sampled and analysed.

Melcher and Peek (1998) (see [12]) have reviewed a number of soil column (lysimeter) tests with wood preservatives. They conclude that the column should have a minimum diameter of 5 cm to avoid wall effects and the soil depth should not exceed 30 cm to ensure ‘justifiable’ test durations and a minimal use of material. The conclude that percolation with leachates containing preservatives supplies values which are sufficiently exact.

The EWPMG have proposed a soil column method using an 11 cm column, 30 cm deep. The preservative treated 5 cm x 5 cm test specimen, 15 cm long is suspended above the soil column. One face of the specimen is sprayed with water (75 ml per day, 5 days per week) to simulate rainfall equivalent to 1400 mm rain per year. The run-off water is allowed to drip onto the soil. Any water which passes through the soil is collected and analysed, or could be used in ecotoxicological testing. The collected water is considered to be ground water.

The test parameters to be decided are the percolation frequency and duration, the amount of liquid added at each time, the ratio of wood to soil volume, soil water content, the choice of soil and the need for a number of different soil types.

3.5 Soil

The environmental risk of preservative treated wood in service in ground contact is considered to be soil and ground water, e.g. the part of a fence post or transmission pole which are is contact with the soil.

Sinclair, Smith, Bruce and Staines (1993) (see [15]) used a 2 m length of pole (which had been remedially treated with a chromium containing preservative) in a grass covered soil bed 55 cm x 108 cm, 55 cm deep, containing buried perforated pipes for leachate collection. Rainfall was from a spray head atomiser 165 cm above the soil, and 15 cm above the pole. There were nine applications of rain, totalling 370,5 l over 40 days. This amount of water is equivalent to 62 mm of rainfall over the soil bed surface. They reported that the total chromium content of the leachate was approximately 50 mg. Assuming a pole diameter of 30 cm, this is equivalent to an emission to groundwater of 0,61 mg/m^2/day. This value is for an unfixed, surface applied preservative exposed to unrealistically high rainfall.

The EWPMG have proposed a method and initial experiments using the protocol have been carried out. Results have been obtained and submitted to scrutiny in the Pilot Scheme of the BPD. The principle is to have a commercial dimension, commercially treated piece of wood, buried to half its length in moist soil. Water is sprayed on the surfaces above soil with the quantity, frequency and intensity of rain. Water which passes through the soil can be collected and analysed, or it can be subjected to direct ecotoxicological test. The test can be run for months, but the 0 day to 10 day period, 10 day to 30 day period and the 30 day to 100 day and after 100 day periods are required to determine the shape of the emission curve and to allow PEC values to be calculated for comparison with acute and chronic PNEC values. The emission rate in mg/m^2/day can be calculated. The soil can be analysed at the end of the experiment to estimate absorption, and it could be used in a standardised soil ecotoxicological test (e.g. OECD earthworm test).

NOTE That the above ground portion of the post is not sprayed with water, so the only route into the soil is from the portion of the post below ground.

The test parameters to be decided are similar to the above ground test : the dimensions of the test specimen, the ratio of wood to soil volume, soil water content, the choice of soil and the need for a number of different soil types, how realistic rainfall would be applied to the system, defining what is realistic rainfall in terms of droplet size, frequency and duration. Also to be decided are need for drying periods and the duration of wetting and drying periods, and how light can be simulated realistically.

3.6 Fresh water

The environmental risk of preservative treated wood in service in water is considered to be fresh water, e.g. the part of a pile supporting a jetty which is contact with the water, or the leaching of preservatives from a building (e.g. boathouse of jetty) without direct contract with the water.

Warner and Solomon (1990) (see [19]) used CCA pressure treated jack pine boards, 1,5 m long, 13 cm wide and 25 mm thick. Six boards were selected from newly treated wood, cut in half and one exposed to natural weathering for one year. From each board, six 5 cm^2 sections were cut. These were submerged in a tank (with a lid) containing 5 l of leaching solution, and air was bubbled through the leaching solution (water, water buffered to pHs from 3,5 to 8,5, citric acid/sodium hydroxide, borax/ hydrochloric acid buffer or sulfuric acid). The ratio of wood volume to leaching solution volume is 1:13,3, and the ratio of wood surface area to leaching solution volume is 1:8,3. At intervals up to 40 days, 15 ml samples were analysed. The highest emission was measured for copper from naturally weathered wood, in a leaching solution at pH 3,5, 17 mg/l, calculated as 0,06 mg/m^2/day.

Van Etvelde, Homan, Militz and Stevens (see [18]) describe the NEN 7345 standard test method which is a static leaching test using commercial dimension wood. The water is changed after 0,25 day, 1 day, 2,25 days, 4 days, 9 days, 16 days and 64 days. Post and board cross sections were 75 cm^2 and 90 cm^2 respectively. The length of the specimens was adjusted to give a wood volume of 1,65 dm^3 and a water volume of 8,35 l, a ratio of wood to water of 1:5. The CCA treated specimens were end-sealed. The main observation of the study was the substantial reduction of emission flux with increasing time. The flux after 6 h was highest for copper at around 1 µg/m^2, falling to around 0,1 µg/m^2 after 10 days and 0,01 µg/m^2 after 64 days. These are equivalent to 0,004 mg/m^2/day, 0,0004 mg/m^2/day and 0,00004 mg/m^2/day. Higher temperatures and acidic leach water increased leaching.

The EWPMG have proposed a test using 150 mm lengths of 50 mm x 50 mm cross section, end sealed, exposed with half of its length exposed to 3,75 l of water. The water is not stirred or replaced for 7 days. The ratio of wood volume to water volume is 1 : 10. The reason for partial immersion is that this is a more realistic simulation of actual exposure than total immersion.

The test parameters to be decided are the dimensions of the test specimen, the ratio of wood volume to water volume, the type of water used (natural lake water, tap water, demineralised water, acidic lake water), the need for agitation, the need to replace the water, and sampling time.

3.7 Sea water

The environmental risk of preservative treated wood in service in sea water is considered to be sea water, e.g. the part of a pile or a dock which is in contact with the sea water.

Baldwin, Pasek and Osborne (1995) (see [8]) CCA Type C treated piles approximately 25 cm diameter and 120 cm long. They were held vertical in a tank with 240 l of seawater so that only the upper 5 cm was not submersed. The water was continuously stirred. After 7 days,14 days, 21 days and 28 days, the water was replaced. Analysis of the water showed that approximately 530 mg of copper by square meter was released over 28 days (equivalent to 19 mg/m^2/day). Little or no chromium was released. Approximately 60 mg arsenic by square meter was released, equivalent to 2,1 mg/m^2/day. To determine the absorption of the elements on sediment, the leach water was transferred to a 20 l tank containing 1,6 l of high or low organic carbon natural sediment. The leachate was used at 100 % or diluted to 50 % or 10 %. Samples of the leachate were also used in a biological test against a sediment dwelling organism.

Lebow, Foister and Lebow (1999) (see [11]) used de-barked southern pine posts, 1,52 m long, 390 mm to 460 mm circumference (124 mm to 146 mm diameter), cut into 76 mm lengths, and sapwood boards 2,44 m long, 89 mm wide and 38 mm thick, cut into 102 mm lengths. The specimens were end sealed and pressure treated with CCA-C to a nominal 20 kg/m^3 or 40 kg/m^3. After treatment they were stored under plastic for 1 week at 23 °C, then air-dried at 23 °C and 65 % relative humidity. Specimens were leached in deionised water, or seawater adjusted to 23 ppt (to define)('brackish' water as in an estuary) or 34 ppt (ocean water) prepared from 'Instant Ocean'. Three post specimens or four board specimens were immersed in a 7,6 l container containing 2 800 g of solution for posts and 2 100 g for boards. The containers were rocked on a platform for 12 h per day using alternating 3 h on and off cycles. The solution was replaced after 1 day, 10 days, 1 month, 3 months, 6 months, 10 months and 15 months.

The ratio of wood volume to leaching solution volume for posts was approximately 1:0,08, and the ratio of wood surface area to leaching solution volume is 1:0,29 (allowing for end sealing). The ratio of wood volume to leaching solution volume for boards was 1:1,5 and the ratio of wood surface area to leaching solution volume is 1:2,0 (allowing for end sealing). The highest value measured was 46,2 mg/m^2/day copper from piling in deionised water after 1 day. After 15 months the rate was 0,1 mg/m^2/day.

The EWPMG have proposed a test using 150 mm lengths of 50 mm x 50 mm cross section, end sealed, exposed with half of its length exposed to 3,75 l of water. The specimen is immersed for 18 h and unimmersed for 6 h each day. The water is not stirred or replaced for 7 days. The ratio of wood volume to water volume is 1 : 10. The reason for partial immersion is that this is a more realistic simulation of actual exposure than total immersion.

The test parameters which need to be decided are dimension of the test specimens, end seal, the ratio of wood volume to leach water volume, the ratio of wood surface area to leach water, the ratio of end grain to leach water, salinity, ion content, synthetic sea water or 'Instant Ocean', agitation/ stirring, temperature, wetting/ drying regime and sample times.

4 Characteristics of realistic emission test methods

First of all, a realistic emission can only be described by a flux function of time, where the flux has to be calculated as release per area exposed (i.e. mg/m^2/d).

From the literature it is clearly established that different parameters that have a strong influence on these flux functions.

Therefore, the test methods should take into account the following parameters (see Table 4) ; the linked recommendations are made following the principle of the « realistic worst case » which should prevail all along the risk assessment process:

Table 4 — Parameters influencing the realistic emission

Type of wood preservative	Wood treated with an organic solvent based organic wood preservative, a waterborne preservative, or a creosote would all have very different fluxes. The wood preservative should only be tested in use categories for which it is designed for
Method of application	Wood treated by brush, dip, spray or vacuum pressure impregnation will have different fluxes. The samples should be treated in the prescribed way for the use category foreseen
Uptake	Wood treated to different Hazard Class specifications will have different retentions (or loadings), and will have different fluxes. The uptake should be controlled to be in conformity with the critical value prescribed for the use category foreseen, and not exceeding this value by more than a defined percentage
Drying	Drying time and conditions after treatment of the wood affect its emission flux. The drying time of the samples should be consistent with the minimum practical drying time practised in the industry before utilisation of the treated commodity
Distribution	Wood treated with different preservatives will have a different distribution profile in the treated wood and each will have a different flux. The distribution of preservative into the samples for testing should be representative of the distribution into full scale commodities for the use category foreseen
Re-distribution	Preservatives can redistribute within wood during service, leading to increases or decreases in flux with increasing time of exposure. This parameter should be taken into account by adapting the uptake in the part of the sample where the re-distribution would increase the concentration, or by doing another test with adapted distribution for long term emissions assessment
Wood species	Different wood species have very different emission amounts and rates. The wood species of the samples should be selected to be the most representative of the foreseen use category, unless some other used species are maximalistic for emission rates ; in this case a test with these species should also be performed
Size	The size of the wood is crucial to the emission rate of a preservative. Small blocks give over estimates of percent emissions, that would be found realistically in service. It could be demonstrated that flux rates of a.i. (mg/m^2 d) are similar between small sized (1,5 cm x 2,5 cm x 5 cm) and larger samples (ø 6cm x 20 cm and ø 12 cm x 20 cm). Values of ratios like the wood surface to the surface of the environmental compartment, or the wood volume to the volume of the environmental compartment (or to the volume of leaching water for spraying for example) should be superior but as near as possible to the real ratios of the foreseen use categories (scenarios) If end grain effects are to be assumed and can not be avoided by sealing, the size of the samples should be sufficient to get rid of end grain effects and to allow averaging of singularities
Wood face exposed	Emission from radial, longitudinal and end grain faces of timber can be very different. The most representative exposed faces and their orientation should be considered when deciding the shape of the samples. A shape similar or proximate to the shape of the commodities commonly used in the use categories foreseen should be chosen.
Surface	Planed and rough sawn wood can have very different emissions and emission rates. The surface state should be representative of the most emissive state commonly encountered in the use category foreseen
Sapwood and Heartwood	Sapwood and heartwood have different emissions and different emission fluxes. The amount of sapwood and heartwood exposed depends upon the wood species, the size and shape of the component, and its orientation on exposure. The samples should have a sapwood/heartwood volume ratio and spatial distribution similar to the most common case in commodities for the use category foreseen, still taking a worst case approach.

"to be continued"

Table 4 (end)

Surface area to volume ratio	The surface area to volume ratio of a sample is a substantial value for the percent loss of preservatives. It is difficult to replicate the range of possible ratios for wood components in service in laboratory tests. It is necessary to estimate an average value of "wood surface" in contact to the environmental compartments to use the flux rates (i.e. mg/m^2 d) for further calculations. The size of the samples should be chosen to minimise the difference between their surface to volume ratio and those of the commodities for the use category foreseen, to a value to be defined.
Fixation	The kind of fixation (at ambient air temperature or accelerated by a vapour-heat treatment) affects possible emissions of actives to the environment especially at the beginning of use
Time of exposure	Changes occurring to the wood surface with time (e.g. due to exposure to UV light) affect emissions. Time of tests should be both reasonably short for practicability and long enough to allow representativity of possible phenomena occuring during the life of commodities (photodegradation, biodegradation, on the wood surface) The influence of this parameter should be considered to see if it can affect significantly the rates of emission in the long term
Rain	The pH, quantity and intensity of rain will affect the emission. The water characteristics for the tests should take this into account, still keeping in mind the realistic worst case approach (most common pH value for rain to be selected) In the hypothesis of a “spraying test”, the sequence of rain should be selected to maximise the emission. (ex : for the same amount of water, a continuous low rate wetting allowing dropping of leachate is probably maximalist to emission compared to a short high rate showering)
Soil	The type of soil will affect the emission from treated wood. The emission flux will depend upon the physics, chemistry and biology of the soil. The type(s) of soils(s) to be selected might be chosen considering the maximisation of emission from the wood, but also maximisation of fixation of the preservative into the soil, or maximisation of the migration of the preservative throughout the soil (transfer to the underground water). If only the initial emission flux from the wood is looked for at this stage, then the first case should be driving the choice of the type of soil, which has to be studied
Water	Although emission from treated wood to rain, soil, fresh water and sea water is apparently the same mechanism i.e. transfer from wood to water, each situation is very different and will have different emission fluxes. Depending on the use categories foreseen, the kind of water to be used in the tests should be adapted. The influence of the differences between rain water, soil water and fresh water will have to be assessed to decide if these should be distinguished in the test methods. Sea water will certainly have to be distinguished from other kinds of waters.

Moreover, one question to be considered is whether to use samples which have been specially prepared for the test or to use samples from pilot plant / commercial scale treatments and the properties of which are determined by analysis ?

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