Umweltforschungsplan
des Bundesministeriums für Umwelt,
Naturschutz und Reaktorsicherheit

Abfallwirtschaft

Förderkennzeichen (UFOPLAN) 206 95 384

# Evaluation of a horizontal approach to assess the possible release of dangerous substances from construction products in support of requirements from the construction products directive

Dr. Hans van der Sloot

Joris Dijkstra

Ole Hjelmar (DHI)

Gerd Spanka (VDZ)

Philo Bluyssen (TNO)

Sara Giselsson (Boverket)

Energy Research Centre of the Netherlands

Institutsleiter
Dr. Hans van der Sloot

IM AUFTRAG
DES UMWELTBUNDESAMTES

ECN-E--08-089

ECN-E--08-089

# Report Cover Sheet

<table>
<tr><td>1. Report No.<br>UBA-FB</td><td>2.</td><td>3.</td></tr>
<tr><td colspan="3">4. Report Title<br>EVALUATION OF A HORIZONTAL APPROACH TO ASSESS THE POSSIBLE RELEASE OF DANGEROUS SUBSTANCES FROM CONSTRUCTION PRODUCTS IN SUPPORT OF REQUIREMENTS FROM THE CONSTRUCTION PRODUCTS DIRECTIVE (TR2)</td></tr>
<tr><td colspan="2">5. Author(s), Family Name(s), First Name(s)<br>Hans van der Sloot (ECN), Joris Dijkstra (ECN), Ole Hjelmar (DHI)<br>Gerd Spanka (VDZ), Philo Bluyssen (TNO), Sara Giselsson (Boverket)</td><td>8. Report Date<br>November 2008</td></tr>
<tr><td colspan="2">6. Performing Organisation (Name, Address)<br>Energy research Centre of the Netherlands (ECN)<br>Biomass, Coal & Environmental Research<br>Environmental Risk Assessment<br>Westerduinweg 3, P.O. Box 1 1755 ZG Petten, The Netherlands</td><td>9. Publication Date<br>November 2008</td></tr>
<tr><td colspan="2" rowspan="4">7. Sponsoring Agency (Name, Address)<br><br>Umweltbundesamt, Postfach 14 06, 06813 Dessau-Roßlau</td><td>10. UFOPLAN-Ref. No.<br>206 95 384</td></tr>
<tr><td>11. No. of Pages<br>Report 132<br>Annex 81</td></tr>
<tr><td>12. No. of Reference<br>78</td></tr>
<tr><td>13. No. of Tables, Diagrams<br>13</td></tr>
<tr><td colspan="2">15. Supplementary Notes</td><td>14. No. of Figures<br>24</td></tr>
</table>

16. Abstract

This report gives recommendations on the development of horizontal testing procedures for the release or content of dangerous substances from construction products. The target groups of the recommendations are the working groups and task groups of CEN/TC 351 “Construction products: assessment of the release of dangerous substances”. The report describes a transparent horizontal approach, which can be used for all types of substances and construction products deemed relevant under the essential requirement nr. 3 “Hygiene, health and the environment” of the Construction Products Directive (89/106EEC).

To assess the feasibility of a common horizontal approach the report investigates in general terms the range of construction products covered by the “Construction Products Directive” (CPD), their intended uses, the state of the art of the relevant test procedures, and makes proposals on how to fit this knowledge into a testing structure. This report focuses on release of regulated dangerous substances to soil, surface water and groundwater and emission of regulated dangerous substances into indoor air.

Based on technical and practical grounds and on consultation of the construction sector, it is concluded that a horizontal approach for testing release of substances from construction products to soil, surface water and groundwater, as well as to indoor air, is possible. Based on these results this report recommends a limited amount of “horizontal” methods to test construction products with respect to dangerous substances, and makes a large number of recommendations concerning the horizontal approach, grouped according to the main questions from the mandate M/366 from the European Commission under which this work was carried out. This report is intended to be published as a CEN Technical Report.

17. Keywords

Horizontal testing, test methods, dangerous substances, regulated substances, volatile organic compounds, VOC, construction products, construction products directive, CPD, technical report, soil, surface water, groundwater, indoor air, release, release scenario, leaching, emission, standardization, product standards

# Berichts-Kennblatt

| | | |
|---|---|---|
| 1. Berichtsnummer<br>UBA-FB | 2. | 3. |

4. Titel des Berichts
Evaluierung eines horizontalen Vorgehens für die Bewertung der möglichen Freisetzung gefährlicher Stoffe aus Bauprodukten zur Unterstützung der Anforderungen der EG-Bauproduktenrichtlinie

| | |
|---|---|
| 5. Autor(en), Name(n), Vorname(n)<br>Hans van der Sloot (ECN), Joris Dijkstra (ECN), Ole Hjelmar (DHI)<br>Gerd Spanka (VDZ), Philo Bluyssen (TNO), Sara Giselsson (Boverket) | 8. Abschlussdatum<br>November 2008 |
| 6. Durchführende Institution (Name, Anschrift)<br><br>Energy research Centre of the Netherlands (ECN)<br>Biomass, Coal & Environmental Research<br>Environmental Risk Assessment<br>Westerduinweg 3, P.O. Box 1 1755 ZG Petten, The Netherlands | 9. Veröffentlichungsdatum<br>November 2008<br><br>10. UFOPLAN-Nr.<br>206 95 384 |
| 7. Fördernde Institution (Name, Anschrift)<br><br>Umweltbundesamt, Postfach 14 06, 06813 Dessau-Roßlau | 11. Seitenzahl<br>Report 132<br>Annex 81<br><br>12. Literaturangaben<br>78<br><br>13. Tabellen und Diagramme<br>13<br><br>14. Abbildungen<br>24 |

15. Zusätzliche Angaben

16. Kurzfassung

Dieser Bericht formuliert Empfehlungen für die Entwicklung einer horizontalen Vorgehensweise zur Prüfung der Freisetzung oder des Gehalts gefährlicher Stoffe aus oder in Bauprodukten. Die Zielgruppen der Empfehlungen sind die Arbeitsgruppen und Projektgruppen des CEN/TC 351 “Bewertung der Freisetzung gefährlicher Stoffe aus Bauprodukten”. Der Bericht beschreibt ein transparentes horizontales Vorgehen, das sich für alle Arten von Stoffen und Bauprodukten verwenden lässt, die als relevant unter der wesentlichen Anforderung Nr. 3 „Hygiene, Gesundheit und Umweltschutz“ der Bauproduktenrichtlinie (89/106/EWG) einzustufen sind.

Um die Machbarkeit eines produktgruppenübergreifenden horizontalen Ansatzes zu beurteilen, untersucht der Bericht auf übergeordnete Ebene die unter die Bauproduktenrichtlinie fallenden Bauprodukte, ihre vorgesehenen Verwendungen, den Stand der Technik der relevanten Testprozedere, und macht Vorschläge, wie dieses Wissen in eine Teststruktur eingebracht werden kann. Der Schwerpunkt des Berichts liegt an der Freisetzung der durch Vorschriften geregelten gefährlichen Stoffe in Boden, Oberflächengewässer, Grundwasser und in die Innenraumluft.

Basierend auf der fachlichen Beurteilung und Überlegungen zur Praktikabilität sowie einer Konsultation des Bausektors, ist der horizontale Ansatz zur Prüfung der stofflichen Freisetzung aus Bauprodukten in Boden, Gewässer und Innenraumluft umsetzbar. Auf der Grundlage dieses Ergebnisses empfiehlt der Bericht eine begrenzte Menge von horizontalen Methoden zu verwenden, um Bauprodukte hinsichtlich gefährlicher Stoffe zu testen. Der Bericht enthält zahlreiche Empfehlungen für den horizontalen Ansatz, die nach den Hauptfragen des Mandats M/366 der Europäischen Kommission unter dem die Arbeit durchgeführt wurde, geordnet sind. Dieser Bericht ist vorgesehen zur Veröffentlichung als einen Technischen Bericht des CEN.

17. Schlagwörter

Horizontale Prüfung, Prüfmethoden, gefährliche Stoffe, geregelte Stoffe, flüchtige organische Stoffe, VOC, Bauprodukte, Bauproduktenrichtlinie, technischer Bericht, Boden, Oberflächengewässer, Grundwasser, Innenraumluft, Freisetzung, Freisetzungsszenario, Auswaschung, Emission, Normung, Produktnormen

ECN-E--08-089

# EVALUATION OF A HORIZONTAL APPROACH TO ASSESS THE POSSIBLE RELEASE OF DANGEROUS SUBSTANCES FROM CONSTRUCTION PRODUCTS IN SUPPORT OF REQUIREMENTS FROM THE CONSTRUCTION PRODUCTS DIRECTIVE

Hans van der Sloot (ECN)
Joris Dijkstra (ECN)
Ole Hjelmar (DHI)
Gerd Spanka (VDZ)
Philo Bluyssen (TNO)
Sara Giselsson (Boverket)

Prepared for CEN TC 351/WG1 and WG2 with support from UBA (contract FKZ 206 95 384) with contributions from members of TG 2 and national mirror committees.

**Draft**
**1-11-2008**

**Contents**

List of figures

# PART 1. BACKGROUND AND OBJECTIVES

## 1. Introduction

This report covers the work item included as Technical Report 2 (TR2) in the Business plan of CEN/TC 351 in response to Mandate M/366. It gives recommendations to the relevant working groups and task groups of CEN/TC 351 on the development of horizontal testing procedures for the release (or content) of dangerous substances from construction products.
This report focuses on the general description of a transparent horizontal approach, which can be used for all types of substances and construction products deemed relevant.

To assess the feasibility of a common horizontal approach the report investigates in general terms the range of construction products covered by the “Construction Products Directive” (CPD), their intended uses, the state of the art of the relevant test procedures, and makes proposals on how to fit this knowledge into a testing structure. This report focuses on release of regulated dangerous substances to soil, surface water and groundwater and emission of regulated dangerous substances into indoor air. It takes into account relevant information that in parallel has been made available by activities in other task groups of CEN/TC 351, as well as the guidance provided by the European Commission.

### *1.1 Background to the harmonisation of the Essential Requirement No. 3 under EC Mandate M/366 EN in CEN/TC 351*

The European Construction Products Directive (CPD) requires that information on the regulated properties of construction products related to the essential requirements of construction works is declared by manufacturers in CE marking. To be placed legally on the single European market the products, when incorporated in works, must enable the works to fulfil the essential requirements of the Directive. The current CPD relates to the in-use/in-service phase of the life-cycle of construction products, only, expressed as "*incorporation in a permanent manner in construction works*".

In addition to essential requirements such as mechanical stability etc., which are traditionally laid down in building laws, the CPD refers also to the protection of hygiene, health and environment (Essential Requirement No. 3). When and where the works in the European Community are subject to notified regulations containing such requirements, harmonised European product standards (hEN) and technical approvals (ETA) must include appropriate provisions for declaring the necessary information for the use of designers/clients/users and regulators. Where, however, a Member State does not regulate construction works for a particular essential requirement, or for a particular characteristic of a construction product in association with an essential requirement, and there is no overarching Community regulation for the same characteristic and product, manufacturers who intend to place their product on the unregulated market of the Member State are not obliged to determine performance for the characteristic (but may do so by choice) even though the characteristic might have been standardised in a European product standard or ETA. This is known as the 'no performance determined' (NPD) option and if this option is selected by a manufacturer, where it is legally permissible to do so, the declaration accompanying the CE marking must take the form of '*No performance determined*' set against the particular chararteristic.

The harmonised technical specifications (harmonised European standards, hEN, and European technical approvals, ETA) that have been published so far, harmonise almost exclusively technical requirements relating to Essential Requirements 1, 2, 4, 5 and 6. The regulatory requirements, when and where they exist, relating to “Essential requirement no. 3 (ER3): Hygiene, health and the environment” have not been formally harmonised in European technical specifications and conformity concepts and related procedures need to be developed for these such that appropriate product specifications can be revised.

The current regulatory requirements that address essential requirement No.3 take two distinct forms. Those that have originated in individual Member States and are national in application but have been officially notified to the European Commission and those that are 'pan-European' in character and application such as EU directives and EU regulations.

In order to commence the harmonisation process, the European Commission issued mandate M/366 EN “Development of horizontal standardised assessment methods for harmonised approaches relating to dangerous substances under the Construction Products Directive (CPD) – Emission to indoor air, soil, surface water and groundwater” 2005. Mandate M/366 asks CEN to implement the horizontal approach needed to harmonise existing test methods on a material-generic basis in order to cover the needs of the large number of construction products addressed by many separate Technical Committees TCs in CEN (about 60 TCs in the construction sector) and by EOTA in a cost effective and manageable manner.

The harmonisation of ER3 has been delayed by the following complicating factors:

- Different traditions, regulatory approaches, and laboratory test methods in the EEA member states
- Lack of precise product and substances specific regulations in many member states
- Lack of expertise in the field of environment and health in the technical committees in the construction sector in CEN
- Open questions concerning how European environmental directives relate to construction products

Now it is the task of CEN/TC 351 to overcome these obstacles and provide harmonised test standards for use with hEN and ETAs that provide solutions for the following situations:

- Different construction products including some intermediate products mandated under the CPD
- Different substances (e.g. metals, organic substances, radionuclides...)
- Different users of information – designers, constructors, do-it-yourselfers, purchase managers, regulators, manufacturers, notified bodies, market surveillance.
- Different exposure conditions
- Different factors affecting the emission characteristics
- Different intended uses

For the development of harmonised test methods, mandate M/366 obligates relevant CEN product TCs and EOTA Working Groups for a range of implied tasks, wherein it is stated (on page 2):

"*Harmonised product standards and ETA's will take into account the intended uses of the product, the content and release of regulated dangerous substances, the assessment of conformity and the information accompanying CE marking, which will contain the values of the characteristics of the product on the basis of the technical specifications"*.

It is the task of CEN product TCs and EOTA WGs, in cooperation with the new test method CEN/TC, as 'standards writers', to adopt, in relation to the CPD and mandate M/366, the principles of EC Guidance Paper H (GP H) '*A harmonised approach to dangerous substances under the Construction Products Directive'* in order to determine if/how their products or families of products are affected by (see GP H):

- regulations for their products at **Community level** (ranging from restriction to total ban) – always to be fulfilled but <u>not</u> to be addressed within the CE marking;
- regulations for their products at **Community level with national derogation** (different levels of requirements at MS level), in order to be addressed within the CE marking;
- regulations for their products in **national provisions** (different levels of requirements and/or different determination methods between MS), in order to be addressed within the CE marking;

For all three categories of regulations test methods may be required. Currently the European Commission is planning to include the relevant substances into the respective product mandates to ease the work of the product TCs.

Note: CEN work is focussed on development of standards, which is not to be confused with regulation nor with regulatory criteria development. Any aspects that relate to criteria or limit values are not to be discussed in CEN, but shall be addressed in the European Commission's Expert Group on Dangerous Substances (EGDS).

In April 2006 a new CEN/TC, TC 351 "Construction products: Assessment of release of dangerous substances", was established. The scope of this TC reads:

*"Development of horizontal standardised assessment methods for harmonised approaches relating to the release (and/or the content when this is the only practicable or legally required solution) of regulated dangerous substances under the Construction Products Directive (CPD) taking into account the intended conditions of use of the product. It addresses emission to indoor air, and release to soil, surface water and groundwater."*.

Presently, the TC has two working groups:

1 CEN/TC 351/WG 1 Release from construction products into soil, groundwater and surface water
2 CEN/TC 351/WG 2 Emissions from construction products into indoor air

Besides Task Group 2 responsible for TR2, Task Groups have been installed to develop recommendations for considering barriers to trade in the sphere of ER3 (TG1), for criteria for products deemed to satisfy ER3 "without testing or without further testing" (TG3), on sampling (TG4), analysis of the content of substances in products (TG5) and radiation (TG6).

CEN/TC 351 aims for horizontal standardization in the field of test method development (focussing on properties that have to be taken into account in many or all product groups), in order to support the informational requirements of existing regulations, whereas most other TCs are traditionally vertically oriented (focussing on a specific product or a specific group of products). For CEN/TC 351 to develop harmonised test methods that will support all notified regulations, it has, as a minimum, to examine the test methods already used by Member States, or called up in Community regulations. These test methods will relate to defined and relevant basic release scenarios for intended use of construction products for release or emission (or content, where applicable) of RDS that are covered in each of the regulations. This will ensure that the harmonised European test methods that are developed will provide information in the form which accords with the requirements of the notified regulations and which has to be declared with the CE marking affixed to regulated construction products. CEN/TC 351 is also charged with assuring the quality of the test method standards (validation) and to describe for specific (regulated) products how the test methods to be adopted fit within the overall evaluation of products under the CPD.

When the hEN and ETAs have incorporated ER3 in a way that fulfils the existing and justified levels of protection in the member states, the member states are expected to adapt their regulations and administrative provisions accordingly.

## *1.2 Outline of this report*

This technical report consists of five parts: This introduction (**Part 1**) provides the background and main requirements. **Part 2** describes the general principles of horizontal testing and the steps to be followed for the structuring of horizontal testing programmes for products. This part, and its main Annex C, is applicable to both the field of soil, surface water and groundwater and to indoor air. **Part 3** of this report summarizes the conclusions and recommendations from this work to CEN/TC 351 and its WG's, grouped according to the questions listed by the mandate m/366. This part contains of specific paragraphs for 1) soil, surface water and groundwater, 2) indoor air, and 3) general conclusions and recommendations that apply to both of these fields. **Part 4** provides detailed discussion on horizontal test methods for constructions products potentially affecting soil & groundwater during service life. Detailed discussion on horizontal test methods for construction products potentially affecting indoor air quality during service life are addressed in **Part 5**.

This TR covers the points included in the TR2-description in the CEN/TC351 Business plan[1], taking into account the specifications given in the Mandate 366 to CEN[2]. The main points from this assignment can be summarized as:

---

[1]This Technical Report (TR), taking into account the state of the art in the Member States, identifies the role of testing in the assessment of construction products in view of possible emissions and makes recommendations on the testing procedures. The TR reviews in accordance with the experience already gained, the basis for deciding whether or not the use of horizontal test method standards for construction products is practicable and/or necessary in the sense of article 7.2 of the Construction Products Directive, and the Guidance Papers , in particular Guidance Papers H and M.
The Technical Report also recommends how harmonized technical specifications (e.g. harmonized product standards) should address the subject of regulated dangerous substances. The TR also recommends how the expertise of product Technical Committees and EOTA Working Groups can be used when drafting the horizontal test method standards. The TR provides recommendations for complete testing procedures in the overall framework according to the methods for the Attestation of Conformity.

[2] Taking into account the state of the art in the Member States, recommendations shall be elaborated for the testing procedures. The testing procedure shall address the following questions: 1) For which products are measurement/test schemes relevant in regard to indoor air, soil surface water or groundwater? 2) How to define

1. Recommendations on testing procedures
   - For which products are measurement/test schemes relevant in regard to indoor air, soil, surface water and groundwater?
   - How to define clusters of products that behave similarly in release tests (basic release scenario) and can thus be assessed by one horizontal standard?
   - For which substances or products is the measurement/test of the content relevant?
   - How to combine individual measurement and test methods to an appropriate test programme to allow the determination of the relevant properties and to allow the assessment of the results.

2. Recommendations regarding the implementation of testing procedures in the overall framework.
   - Review the basis for deciding whether or not for products horizontal test standards can be used.
   - Which are the mechanisms by which required amendments of horizontal standards or in special cases vertical standards are identified for specific products or product families.
   - How should harmonized technical specifications address the subject of regulated dangerous substances, and how are the measurements of emission of regulated dangerous substances included in their testing programme. The report shall also recommend how the expertise of product Technical Committees can be used adequately when drafting the horizontal test standards. Recommendations shall be elaborated for complete testing schemes which take into account all relevant elements according to the methods for the Attestation of Conformity (see Annex III of the CPD).

When judging the relevance of construction products for environment and health it was not possible to investigate in detail all currently applicable regulations for ER3 in the member states for this report. Therefore the assessment of the relevance of products has been carried

---

clusters of products that behave similarly in release tests (release scenario)? 3) For which substances or products is the measurement/test of the content relevant? 4) How to combine individual measurement and test methods to an appropriate test programme to allow the determination of the relevant properties and to allow the assessment of the results.

This Technical Report shall review in accordance with the experience already gained the basis for deciding whether or not the use of horizontal standards for construction products is practicable and/or necessary in the sense of the CPD art. 7.2. The report shall include the mechanism by which required amendments of horizontal standards or in special cases vertical standards are identified for specific products or product families. In particular it shall identify the procedures and limitations for amending horizontal standards and describe the justification process for vertical standards. Attention shall be given to the intended conditions of use as well as to the required specific conditions of use for certain products especially in the definition of the testing conditions in order to allow for an adequate assessment.

The report shall also recommend how harmonized technical specifications should address the subject of regulated dangerous substances, and how the measurements of emission of regulated dangerous substances are included in its testing programme. The report shall also recommend how the expertise of product Technical Committees can be used adequately when drafting the horizontal test standards. Recommendations shall be elaborated for complete testing schemes which take into account all relevant elements according to the methods for the Attestation of Conformity (see Annex III of the CPD).

out on technical grounds. Before the horizontal test concept proposed in this report can be applied to any certain product covered by a hEN further administrative steps are necessary. It is expected that the European Commission will amend the standardisation mandates for construction products under the CPD step by step during the next years. For the preparation of the mandate amendments the applicable notified regulations will be scrutinised more thoroughly than was possible for this report. Therefore not all construction products identified as relevant here may necessarily be affected by the mandate amendments in the future. Only the construction products covered by mandate amendments for ER3 need / are allowed to implement ER3 in CE marking in the future.

Although not all products discussed in this report are to the authors' knowledge covered by product specific member state regulations for ER3, they have been included for the following reasons: 1) Not all currently valid regulations may be known to the authors. 2) It would be practicable for manufacturers, if the methods used under the CPD could be applied under other directives too (e.g. under the biocidal product directive elution methods for wood and plastics are currently discussed). 3) Potential future barriers to trade can be avoided, when the applicability of the proposed concept to the main groups of construction products currently manufactured in Europe is assessed.

The document CEN/TC 351 N 0054 ("indicative list of regulated dangerous substances") lists substances and parameters, which CEN TC 351 should focus on first when assessing the availability of test methods and the need for developing harmonised test methods. With this document the Commission and its Expert Group on Dangerous Substances in the field of Construction Products (EGDS) provide guidance as foreseen in Mandate M/366 for CEN TC 351 and all product TCs and EOTA WGs in the construction sector.

As such, the terms "substances" used in this report refers to the substances listed in document N 0054.

It should be noted that there are chemical compounds and parameters that can, through their chemical or physical behaviour, retard or accelerate the release of the substances of concern (see the discussion of processes in part 4 (soil, surface water and groundwater) and part 5 (indoor air)). Information on these chemical compounds and parameters not listed in N 0054 may be needed in some stage of the process of developing horizontal release tests to make a reliable translation from test result to environmental impact during the service life of products. Typical examples of such compounds and parameters are iron, calcium, porosity, water saturation (influencing release of substances from products to soil, surface water and groundwater) or the parameter temperature and moisture (influencing release of substances from products to indoor air).

The report points out for which construction products the determination of the content of substances (as opposed to measured release) can be relevant or advantageous. The analytical methods for quantification of substances will be addressed in that context. Furthermore it includes recommendations as to how the expert knowledge of the product Technical Committees regarding the "Essential requirement no. 3" can be used and implemented.in the respective harmonised technical specifications in order to achieve test standards that fulfill the needs of the product standardisers. The implications of the different systems of the attestation of conformity (AoC, Annex 3 to the CPD) for the types/scope of test methods needed are taken into consideration.

In evaluating construction products with regard to ER3 of the CPD the following considerations apply:

- For all construction products, general regulations in the EU or in individual member states on substances that fall under a restriction or a ban (e.g., specific heavy metals, asbestos) are equally applicable. Methods that may possibly be needed to demonstrate compliance with these general regulations will be covered by TR 5 on content.
- In some cases, products contain radioactive substances from natural origin. These may fall under a content type evaluation in case of direct radiation (e.g. gamma radiation, no transport of substances) or can be assessed in a release scenario (soil, surface water, groundwater and indoor air). These aspects, as far as they are specifically related to radioactivity, will be addressed by a separate CEN/TC351 group on Radiation (Task Group 6). Thus this report does not further discuss the issue of radiation.

## 1.3. Towards a horizontal approach

The development of tests that determine the possible release of a range of possible substances from the **wide** variety of construction products in a number of different exposure conditions calls for an approach, which is suitable for as many construction products as technically possible (horizontal approach, i.e. across fields covered by different technical construction TCs). In this approach, it is important to realise that many construction products do not endanger human health or the environment either due to benign constituents or an intended use where release of dangerous substances is not possible or very low. This calls for an approach where testing is performed only when it is needed.

When a product is tested under the CPD, a distinction is made between Initial Type Testing (ITT) that provides necessary detail to answer specific regulatory questions (equivalent to the “characterization tests” in the terminology of the Technical Committees in the environmental sector), and factory production control (FPC) testing for ensuring the achievement of the required product charcteristics (equivalent to "compliance testing" in the terminology of the Technical Committees in the environmental sector). The extent of the tests included in an ITT depends on the available information for the products and raw materials covered by a technical specification. The testing programme discussed in this report must be compatible with the methods of control of conformity provided in Annex III of the CPD. These include under all systems for attestation of conformity an initial type testing of the product by the manufacturer or an approved body and a factory production control.

The emphasis of test development in this project is strongly on *release,* as *content* is a poor indicator for environmental exposure in the in use phase of products and there is generally no relation between content and release or emission. Judgment of environmental impact based on total content of substances in the product may lead to over-estimation of the release potential, as substances are generally subject to many chemical and physical constraints that determine the actual release. Only when an assessment of release is not possible or it is deemed too expensive or not practicable for ITT and/or FPC, methods based on content may be used. For methods based on determination of total content, which are not treated here extensively, more information will be provided by Task group 5 preparing TR14.

Another situation, in which content needs to be addressed, is when substances fall under a restriction or a ban (e.g. Hg, Cd or asbestos). In such cases, content may be the most relevant property. If bans or restrictions are in force under existing European regulations and harmonised test methods have been agreed upon, they do not need to be addressed here separately. However, when content is restricted or banned in national notified regulations applying to construction products (e.g. pentachlorophenol in Germany and the Netherlands, short-chained chlorinated paraffins in the Netherlands, Decabromodiphenylether in Sweden, Germany and Norway, certain wood preservatives in wood products in the Netherlands, fluorinated greenhouse gases in Austria and Denmark) or when European restrictions have been implemented with different test methods in the member states (e.g. cadmium in PVC or penta- and octabromodiphenylether in plastics), these need to be addressed under the CPD. With respect to possible methods relevant for evaluation of restricted or banned substances more information will be provided by Task group 5 preparing TR14.

The basis for establishing a horizontally harmonised testing framework is the proposition that it is not feasible and necessary to develop test methods for each different product, under different conditions and release scenarios in the field.

It should, however, be clear that recommended test methods for soil, surface water, groundwater and indoor air do not have the ambition to “capture” all different conditions that can occur in practice. Instead, the information collected by initial type testing methods, and the insights that can be gained from this information, form the starting point for the translation from test result to specific release scenarios, of which the conditions are almost per definition outside the measurement range of the tests (e.g. with respect to the time scale, composition of percolating water, indoor and outdoor temperature, etc.). Such a translation to specific release scenarios generally involves a modelling step.

# PART 2. PRINCIPLES OF HORIZONTAL TESTING

## 2.1 Goals and scope

The mandate M/366 asks how to combine individual measurement and test methods to an appropriate test programme to allow the determination of the relevant properties and to allow the assessment of the results. In this chapter this question is considered from a horizontal point of view. This document is primarily aimed at WGs of CEN/TC 351. Guidance on implementation of the concept in product TCs will be the subject of TR 4 (to be developed). The 'horizontal approach of testing and declaring performance aims at bringing all experiences together, minimizing the number of descriptions for testing the same characteristic and so provides a structure for more efficient testing and evaluation of material and product performance characteristics[3].

The present report covers a large amount of different construction products for which an efficient evaluation and testing of release/emission of dangerous substances may be required. In principle, the concept of horizontal testing can be used for testing many characteristic properties of products, materials, etc.

Apart from showing conformity to harmonised product standards and regulations with regard to regulated dangerous substances, the goals of horizontal testing are:

- Saving time and money in development, explaining and using test procedures.
- Increasing efficiency of (laboratory) testing and simplifying certification of testing activities.
- Transparency in testing release properties of products.
- Simplifying legislation, regulations, contracts, etc.
- Improving comparability and reliability of test data.
- Avoiding duplicate testing of the same parameter by different test procedures for the same product.

These goals fit within the objective of simplifying regulations and diminishing administrative and financial burdens to industry, public and authorities. These goals also fit within the needs for better information on health and environmental impacts.

## 2.2 The concept of horizontal testing

In the past, many different testing methods and testing protocols were developed to capture the supposedly unique, specific behaviour of a product in the specific conditions of use. The aim was often to simulate a specific real situation. However, past experience has shown that single simulation-type test methods, including those resembling "worst case" release

[3] Remark on the meaning of the word "testing". It should be noted that some properties can be judged by visual inspection, or plain common sense. However, usually "testing" of a property is needed, once, periodically or continuously in order to know, from experience, that certain criteria for that property are always met. For example, once a mould is made for making prefab concrete tiles, the size will not change. However, a periodic check may be necessary, e.g. due to wear. The last example shows that 'knowing' and 'testing' of a property are related. A contractor may want to know for sure that each brick has the same size which was agreed upon when ordering the bricks. It is necessary to do initial measuring and control testing, but after having gained a lot of experience, the testing frequency can be decreased or testing can even be left out.

scenarios, typically provide too little information to allow extrapolation of the test results beyond the experimental conditions.

Rather than simulating each specific combination of product, release scenario and intended use and conditions of use, it is more practical to determine the basic mechanisms that determine the release behaviour of a product. Determining and testing these basic mechanisms, combined with simple or more complex modeling, may give a better basis for evaluation of a product performance in the foreseen intended uses, than a single “simulation test”. Even if such simulation approaches would be possible and would provide adequate answers, it might still be considered an undesirable, costly and inefficient route. These observations are the basis for further harmonisation of test methods.

*Horizontal “modules”*
In many cases, testing for a specific performance parameter includes a number of testing steps. In testing the same parameter for different products, all testing steps may be equal, but there may be also slight differences within one step only. These differences have often been solved in standardisation by writing complete new procedures including all steps in product specific wording. This results in much duplication of work. This can be overcome by splitting testing in steps and writing test “modules” for each step. When preparing/selecting a test protocol for a specific product in a specific situation, the relevant modules can be selected and simply put together. This approach is called the ‘horizontal modular approach’.

The concept of horizontal testing in the context of ER3 and the CPD can function smoothly when it is transparent to all stakeholders. The following conditions should be met:
- all relevant bodies should be aware of the development
- all relevant bodies should accept the approach
- the general needs of all relevant bodies should be known and taken into account
- the harmonised standards should cover special needs, or should indicate how to handle these
- the approach needs a clear structure
- all separate items must be dealt with in an appropriate, harmonised way and fit together in the final structure
- there must be a quite flexible way to update separate items in the structure
- the system should be managed well. A horizontal system goes beyond individual standardisation technical committees and working groups in standardisation bodies such as CEN and EOTA, so it should be centrally covered. However, all relevant standardisation TCs and other relevant bodies should be able to contribute.

This document briefly describes both technical and organisational elements. It focuses on approaches for dangerous substances and construction products.

## 2.3 Testing steps, modules and test protocols

Testing for release /emission of dangerous substances from construction products consists of several “fixed” steps. This chain of steps can be called the “measurement chain” and is the basis for a horizontal testing programme.

The steps are similar for assessment of technical parameters for each construction product/product group (Figure 2.1, step 1-7). For each step, a number of modular test standards are or should be available. For instance, when developing a testing programme for a specific product the relevant modules (see previous paragraph) can be selected.

Measurement chain Horizontal modules

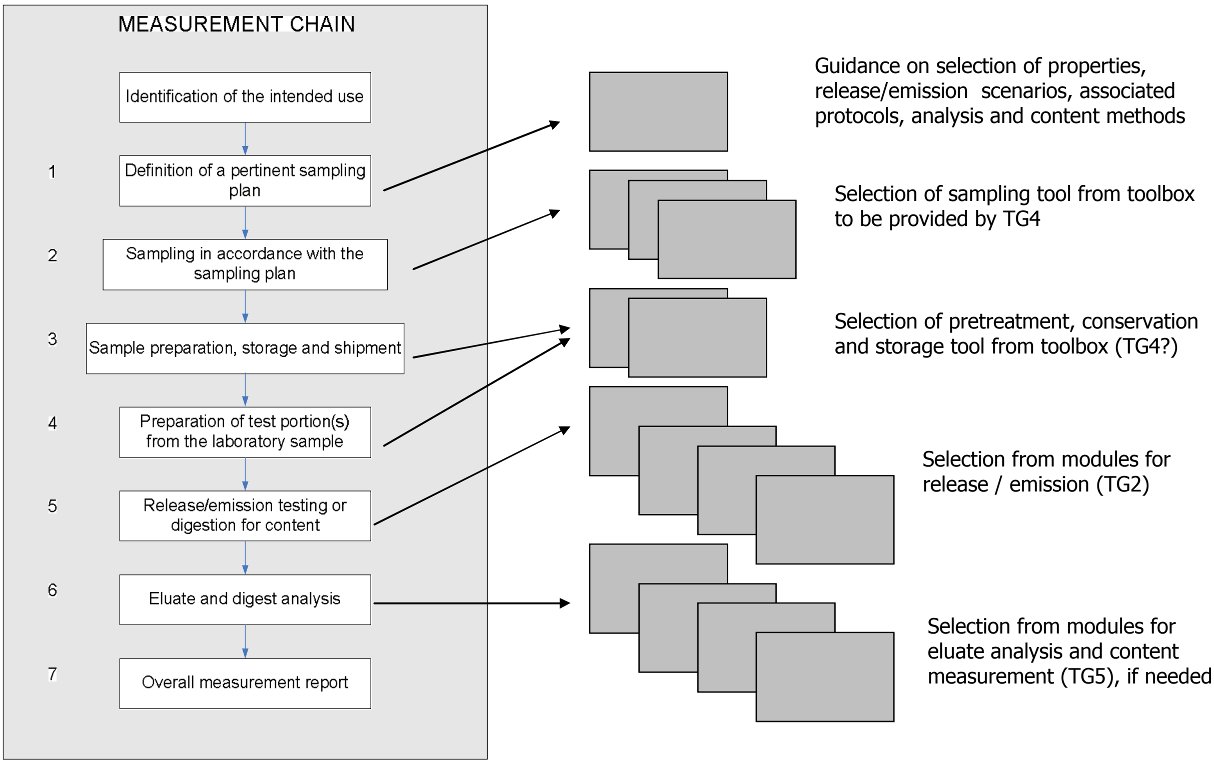



*Figure 2.1. The scheme for developing a testing programme for assessment of almost any property illustrating the modular horizontal approach in providing selection of relevant tools (modules) at different steps in the measurement chain. To the right different Technical Reports (TR) are referred to covering the specific issues in detail.*

In each testing programme, and in each test protocol or product test standard, the subparagraphs referring to the individual steps should be numbered according to the scheme above (Figure 2.1). Each of these paragraphs refer to the selected modules of concern.

Of course, flexibility is needed to cover unique (aspects of) construction products where needed. Should there be any product specific instructions and product specific selections from the referred modules, these should be included in the protocol. Also, the combination of steps is possible and may in some cases be practical (e.g. if digestion for content in step 5 is linked directly to analysis in step 6). Also, steps may be left out if they are not relevant (e.g. if direct analyses in step 6 is possible, without a digestion step in step 5).

The complete instruction concerning the description of the above steps is provided in Annex C of this report.

### 1.3.1 Common basic release mechanisms as a basis for common aspects in test development and data presentation

Past research has indicated that the release from construction products to a water phase in relation to impact to soil, surface water and groundwater or from construction products to the gas phase in case of indoor air emission is governed by very similar fundamental mechanisms, such as diffusion, sorption and solubility. In individual situations, usually only some of these mechanisms and factors of influence are predominant, and will mainly determine the release of substances into water, soil or air. In Table I, the similarity in mechanisms and factors of influence are summarized.

*Table I. Overview of main release mechanisms and factors that influence release. A number of these are relevant for leaching to soil/water as well as for emission to indoor air (common factors of influence).*

| **Main release and emission mechanisms** | |
|---|---|
| *Release to soil and groundwater :*<br>Chemical reaction (e.g. dissolution, complexation)<br>Sorption (chemical or physical)<br>Diffusion (monolithic products)<br>Percolation (granular products)<br>Surface wash-off<br>Erosion | *Emission into indoor air :*<br>Evaporation/desorption<br>Diffusion<br>Chemical reaction (e.g. with ozone, with $H_2O$)<br>Sorption (chemical or physical) |
| **Specific factors that influence these processes:** | |
| pH and acid/base buffering capacity<br>Amount and type of reactive surfaces (DOC, oxides, clays)<br>Composition water phase/ionic strength<br>Oxidation/reduction potential<br>Amount of water | Ventilation rate<br>Physical structure (layers etc.)<br>Humidity |
| **Common factors of influence:**<br>Chemical form (speciation) and substance-specific characteristics<br>Biological degradation (organic chemicals)<br>Total composition/ availability<br>Size and shape (fine or coarse, particles, monoliths, sheets, etc.)<br>Other physical factors: porosity, permeability, tortuosity, time, temperature | |

The similarity in release mechanisms and other common aspects imply that experiences between the different fields can be exchanged and can benefit the further development of measurement and data interpretation techniques.

In principle, the basic conditions in test methods to assess release in water and emission to the gas phase can on some points be similar. *For instance*, when “diffusion” is considered to be an important process, a “tank” can be used with specified dimensions, operated at a specific temperature, with specimen of well-defined surface area, with a form of removal of the external solution or gas phase (flow or periodic renewal) and expression of results in specified units. Such an approach allows a single interpretable, mathematical quantification of the release rate in, for instance, an (effective) diffusion coefficient. With such a derived parameter as input in a diffusion model (a computer model incorporating the mathematics of diffusion), an endless amount of different conditions can be objectively evaluated. Note that "diffusion" in this example is used in general terms, as there is *no* difference in the physical process of diffusion in water and in air, rather than the value of the diffusion coefficients themselves in different media.

In summary, important common aspects to be considered in testing release / emission are:

- The test methods used for ITT, developed to assess release / emission, should as much as possible provide information on intrinsic product properties rather than attempt a simulation. The intrinsic properties are the basis for subsequent modelling and for the translation of test results into an environmental impact.
- Careful selection of time steps of liquid renewal in "tank tests", in order to eliminate the wrong interpretation of the release mechanism when testing the release from monoliths to the water phase (and ultimately to soil, surface water and groundwater). Similarly, stopping the air flow or varying the flow rate can provide insight into emission mechanisms in chamber testing for indoor air.
- The expression of the results of a given test in different manners allows conclusions to be drawn on release behaviour. For instance, plotting results as cumulative release/emission will show, whether any further release is possible due to depletion of a substance. By plotting results of emission on a log scale instead of a linear scale it may become obvious that the emission process is not reaching a plateau after a certain time, but continues to decrease.
- Too simple calculation principles for the quantification of emissions can lead to serious overestimation of emissions and seriously jeopardize any attempt to use test information to predict indoor air quality or soil and groundwater impact. In other words: calculation principles should be as simple as possible, but not simpler (quote A. Einstein).

Examples on similarity in mechanisms, test development and data presentation can be derived from Part 4 (Soil and Groundwater) and Part 5 (Indoor air).

In evaluating the needed background information for technical product specifications like compressive strength and environmental aspects - release to soil and groundwater and emissions to indoor air - many similarities are found. Technical specifications for compressive strength date back for more than a century and are widely accepted. For a new subject like environmental properties the appropriate background information needs to be established. The manner of assessing these properties is not very different from the way in which the technical specifications of today have been derived. Below a comparison is given.

| Property/condition | Technical specifications | Release to soil, surface & groundwater | Emissions to indoor air |
|---|---|---|---|
| Problem definition | Sufficient strength to maintain structural integrity for a given application | No adverse effects on soil, surface and groundwater during service life | No unacceptable concentrations resulting from emission to indoor air |
| Target | Minimum strength requirement derived from load bearing calculations using sophisticated programs developed in civil engineering | Soil, surface and groundwater quality objectives set by regulation and translated in a source term release with sophisticated chemical reaction/transport models | Limits for concentration of substances in the indoor air in buildings translated into product emissions measured by testing using models |
| Key property | Compressive strength (assumption no reduction in gained strength with time) | Leached amount of substances as a function of time under a given release scenario | Emission of substances as a function of time under given exposure conditions |
| Initial type testing | Compressive strength development over 90 days | Release behaviour as a function of pH and L/S or time | Understanding of emission of substances from construction products as a function of time, temperature and moisture |
| Factory production control in case of FT | 28 day compressive strength | Optimized pH condition, low L/S condition (granular) or short time release (monolithic) | Simplified test condition depending on the nature of the substances emitted |
| Quality control | Data from FPC placed in context with ITT and shown on QC chart with error margins | Data from FPC placed in context with ITT and shown on QC chart with error margins | Data from FPC placed in context with ITT and shown on QC chart with error margins |

### 1.3.2 Relationship between test results and environmental impact

The mandate M/366 uses two interrelated concepts, i.e. intended use and emission or release scenario. In short, the intended use of a product determines largely whether a product may potentially show release to soil, surface water and groundwater and/or indoor air. The translation of test results to “true” emissions of the product during its use requires a modelling step, which may be referred to as the “release scenario”. In this report the following definitions are used:

- *Intended use* refers to the role(s) that a product is intended to play in the fulfilment of the essential requirements of the CPD (definition in the Interpretative Documents). The intended use is thus related to the function of a product in a construction work (e.g. subbase, pile, wall, etcetera).

- *Intended use conditions* refer to all environmental conditions that a product may undergo during use and that influence its release behaviour. These conditions are expressed in parameters such as temperature, amount of water during exposure, wetting/drying, ventilation rate. *Intended use conditions* may vary for a single intended use, for instance as a function of time, location, orientation, geohgraphical location, etcetera.

- A *release scenario* is a (model) description of how test results from a specified (group of) product(s) are related to the actual release under intended use conditions. The release scenario describes the release of substances during the entire service life of the product(s), including changes in the release behaviour due to e.g., depletion of substances and external factors that influence release behaviour. One can make a distinction between general (basic) release scenarios and specific release scenarios:
  - The *basic* release scenario is a conceptual or a model description of the release in practice based on product properties and the fundamental mechanisms that control the release of substances from the product during service life. As the amount of dominant mechanisms that control release is not large (see Table 1) the amount of basic release scenarios is limited. See Part 3 and/or Part 4/5 for a description of these basic release mechanisms.
  - The *specific* release scenario is a conceptual or a model description that takes specific factors influencing release and relevant for *specific* intended use conditions and regulatory needs into account. Factors that influence release are listed in Table 1: examples for indoor air are humidity, temperature, ventilation rate and for soil and groundwater the infiltration rate. A specific release scenario is a more detailed version of a basic release scenario.

Understanding the mechanisms of release or emission forms the starting point for the translation from test result to practice. The conditions in real life are often outside the measurement range of the tests (e.g. with respect to the time scale, composition of percolating water, indoor and outdoor temperature, etc.). Therefore, an important criterion for the selection of generally applicable release tests for construction products is that the tests allow correct identification of the main release controlling mechanisms as well as the quantification of the factors influencing these mechanisms. Models that incorporate the identified mechanisms may serve as important tools to estimate actual release under intended use conditions. In principle modelling allows the assessment of impact of products under any conditions, at any distance from the source.

When translating test results to potential environmental impact two modelling steps need to be recognized:

I. The “source term”. The source term is a model description of the release behaviour of the product under intended use conditions and can be referred to as the “release scenario”. This model description is based on the main mechanisms that control release, and the factors that influence these mechanisms, such that release under the intended conditions of use can be adequately described (including factors such as angle of exposure, rainwater quality, temperature, chamber size, physical and chemical conditions that influence release (etc.). Ad Hoc group 1 of CEN/TC 351 / WG 1 is concerned with identifying basic release scenarios on which these source terms should be based.

II The “pathway”. Whenever the release under the intended conditions of use in a basic or specific release scenario is to be compared to environmental quality criteria in the compartment of interest (e.g. groundwater limit value, maximum allowable concentration in indoor air), the soure term from step I above must be extended with a (model) description of the transport of released substances to the point of compliance (POC)[4] where certain “quality levels” need to be met. This “pathway” –part of the model describes the transport and attenuation processes that take place between the product and the POC, such as dilution, diffusion, mixing, degradation, and sorption of substances that occurs in the soil below and downstream of the construction work, or in the indoor air environment. Without such a pathway- approach, any estimated environmental impact would be overestimated[5].

Although the source terms, may be different, depending on product characteristics and intended use, the “pathway” may essentially be similar. For instance, the scenario of the release of substances from a monolithic product such as concrete walls, and a granular product such as a road base is different. However, the pathway to the POC (point of compliance) may be similar for these cases: transport though soil and groundwater. Figure 2.2 below is a schematic representation of different source terms and similar pathways.

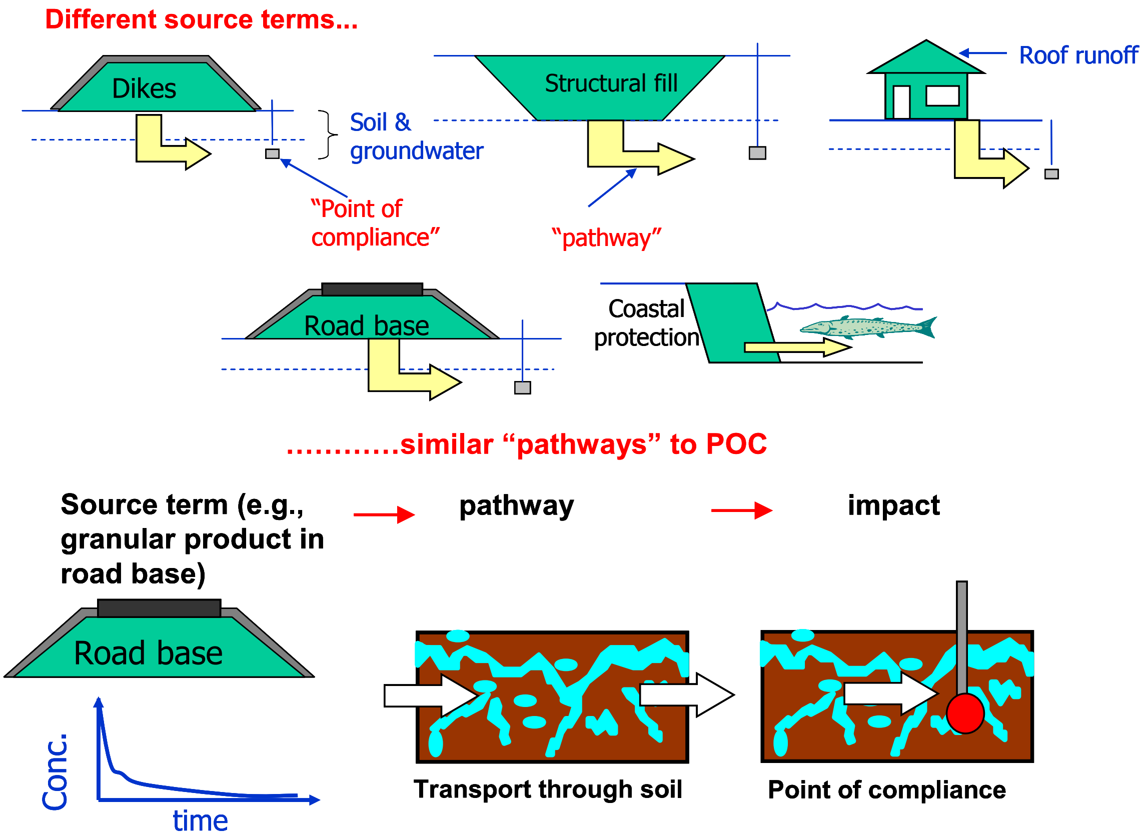



*Figure 2.2. The upper part shows a number of different source terms. The lower part shows their common “pathway” of potentially released substances to a certain point of compliance where environmental quality objectives must be met (e.g., groundwater concentrations).*

[4] A point of compliance is the position at some distance from the construction works at which quality objectives must be met.

[5] Note that even a 1:1 comparison of test results to environmental criteria at a POC is a simplified form of the “source-pathway-POC” approach, albeit that the pathway-part is strongly simplified or considered not important. This approach is sometimes chosen to enable worst-case judgements of environmental impact.

Under the CPD the focus in each scenario is to determine the release / emission from products and the declaration of the product's release / emission performance in CE-marking. Authorities may have set limit values for release or emission from products (i.e. pass/fail values), based on complete source, path and effect assessments (figure 2.3). A model description of both source term and pathway (step I and II above) may be an important tool for regulators to judge the impact at the point of compliance and/or to establish a set of pass/fail criteria for products that are fully consistent with chosen environmental quality levels at a given point of compliance in the compartment of interest (soil, surface water, groundwater, indoor air). These environmental quality levels may consist of e.g. groundwater limit values downstream from the construction work (guidelines from the Water Framework Directive, etc.), limit values in indoor air (e.g., maximum acceptable concentrations of volatile organic substances in new buildings after six months from construction). The mutual consistency between the – in this manner calculated - release limit values (pass/fail values) and environmental quality criteria ensures that measures only are taken in case there is a clear risk that environmental criteria in indoor air or soil, surface water and groundwater, are exceeded. In this approach, "arbitrary", "worst case" and/or "unrealistic" limit values for release (pass/fail values of test results) are avoided. It is stressed that any of such (model-) evaluation is not part of CEN/TC351 work, nor is it foreseen to be part of FPC testing of products. This modelling takes place outside CEN by experts hired by EU and/or MS regulators.

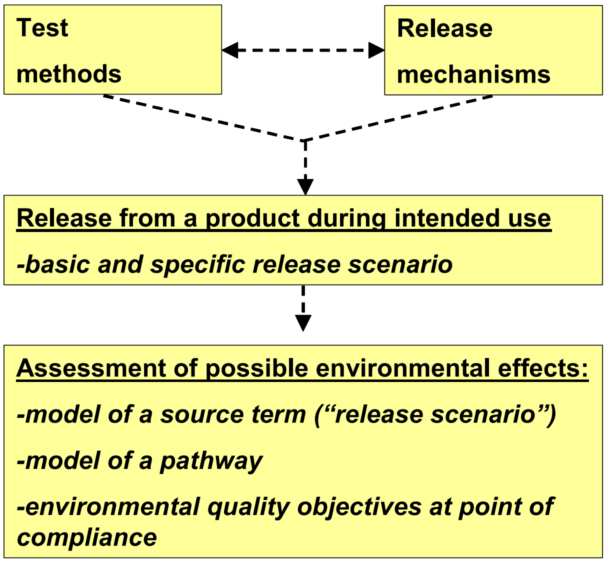



*Figure 2.3. Relationship between test methods, release mechanisms, risk assessment (using modelling) and the actual effect in the environment. Mechanisms should be understood for consistent translation of test results to risk assessment. Tests should provide data and information based on these mechanisms.*

However, if authorities only have set environmental limit values in the compartment of interest i.e. the construction work itself or the soil and water in its vicinity as foreseen by the CPD, and not on the product level (pass/fail values), and if the building level requirements will be added to the product mandates under the CPD as envisaged in the Interpretaive Document 3, the manufacturers may in the future need to establish the link to the building level requirement (ER3) and create the corresponding pass/fail criteria for the product level themselves. Here modelling is needed to predict, whether a product will fulfil the building level criteria in its intended uses. For manufacturers models based on the underlying release mechanisms may also be helpful to predict whether a (new) formulation / composition for a product will conform to existing regulations (pass/fail criteria of test results, or pass/fail criteria at the point of compliance).

It is important that model predictions need verification by measurements, and suitable testing methods may be used to generate adequate verification data in conjunction with pilot scale/field data as far as possible. For model verification purposes, adaptation of the test methods to "simulate" a specific intended use condition will sometimes be needed. For instance, the leachant may be changed (e.g., demineralised water) for water containing high levels of organic carbon to simulate a peat environment, or seawater to simulate interaction of concrete used in coastal works. However, because such interventions in the test protocols may complicate the identification of release controlling factors, it is strongly emphasized that the only purpose of such adaptations should be model verification, and not to replace an original test method by a product- or scenario- specific *simulation test.*

### 1.3.3 Hierarchy in testing and attestation of conformity

With a "hierarchy" in testing and evaluation, e.g. a set of tests for ITT and another test for FPC, efficient procedures can be found. This basic principle is reflected by the methods for the attestation of conformity under the CPD. The overall objective is to set out a framework for an effective, appropriate and cost effective system for providing users (constructors, manufacturers…) with information on the release/emission of regulated dangerous substances from construction products under ER3, where respective regulations exist.

In general a differentiation should be made between:
- Evaluation: using all available information and experience, including test results, to determine if a product fulfils the criteria.
- Testing: test results that support evaluation. For example, limited testing to complement available information.

The testing hierarchy for ER3 must in the future be included in harmonised technical specifications under the CPD, where relevant, under "Conformity assessment" i.e. a procedure to show that the product conforms to the technical specification. This may according to Guidance Paper M be in the product hENs or ETAs itself, or in another standard referred to by the harmonised technical specification.

The ITT procedure includes the full investigation of a product, producing all data needed for declaration and guaranteeing product quality and for convincing suitability of selected simplified tests for FPC-testing. If no information on the product is available the producer should use the complete reference tests and other supporting tests if these are necessary to complete the needed information. But if sufficient information and data is available on the relevant type of product, the investigation and quality declaration can be based on the combination of such available data and simplified control testing. The producer (or e.g. the product TC) should adequately motivate the simplified procedure. (see e.g. CPD, art. 4.4. about the option for simplifying procedures on the basis of available information.)

According to the CPD, Member States shall take all necessary measures to ensure that construction products, may be used in works only if they are fit for use. The CE marking shows that a product complies with a harmonised European standard (hEN), or a European Technical Approval (ETA), and that the system of Attestation of Conformity (AoC) laid down in the Commission Decision relating to the product has been applied. The CE-marking further provides information on performance levels, which enables users to conclude if the product can fulfil the technical and/or legal requirements.

The producer is responsible for the attestation that products are in conformity with the requirements of a technical specification. The involvement of a third party (notified body), even to provide an EC certificate of conformity, does not relieve the producer of any of his obligations. Within a given system of AoC certain tests of a product's performance have usually been allocated to the notified body and the rest to the producer. Details of this allocation of tests are specified in the technical specifications, elaborated on the basis of mandates from the Commission. Many Commission Decisions relating to the AoC of construction products are based on a cumulative procedure, in which different systems of AoC are allocated to the various possible intended uses of a product. Table XX summarises the different systems for the Attestation of Conformity. Which AoC sytem will be applicable to ER3 has not been decided yet by the European Commission.

Table 3 Attestation of conformity systems and tasks of the notified bodies. See also Guidance paper K (The attestation of conformity systems and the role and tasks of the notified bodies in the field of the construction products directive, rev 9/2002). The term "Notified Body" is used only for organisations notified under article 18 of the CPD to avoid confusion with the terminology used for organisations designated by member states under article 10 of the CPD (ie EOTA Approval Bodies).

Table 3.

| **System** | **Task for manufacturer** | **Task for notified body** | **Basis for CE marking** |
|---|---|---|---|
| 1+ | Factory production control<br><br>Further testing of samples according to prescribed test plan | Certification of product conformity on basis of tasks of the notified body and the tasks assigned to the manufacturer<br><br>Tasks for notified body:<br><br>• initial type-testing of the product;<br>• initial inspection of factory and of factory production control;<br>• continuous surveillance, assessment and approval of factory production control;<br>• audit-testing of samples taken at the factory, on the market or on the construction site | Manufacturers conformity declaration<br><br>accompanied by<br><br>certificate of product conformity |
| 1 | Factory production control<br><br>Further testing of samples according to prescribed test plan | Certification of product conformity on basis of tasks of the notified body and the tasks assigned to the manufacturer<br><br>Tasks for notified body: | |

| System | Task for manufacturer | Task for notified body | Basis for CE marking |
|---|---|---|---|
| | | • initial type-testing of the product;<br>• initial inspection of factory and of factory production control;<br>• continuous surveillance, assessment and approval of factory production control | |
| 2+ | Initial type-testing of the product<br><br>Factory production control<br><br>Testing of samples according to prescribed test plan | Certification of factory production control on basis of initial inspection<br><br>Continuous surveillance, assessment and approval of production control | Manufacturers conformity declaration<br><br>and<br><br>certification of factory production control |
| 2 | Initial type-testing of the product<br><br>Factory production control | Certification of factory production control on basis of initial inspection | |
| 3 | Factory production control | Initial type-testing of the product | Manufacturers conformity declaration |
| 4 | Initial type-testing of the product<br><br>Factory production control | | |

### 1.3.5 ITT and FPC

In the construction sector Initial Type Testing (ITT) and Factory Production Control (FPC) have been established by the CPD as the main categories of tests for the CE marking of construction products.

An **ITT is** the complete set of tests or other procedures (e.g. calculation) described in the technical specification, to determine the performance of samples of products representative of the product type, for the mandated characteristics. The ITT for ER3 may include an evaluation of all available information, knowledge and data as well as a test or set of tests deemed necessary. In an ITT a product is evaluated before it is brought to the market. It ensures that the requirements of the harmonised technical specification (reflecting regulatory criteria) are met and that the performance declarations represent the true behaviour of the product.

The **FPC** demonstrates that the performance declarations based on initial type testing results remain valid for subsequent products. The factory production control brings together operational techniques and measures allowing maintenance and control of the conformity of the product with technical specifications. Its implementation may be achieved by controls and tests on measuring equipment, raw materials and constituents, processes, machines and manufacturing equipment and finished products, including material properties in products, and by making use of the results thus obtained. In the harmonised Technical Specification the test methods and frequencies for testing under FPC have to be given. In factory production control direct as well as indirect tests are possible. In ITT the correlation or relationship between a specified characteristic X - the characteristic to be verified - and another characteristic Y (measured by FPC) which is easier, faster and/or safer to measure than characteristic X, must be established and verified when indirect test methods are retained (when available and appropriate). Efficient use of this hierarchy may reduce the overall testing efforts dramatically.

For new products, information with sufficient detail is needed to allow a proper assessment of the release behaviour of products according to the regulations by a full Initial Type Testing ( ITT). Such information is suitable for evaluation of impact during intended use. However, once the release characteristics of a product or product type have been established, usually *much simpler* Factory Production Control (FPC) testing will suffice for potentially critical parameters only at a frequency consistent with the risk of approaching/exceeding set pass/fail criteria by (national) regulation. In cases ITT has shown release of dangerous substances will always be far below the limit values, specific testing for dangerous substnces as a part of the FPC may not be necessary; In such cases tests for other technical properties may suffice to ensure that the product still is manufactured according to the criteria specified in the product standard and in the ITT procedure.

### 1.3.6 Principle of the selection of tests for Factory Production Control (FPC)

For the development of FPC tests, different options are available such as:
1. Carrying out full reference test with determining all mandated substances
2. Reference test, restricted to the analysis of key parameters
3. Reference test, but executing only first steps for key parameters
4. Alternative test
5. Screening test

Since the AoC system for ER3 may in future be different in different product groups , the methods to be recommended in this TR are considered suitable for any form of AoC as described in table 3.

The selection of the tests for FPC should be based on knowledge, understanding the underlying release processes and data. The best way to guarantee this requirement on FPC tests is that they are a shortened and/or simplified form of a full reference test (step 1-3 above, see also example below). Based on experience, testing can be reduced to even simpler forms of testing (such as a visual test: e.g. product structure or color). An example of correct “simplification” of a full reference test is presented in Figure 2.4. When for a product group a consistent emission behaviour is verified through test data and modelling, test duration can be limited.

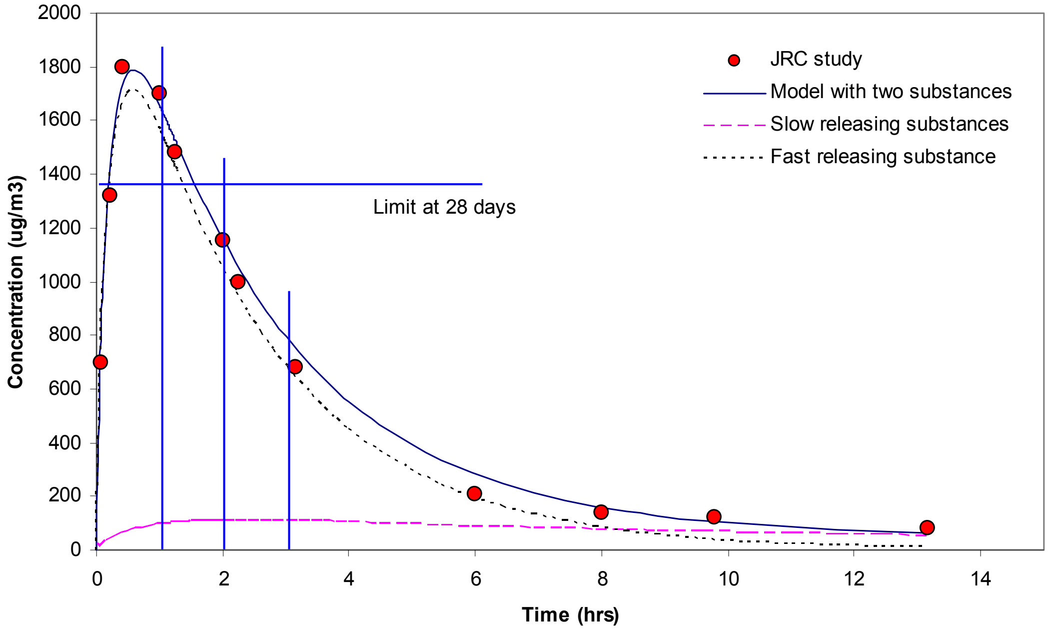



*Figure 2.4. Example of test results and emission modelling showing consistent emission behaviour of a product. This example shows that the product may qualify for Without Further Testing.*

When the amount of dangerous substances in a product is expected to be so low, that release will never be able to exceed limit values, for example a content test may be suitable.

# PART 3. CONCLUSIONS AND RECOMMENDATIONS REGARDING TESTS TO ASSESS IMPACTS TO SOIL, SURFACE & GROUNDWATER AND EMISSIONS INTO INDOOR AIR

## 1. Testing with respect to release to soil, surface water and groundwater

Below, the conclusions and recommendations are grouped according to the main questions from mandate M/366 and the description of TR2 in the CEN/TC 351 business plan (see Part 1) point by point in a logical order as much as possible. General recommendations that apply both to the field of soil, surface water and groundwater and emissions to indoor air are given in subchapter 3 of this Part (see also Part 4 for background details).

*Taking into account the state of the art in the Member States, recommendations shall be elaborated for the testing procedures.*

- Based on technical and practical grounds as outlined in Part 2 and Part 4 of this report, it is concluded that a horizontal approach for testing release of substances from construction products to soil and groundwater is possible.
- The following requirements for horizontal test methods for the release of dangerous subtances from construction products to soil and groundwater are identified:
  - The horizontal tests to be adopted for assessing impact to soil, surface and groundwater need to be applicable to as many products as technically feasible.
  - The tests must provide the information that is relevant for the notified regulatory systems including information on the content of regulated dangerous substances.
  - The test to be adopted shall address the release of substances in the intended use of the respective construction products.
  - The test shall take into consideration long term behaviour including changes in release behaviour during service life, if that could lead to higher release than the initial release.
  - The tests must fit with the scheme of conformity testing as part of the CPD
  - The tests shall be suitable for ITT and FPC
- Based on the insight that the release of substances from construction (and other) products to soil, surface water and groundwater is controlled by a manageable number of physical and chemical factors (for detail refer to Part 2 in general and Part 4 in particular), a limited set of already existing, generally applicable, standardized test methods is recommended. As a result of this technical and practical possibility for a horizontal approach, and based on consultation of the construction sector, the following generally applicable test methods for construction products are recommended to be adopted and if necessary amended by CEN/TC 351 (see Table 4). Note that the test methods for each product category (granular, monolithic, etc.) are not listed in a specific order.

**Table 4.**

| **Reccommended ITT level reference test methods** | | | | |
|---|---|---|---|---|
| **Product** | **Substances** | **Test reference** | **Test name** | **Status** |
| Granular | Inorganic | CEN/TS14405:2004 | Characterization of waste - Leaching behaviour tests - Up-flow percolation test (under specified conditions) | published |
| | Inorganic + non-volatile organic | ISO-21268-3:2007 | Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials -- Part 3: Up-flow percolation test | published |
| | inorganic | CEN/TS14429:2005 / CEN/TS14997:2006 | Characterization of waste - Leaching behaviour tests - Influence of pH on leaching with continuous pH control (TS14997) / initial acid/base addition (TS14429) – provide equivalent results | published |
| | Inorganic + non-volatile organic | ISO/TS21268-4:2007 | Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials -- Part 4: Influence of pH on leaching with initial acid/base addition | published |
| Monolithic, plate- or sheet-like | Inorganic | "DMLT-PLR" | Dynamic Monolith Leaching Test – Periodic Leachant Renewal (DMLT-PLR) | In development (Work Item 292010 of CEN/TC 292) |
| | Inorganic + non-volatile organic | prCEN/TS15119-2:2007. | Wood tank test | |
| Compacted granular[#] | Inorganic | NEN7347:2006 | Leaching characteristics of solids earthy and stony building and waste materials - Leaching tests - Determination of the leaching of inorganic components from compacted granular materials. | Published (national standard) |
| Solid metal products | Inorganic | CEN/TS14429:2005 | Modified for plate products; | To be developed |

[#] Test relevant for granular products behaving as a monolith (no percolation) in intended use (similar principle to DMLT-PLR).

- Due to the recommended hierarchy of comprehensive test methods (used for a ITT) and related simpler test methods (for FPC and for reduced ITT), the efforts of concerned producers can be kept limited or be reduced.
- For factory production control, simplified versions of the recommended ITT tests are recommended as this guarantees justifiable correlation between ITT and FPC testing. In addition, need for validation is reduced, when the simplified procedure is a part of the validated full reference test procedure.
- The recommended simplified versions of the recommended reference test methods for ITT, which can be used for FPC, are listed and discussed in Part 4.

*For which products are measurements/test schemes relevant with respect to soil, surface water or groundwater?*

- After evaluation of the scopes and construction products from 65 CEN/TCs and 32 EOTA WGs identified by CEN/TC 351 as part of the construction sector, it is concluded that not all of these TC's and WG's focus on products that may potentially release substances to soil, groundwater and/or surface water. A preliminary assessment is made whether products covered by TCs and WGs may potentially release substances to soil, surface water and groundwater during service life, based on a number of technical considerations outlined in Part 4; the most important consideration is whether the product is, under conditions of intended use, used outdoors and exposed to soil, ground-, rain- and/or surface water. For more detailed information see Part 4.

Table 5. Preliminary assessment based on technical considerations of which CEN/TC's cover products that (1) may potentially release substances to soil, surface water and groundwater quality (column 2); (2) are constituents /intermediate (half)products (column 3), (3) that are products only used indoor and do not release substances during service life (column 4) and (4) products that are not relevant with respect to potential release to soil, surface water and groundwater (column 5).

| Column 1 | Column 2 | Column 3 | Column 4 | Column 5 |
|---|---|---|---|---|
| Classification of intended use conditions | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
| CEN/TCs | 28 | 11 | 7 | 19 |
| EOTA WG | 15 | 4 | 8 | 5 |

Table 6. The 28 CEN/TCs and 15 EOTA WGs in the first column of Table 1 cover final products including those that may potentially release substances to S&GW during intended use (i.e. outdoor use). It has been attempted to cover the different EOTA lists of WGs by referring to relevant CEN TCs that cover the same or similar product groups.

| CEN/TC: | |
|---|---|
| 33 | "Doors, windows, shutters and building hardware” |
| 67 | "Ceramic tiles” |
| 104 | "Concrete” |
| 124 | "Timber structures” |
| 125 | "Masonry” |
| 128 | “Roof covering products for discontinuous laying and products for wall cladding” |
| 129 | "Glass in buildings” |
| 154 | “Aggregates” |
| 155 | "Plastic piping systems and ducting systems” |
| 164 | “Water supply” |
| 165 | "Waste water engineering” |
| 166 | "Chimneys, flues and specific products” |
| 167 | "Structural bearings” |
| 175 | "Round and sawn timber” |
| 177 | "Prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure” |
| 178 | "Paving units and curbs” |
| 189 | "Geotextiles and geotextile-related products” |
| 203 | “Cast iron pipes, fittings and their joints” |
| 217 | "Surfaces for sports areas” |
| 221 | “Shop fabricated metallic tanks and equipment for storage and for service stations” |
| 226 | "Road equipment” |
| 227 | “Road materials” |
| 229 | “Pre-cast concrete products” |
| 246 | "Natural stones” |
| 249 | “Plastics” |
| 254 | "Flexible sheets for waterproofing” |
| 266 | “Thermoplastic static tanks” |
| 297 | "Free-standing industrial chimneys” |

Table 6 (continued)

| **EOTA WG:** | **Title:** |
|---|---|
| 5 | “Structural Sealant Glazing Systems” |
| 6 | “External Thermal Insulation Composite Systems/kits with rendering” |
| 7 | “Non-load bearing permanent shuttering systems based on hollow blocks or panels of insulating materials and, sometimes, concrete” |
| 8 (see CEN/TC 128) | “Systems of mechanically fastened flexible roof waterproofing membranes” |

| | |
|---|---|
| 9 | “Liquid applied roof waterproofing kits” |
| 11 (see CEN/TC 128) | “Self-supporting translucent roof kits (except glass-based kits)” |
| 15 | “Timber Frame Building Kits” |
| 16 | “Log Building kits” |
| 19 (see CEN/TC 128) | “Self-supporting composite light-weight panels” |
| 20 | “Expansion joints for road bridges” |
| 22 | “Ventures (prefabricated) insulation Kits and Cladding Kits” |
| 24 | “Prefabricated Building Units” |
| 26 (see CEN/TC 104) | “Concrete and Metal Frame Building Kits” |
| 30 (see CEN/TC 227) | “Ultra Thin Layer Asphalt Concrete” |
| 31 (see CEN/TC 88) | “Inverted Roof Kits” |

- The products identified in column 4 and 5 of table 1 are , with respect to their impact to soil, surface and groundwater during service life, due to the intended use not submitted to regulation, so no testing is needed.
- The products referred to in column 3 relate to intermediate or half-products, their possible impact to soil, surface and groundwater can only be assessed by evaluating them in a (standardised) final product, as assessment of release from an intermediate product bears no relation to the behaviour of that product in a final product (see Part 4).
- For the products referred to in column 2 and based on additional information or test data (to be described in a dossier), it is expected that a number of them will likely be WT. However, this assessment is not up to CEN/TC351 or TG2, but resides with procedures to be stablished by the European Commission in liaison with CEN/TC 351 and the respective products TCs. At this point reference is made to TR 3 (prCEN/TR 15858, WI 00351001).

*How to define clusters of products that behave similarly in release tests (release scenario)?*
- Based on insight in the fundamental mechanisms that determine release of substances, a basic distinction is made between construction products that are granular (percolation dominated release) or monolithic (surface area related release), as denoted in Tables 1 and 4. Horizontal tests suitable for both groups of construction products are recommended. For the vast majority of product (group)s, the distinction granular/monolithic is straightforward.
- For materials for which the distinction granular/monolithic is not straightforward (e.g., metal plate material, heterogeneous and coarse granular material) recommendations are made for horizontal test methods that are fully compatible with those listed in table 1 (see Part 4 for detail, and below).

*For which substances or products is the measurement of content relevant?*
- It is recommended that horizontal test methods should be based on *release,* as *content* is a poor indicator for environmental exposure and there is generally no relation between content and release or emission. Judgment of environmental impact based on total content of substances in the product may lead to over-estimation of the release potential, as substances are generally subject to many chemical and physical constraints that determine the actual release. Methods based on content must be used when they are legally required only, and should be used when an assessment of release is not possible, or deemed to be

too expensive or not practicable . Examples and differences between release and content testing are given in Part 4 of this report.
- For methods based on determination of total content, more information will be provided by Task group 5 preparing TR14.

*How to combine individual measurements and test methods to an appropriate test programme to allow determination of the relevant properties and to allow the assessment of the results?*
- Testing for release /emission of dangerous substances from construction products consists of several “fixed” steps, the “measurement chain”. In short, it starts with the sampling procedure, it is followed by storage and test portion preparation, conducting the test, analysis of the eluates and finally, reporting the results (for detail see Part 2). Many of those steps are similar in different testing programmes. Duplication in developing test programmes is greatly avoided when each of these steps are written down in “horizontal modules”. When preparing/selecting a test protocol for a specific product in a specific situation, the relevant modules can be selected and simply put together. This approach is called the “horizontal modular approach”. It is recommended to structurally follow this approach, explained in detail in Part 2, for the development and use of test procedures for dangerous substances.
- A stepwise guideline for TCs for structuring horizontal test protocols for products is given in Annex C. A description of the principles of horizontal testing approach is given in Part 2.

*This Technical Report shall review in accordance with the experience already gained the basis for deciding whether or not the use of horizontal standards for construction products is practicable and/or necessary in the sense of the CPD art. 7.2.*
- Reviewing the experience already gained, it is can be concluded that an advantage of the recommended test methods is that there is already much (worldwide) experience with them for many different construction products. Test methods that are based on similar principles as TS14405 (percolation test) and DMLT-PLR (tank test) are since 1995 directly referenced in Dutch construction products regulation since 1999 (Building Materials Decree; now Soil Quality Decree; NEN7345/7375 and NEN7343/7373, respectively). As a result of this, there is a vast amount of experience and data from a wide range of products already available. Due to the recommended testing hierarchy, ITT (full reference tests) versus simplified testing for reduced ITT and for FPC (see Part 4) and the horizontal modular approach (see Part 2 and Annex C), a large reduction in testing effort is expected compared to a traditional “vertical” approach. Therefore it is concluded that the use of horizontal standards for construction products is both practicable and necessary.
- For coarse granular material (used as aggregates) the existing European standard EN 1744-3 needs to be evaluated for its use in a regulatory context, as questions have been raised on its suitability for that purpose. In addition, it will be necessary to compare results from EN1744-3 with data obtained with the recommended horizontal reference test methods (see Table 4) on the same materials to be able to draw better conclusions on the suitability of the test results for conformity assessment.
- The test protocol developed in OECD (method 2) for treated wood (Biocide Directive) is very similar to the tank test described above (DMLT-PLR, see Table 4). This would imply that this test would have preference for horizontal testing over the recommended horizontal test methods (with some slight adaptations in interpretation of results, see Part 4).

*The report shall include the mechanism by which required amendments of horizontal standards or in special cases vertical standards are identified for specific products or product* *families. In particular it shall identify the procedures and limitations for amending horizontal standards and describe the justification process for vertical standards.*

- It is concluded that there are no “vertical” tests (tests specific for a product, substance or specific release scenario) necessary. If there are suggestions to develop 'Vertical tests', such intentions are often based on the idea of “simulation” of intended use conditions. For reasons outlined in Part 1 (general), 2 and 4 (more specific), such tests are generally not suitable for judgement of the environmental behaviour of products during service life. It is therefore in general not recommended to develop vertical tests for individual products.
- Horizontal *modules* that are adapted to “fit” for a specific product may sometimes be needed. Examples in which this may be necessary are (in order of the steps in the measurement chain):
    - sampling (specific products may require a specific approach);
    - storage and sample preparation (some products may have reducing properties which may require certain measures to prevent oxidation while working with them);
    - testing; some products require slight adaptations to the recommended test protocols. An example is the adaptation of existing tests to make them suitable for solid metal products (see Part 4)
    - chemical analysis (e.g. bituminous material may require particular measures that are different from predominantly inorganic material)

If it turns out that a horizontal test is not possible, vertical tests for one product group are deemed acceptable only after checking if an intended vertical test is not suitable for other related product groups (see Annex C).

*Attention shall be given to the intended conditions of use as well as to the required specific conditions of use for certain products especially in the definition of the testing conditions in order to allow for an adequate assessment.*

- Results from the recommended test methods can be related to the actual “impact” in the environment (concentrations of substances downstream of the application, at a certain point of compliance) through modelling, based on the insight of underlying mechanisms that control release. The recommended test methods provide, when such a development is needed, the type of information needed for such a modelling step.

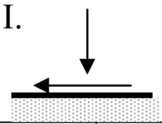
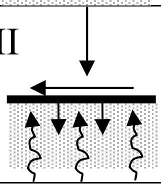
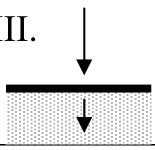
- Modelling the release of a product during service life can be done by defining one or a limited number of default “basic release scenarios” that are based on the intended conditions of use. At present three basic release scenarios are discussed in the Ad hoc group of WG1 (AH1) for emissions to soil and groundwater, based on product characteristics and resulting differences in release mechanism:

- <u>Scenario I:</u> Impermeable product. Water is redirected at the surface of the product. For products used above ground this is surface runoff. For example, sheet metal, surface coating, glazed tiles, glass surfaces etc. The scenario is also relevant for products used underground, or submerged into water. For example: Foundations such as steel piles (a cover of polythene, epoxy, zinc are commonly used as corrosion protection) used in ground or in water.

- <u>Scenario II:</u> Low permeable product. Water is transported into the matrix by capillary forces, and a fraction may be redirected at the surface of the product. In the matrix the capillary force is considered to be significant and the water movement is slow. Dissolved substances are transported out of the matrix by (capillary driven-) advection and diffusion. At the surface substances may dissolve and precipitate. This scenario is relevant for typical monolithic products used above ground, under ground, or submerged into water. For example, tiles (non-glazed), bricks, concrete, and pipes. A special case is permeable compacted granular material used in constructions partially sealed by impermeable layers, for example a paved construction. The physical properties of the pavement structure influence the way and the extent to which the construction materials become exposed to water, here different zones develop dominated by gravity flow and capillary flow and diffusion, respectively.

- Scenario III: Permeable product. Water may infiltrate into the matrix driven by gravity (pressure head gradient). A fraction of the water may be redirected at the surface of the product. The main transport process is advection through the matrix with the gravity driven flow. Transport with any water that is redirected at the surface is considered to be negligible (for this reason the horizontal arrow has been omitted in table Y). For example, granular products, building debris, soil, etc, used above ground or underground, or submerged into water. This release scenario also applies to coatings

Table Y. Water contact and leaching scenarios.

| **General scenario** | **¤Relevant test methods** |
|---|---|
| I.  | Tank test (DMLT) |
| II  | Tank test (DMLT) alt.<br>Compacted granular tank test |
| III.  | Column test (CEN/TS 14405)<br>Batch test (EN 12457) |

Note that all three scenarios are relevant for products used above ground, under ground, or submerged into water. Both the construction product and the specific use of that product will influence the choice of an appropriate category of scenario. Based on subsequent discussions, it may prove necessary to reduce or expand the above number of release scenarios; see therefore the activities in WG1. In case of materials applied under isolation measures, the same release test is used as for the uncovered product, but in the evaluation of the results other criteria are applied (obtained by taking reduced infiltration into account).

Based on subsequent discussions, it may prove necessary to reduce or expand the above number of basic release scenarios; see therefore the activities in WG1. In case of soil injection and grouts that set in situ, the release may be dominated by percolation for a certain period and later on, the product may behave as a monolith. In that case the relative importance of the two exposure conditions needs to be evaluated to decide upon the main approach for assessing fulfilment of ER3 criteria.

- A release scenario can be seen as a description of a “source term” that describes the release of a product during service life under intended conditions of use. For assessment of the environmental impact, the “source term” needs to be coupled to a “pathway” that describes the processes that substances undergo between the construction works and the ”point of compliance”, that is, a certain point at which quality criteria with respect to soil, surface water and/or groundwater criteria have to be met. In principle each of the AH1 scenarios above can be coupled to a “pathway” such as “soil” or “water”. See also Part 2 for a general description of “source term” and “pathway” and Part 4 for a specific description.

*Recommendations on uncertainties and validation*
- There is already a fair amount of data and information in relation to uncertainty and sensitivity to test parameters available on the tests that have been identified as potential horizontal test methods for construction products (see Table 4). This implies that the robustness study, needed prior to the mandated intercomparison validation, can be for a large part a desk study to bring all existing information together. Only a limited amount of experimental work is foreseen as necessary for verifying suitability of test conditions.
- The following verifications are foreseen with respect to the applicability of existing test methods in specific product fields (partly already referred to in the recommendations above):
  - For the testing of plate metal products, some verification work is needed to check, whether the proposed test modifications to TS14429 are practical. For instance, it is expected that pH control in steps as described in TS 14429 will not be necessary.
  - For coarse granular material (used as aggregates) the existing European standard EN 1744-3 needs to be evaluated for its use in a regulatory context, as questions have been raised on its suitability for that purpose. In addition, it will be necessary to compare results from the EN1744-3 with data obtained with the recommended horizontal ITT level reference methods (see Table) on the same materials to be able to draw better conclusions on the suitability of the test results for conformity assessment.
  - The test protocol developed in OECD (method 2) for treated wood (Biocide Directive) is very similar to the tank test described above (DMLT-PLR, see Table 4). This would imply that this test would have preference for horizontal testing over the recommended horizontal test methods (with some slight adaptations in interpretation of results, see Part 4).
- The main work in relation to validation will be focussed on a proper selection of construction products to be tested in the intercomparison validation, which sufficiently cover the range of products that can be encountered. It is clear that it will not be possible to test all construction products, nor will that be necessary.

*Recommendations regarding pre-normative work*
- No major pre-normative research is foreseen at this stage.

# 2. Testing with respect to emission to indoor air

Below, the conclusions and recommendations are grouped according to the main questions from the mandate M/366 and the description of TR2 in the business plan (see Part 1) point by point in a logical order as much as possible. (See also Part 5)

*Taking into account the state of the art in the Member States, recommendations shall be elaborated for the testing procedures.*

The general requirements for a horizontal approach that can be used to test/evaluate construction products on their emission of dangerous substances to indoor air in their intended conditions of use under the CPD are the following:

- Integrates the requirements of current valid, notified regulations on emission of dangerous substances (formaldehyde, VOC) and indoor air quality n buildings in the different member states (e.g. 2005-255-D, 2005-592-S, 2002-271-FIN, 2007-0090-DK and several content regulations for products used in indoor spaces).
- Makes use of existing testing methods for emissions of construction products to indoor air.
- Is efficient, precise enough, reliable and applicable for the products to be tested.
- Takes into account current developments on legislation and on evaluation of emissions to indoor air as far as they are well enough established to be included, without extra development time.
- Fits in the general structure, under development now for the evaluation of dangerous substances released from construction products.
- The test should be performed with an adequate precision to make an evaluation of the product possible and reliable.
- The relation between generation of emission from the product produced / placed on the market and the emissions from the product in its intended use situation is well understood: the outcome of the test provides data with which the product can be evaluated in its intended use
- A “hierarchy of testing” is integrated, comprising a reference test used for ITT and a simplified test for FPC.
- The construction products that are to be tested comprise construction products mandated under the CPD. In future heating, ventilating and air conditioning (HVAC) products will most likely be included once they have been mandated.
- Substances to be evaluated comprise of the following groups: volatile organic compounds, VOCs (including VVOCs, VOCs and SVOCs), particles and radioactive emissions. These can be evaluated chemically, physically and/or sensory.
- Characteristics to be tested: susceptibility to the growth of micro-organisms
- Emission of radioactive species will be dealt with by Task Group 6 (TG 6) of CEN/TC 351.

For HVAC systems, particles, susceptibility to growth of micro-organisms as well as for sensory evaluation the currently valid notified regulations are based on a descriptive approach. Here test methods in line with the performance approach are not yet available (standardisation work in progress or not yet carried out).

The horizontal approach for addressing emissions of VOC from construction products is feasible, based on the experience from Germany gained with the application of the mandatory “Principles for the health assessment of construction products used in interiors” (DIBt Principles), and the experience of several national voluntary labelling systems which use mainly the ISO 16000 series. Although the current available testing schemes and the DIBT Principles are mainly concerned with VOC emissions (sum of SVOC is evaluated too), it is foreseen in the near future that the methods applied in the DIBT Principles can be expanded for other types of emissions (such as VVOC) and for other types of products than flooring materials. To test the emission of formaldehyde from mainly wood based panels another method is applied (EN 717). It is most likely that wood based panels can be tested for VOC in the same way as flooring materials are. For the sake of comparability of products and test results it is recommended to use only one method in the future.

*For which products are measurements/test schemes relevant with respect to indoor air?*

The construction and furnishing products to be tested can be divided into the following groups:

| Group | Product TCs |
|---|---|
| **Flooring** | TC 134 resilient, textile and laminate floor coverings |
| | TC 175 Round and sawn timber |
| | TC 217 Surfaces for sports areas |
| | TC 303 Floor screeds and in-situ floorings in buildings |
| **Walls** | TC 99 Wall coverings |
| | TC 33 Doors, windows, shutters and building hardware |
| | TC 128 Roof covering products for discontinuous laying and products for wall cladding |
| | TC 175 Round and sawn timber |
| | TC 241 Gypsum and gypsum based products |
| | EOTA WG 5 Structural Sealant Glazing Systems |
| | EOTA WG 29 Watertight coverings for bathroom walls and floors |
| **Ceiling** | TC 277 suspended ceilings |
| | TC BT/TF/119 stretched ceilings |
| **Sealants** | TC 349 Sealants for joints in building construction |
| | EOTA WG 10 Internal partition kits |
| | EOTA WG 12 Prefabricated stair kits |
| | EOTA WG 17 Fire Stopping, Fire sealing and Fire Protective products |
| | EOTA WG 27 Cold Storage Rooms and Building Kits |
| **Adhesives** | TC 193 Adhesives |
| **Panels** | TC 112 wood-based panels |
| | EOTA WG 18 Pre-fabricated wood-based load bearing stressed skin panels |
| | EOTA WG 19 Self-supporting composite light-weight panels |
| | EOTA WG 21 Three-dimensional nailing plates |
| **Others** | TC 88 Thermal insulating materials and products |
| | TC249 Plastics |

For construction products to be tested it is recommended to focus on a testing procedure that can test the product as test specimens (detailed recommendations will follow from TG4 on sampling). For products that comprise several parts, it would be preferred to test them in the structure or system, but in most cases that will not be feasible and then these parts need to be tested separately.

*How to define clusters of products, taking into account intended use situations and conditions, that behave similarly in release tests (release scenarios)?*

For indoor air, one main 'basic release scenario' could cover all release situations to indoor air. This scenario can be covered by one test procedure. The ISO-16000 can provide the basis for this procedure.

It is recommended to only test for one scenario in other words a single scenario is selected even though it is realised that changing the parameters of the environment (ventilation rate, temperature, humidity, etc.) in which the product is tested can have an effect on the emission and consequently the immission. The following conditions are assumed:
- No sorption and no cleaning
- No other source of a certain pollutant than the product subject to test
- Ventilation efficiency of 1 (same concentration of pollutant at each point in the space)
- A steady ventilation rate
- Fixed climate conditions (temperature, humidity and ventilation rate) , particularly relevant for the emission of formaldehyde
- Fixed loading factors for groups of products, depending on their intended use.
- Homogeneous emission of source
- No covering layer on products

Only if it would appear that for a specific scenario other test procedures would be necessary an extra basic release scenario for indoor air could be specified. Within the 'basic release scenario Indoor Air' further specifications can be made without the need of changing the main test procedure and the main basic scenario description. An impartant topic of discussion has been whether a distinction should be made between products in direct contact with indoor air and products (partly) in indirect contact, such as products covered by other products of by coatings. Construction products could then be evaluated in two different ways of performance
1. In direct contact with indoor air: for example a textile flooring product
2. Not in direct contact with indoor air, possible emission to indoor air: for example gypsum board covered with a coating.

It is recommended not to make this difference for covered and non-covered products, and test all products as if they would be in direct contact to indoor air. (See part 5)

*For which substances or products is the measurement of content relevant?*
For substances under a ban or a restriction such as asbestos, PCB, certain metals and flame retardants, it is assumed that the content approach is used (TG5 of CEN/TC 351 deals with content).

*How to combine individual measurements and test methods to an appropriate test programme to allow determination of the relevant properties and to allow the assessment of the results?*
For the characterisation test it is recommended to apply EN ISO 16000. It is advised to limit chamber size such as to meet requirements of representativity and reproducibility and use the procedures, test chamber and chamber conditions as described in EN ISO 16000-9 (and **not** EN ISO 16000-10). Robustness validation should provide the boundaries for this. If one wants to test with other sizes of chambers, a transfer function for the test results or proof that no difference occurs should be available. The difference in tst results is most obvious between micro chambers and other chambers. The type of pollutants are in general the same, the main difference can be found in the quantity.
For routine testing it is advised to check the possibility to use micro-chambers for the generation of emissions. However, this test should be possible to be applied in the factory and needs to correlate with the characterisation test. Validation is necessary.

The procedures in EN ISO 16000-9 need to be adapted by CEN/TC 351 to become more specific and detailed to provide reliable test results for the CPD. Points of attention are:

- Dimensions, materials and cleanliness level of the test chamber
- Ventilation rate, temperature, relative humidity, mixing rate, velocity/turbulence, background levels of pollutants (Ozone, VOCs, $CO_2$, CO,…..), ad/desorption rate of surfaces; and influence of ranges on precision, reproducibility and on level of release.
- Constant conditions for the product: i.e. loading factors

The default values for testing points are 3 and 28 days, provided that the producer has access to the emission behaviour of their product (i.e. which indicates the emission pattern over time). However, for the collection in the full ITT test or for a WT dossier, it is advised to reconsider the number of testing points (more than two) and the long term testingpoint, i.e. the last point being 28 days after start of the test, if this is compatible with the current regulations. For some products it might be apparent that already after 3 days or one week emission has reached a steady state level while for other products, especially when considering the possible SVOC emission pattern, this will be too soon.
For the translation to the in-use situation, a simplified procedure is assumed, which in some cases will overestimate the real exposure concentration and in some cases will underestimate the real exposure.

Apart from the notified "Principles for the health assessment of construction products used in interiors" (DiBT, 2005/255/D) which defines emission limits directly for products, other relevant notified regulationa in regard to indoor air quality under ER3 are either concerned with exposure levels (concentration in $\mu g/m^3$, e.g. according to the Finnish regulation 2007-372-FIN) or require generally to use products with low emissions (without limit values, e.g. the Dansih regulation 2007-0090-DK). In order to comply with regulations for indoor air quality in buildings the emission rates of the products must be transferred to a concentration or an exposure value. This exposure can be defined as the concentration of the pollutants over time expressed in $\mu g/m^3$ and for a simplified scenario and steady state concentration of a pollutant emitted by a certain surface area, can be expressed as:

$$C = E/Q$$

With: Q = ventilation rate ($m^3/h$); C = concentration ($g/m^3$); E = emission (g/h)

Understanding the emission behaviour of dangerous substances from construction products is crucial to making choices on test conditions for a horizontal standard to assess impacts to indoor air quality.

It should be nsured that in initial investigations of new types of products sufficient measurement points are taken for a proper release curve to be established for a given product. This can be seen as a material characteristic or product reference against which conformity test data can be placed for judgment. Adequate basic information and good understanding of the product behaviour (ITT) may provide a basis for efficient FPC testing so thatcriteria for determination of the most practical and acceptable FPC can be provided. Experiences with other kinds of products and release can be used for deriving such criteria. Use of knowledge of different mechanisms which determine the emission patterns needs to be used for further selection and specification of test methods and for determining needs in ruggedness testing.
As discussed before full testing for product understanding is useful and necessary for new types of products for which no or only very limited information is available. For new products that are quite similar with known products, ITT can be reduced when taking into account the available information and knowledge.

Factors such as temperature (and most likely also humidity for some substances such as formaldehyde), loading and thickness of product, may have a significant impact on the emission. The size of test chamber doesn't seem to have the same effect, except for micro-chambers. Fixing the factors of influence is therefore important when comparing test results from different testing environments.

**Uncertainties and validation**

From several inter-laboratory comparisons, four causes have been identified as key factors for the reliability in measurements of emissions from products to indoor air:

- Homogeneity of test sample,
- Conditions of the test chamber: sink effects (interactions of measured compounds with chamber walls), unpredictable behaviour of certain compounds with variations in relative humidity or temperature
- The analytical procedure followed: for example the columns used in the gas chromatograph, whether these are polar or non polar, length of column, temperature programme, flow
- The person that is performing the analysis and the evaluation of the test results: interpretation of the chromatogram, regarding peak identity, peak integration and quantification/ calibration by the testing laboratory.

The procedures as described now in the EN ISO 16000-9 are not specific or detailed enough to prevent these unnecessary errors. Therefore, it will be necessary in CEN/TC 351 to make the procedures more detailed. With respect to the analytical part, both for characterisation and routine testing, the procedures need to be very clear and detailed enough to prevent unnecessary errors due to analytical procedure and equipment and due to interpretation of results.

Considering the previous validation tests and awaiting the results of the latest validation tests (carried out by the Federal Institute for Materials Research and Testing in Germany, BAM) the following parameters need to be considered for validation:

- Parameters for testing robustness of method:
  - Use of micro-chambers: the relation between emission rates measured in micro chambers versus other chambers in order to check the possibility for using micro-chambers as a fast measurement technique
  - The number of measurement points to determine the emission pattern(s)/ mechanisms for products to provide an evaluation of health impact by emission into indoor air (testing times representative for long-term exposure and for exposure after renovation in occupied houses)
  - Details of procedure description (incl. details of procedure for generation, collection and analysis of chemicals) such as duration of air sampling, test specimen in test chamber continuously or not, influence of humidity, temperature.
  - Short time testing at 3 and 28 days (5 to 100 minutes as recommended in EN ISO 16000-6) or cumulative air sampling over days, weeks, month.
- Parameters for testing performance in the sense of within and between lab variability[6]:
  - Homogeneity of the product tested and
  - The variance or error occurring from different interpretations of complicated gas chromatographic results (e.g. incomplete separation of substances in complex mixtures) .

[6] The outcome of the BAM project will need to verify this conclusion

**Pre-normative research or development of supporting test methods**

The following aspects need to be considered by the TC and may require pre-normative research or development of supporting test methods. Procedure for testing:

- SVOC release from construction products (scope of existing regulations under the CPD).
- Procedure for translating the results to intended-use situations (relations between specific emission rates and the environmental parameters described are required, scope of existing regulations under the CPD)
- Emissions of HVAC-systems (and their components, scope of existing regulations under the CPD, product mandates not yet issued).
- Sensory emissions of construction products (including HVAC components, scope of existing regulations under the CPD).
- Sensitivity of materials to growth of micro-organism (scope of existing regulations under the CPD).

# 3. General recommendations regarding testing with respect to release to soil and groundwater and emission to indoor air

The following conclusions and recommendations apply both to the field of release to soil, surface water and groundwater as well as emission to indoor air. The conclusions and recommendations are grouped according to the remaining questions from the mandate M/366 and the description of TR2 in the business plan (see Part 1), as far as not already covered in the preceding sections.

*The report shall also recommend how harmonized technical specifications should address the subject of regulated dangerous substances, and how the measurements of emission of regulated dangerous substances are included in its testing programme.*

- Guidance for the use of the horizontal tests in product technical specifications (hEN and ETAs) will be given in a follow-up technical report (TR 4). TR 4 will address, on the one hand, the implications of MS notified regulations for assessing and declaring information on the release/emission (or content, where applicable) of regulated dangerous substances from construction products. TR4 will provide the means for introducing the harmonisation processes into CEN standardisation in a 'staged' and manageable manner dealing with the present and looking to the future.
- In TR3 (prCEN/TR 15858) classes are for product performance declarations in CE-marking. A 'Class' is determined by a maximum level and a statistical definition of the certainty that the limit value of the class is met. Where a national regulator requires product performance to be declared, the product will be delivered with a reference to a class. If no data on performance is required, 'NPD' (No Performance Determined) can be declared. In Annex I this is elaborated further.

*The report shall also recommend how the expertise of product Technical Committees can be used adequately when drafting the horizontal test standards.*

- The expertise of the TCs should be utilized and will be necessary in different phases, including:
  - Input in the selection or development of test methods and product testing protocols
  - Identification of relevant regulations and dangerous substances regarding the products.
  - Inventory of available information on (possible) content and release of dangerous substances in/from the product.
  - Specification of the sampling and possibly test-specimen preparation procedure.
  - Specifying procedures for Initial Type Testing
- During the preparation of this TR, a good and constructive response was obtained from the questionnaires regarding various aspects of testing, by which the various construction TCs were consulted. Product TCs contributed also in other ways. The comments (for detail see Part 4 and 5) have led to modification of the TR2 in several parts and in relation to specific product groups.

*Tasks and responsibilities of CEN/TCs and organisational aspects of the horizontal approach*

- The horizontal approach on dangerous substances in construction products should deliver test methods for more than 60 construction product TCs and a number of "environmental" TCs. Mandate/366 requires the horizontal/harmonised methods to be based on existing testing methods/standards as far as possible. Once the test methods for dangerous

substances in construction products are validated and finalised, it may be expected that these will also be used in other environmental and product sectors.
- Construction product TCs are expected to give direct input in the phase of investigating and determining the needs, selecting, further developing and formalizing test standards, and in determining and evaluating validation (ruggedness testing as well as precision validation). In the next phase, product TCs have to integrate the tests for ER3 in the product hENs as far as there are regulations that justify this.
- It should be noted that until now CEN is "vertically" organized, i.e. on the basis of individual TCs being responsible for tests to be developed and used within their scope. Collaboration with other TCs takes place by means of liaisons and cooperation in working groups or other special groups. The further development and maintenance of the matrix structure of horizontal test modules is a task of TC 351 acting as coordinating body.
- TR2 and TR4 should give sufficient guidance for selecting, development and integration in hENs of product testing protocols on dangerous substances.
- In cases where the horizontal modules cannot be made to fit for specific products, solutions should be found in cooperation between product TCs and CEN/TC351 (see question above on special cases in which vertical standards or modules need to be developed)

*Recommendations shall be elaborated for complete testing schemes which take into account all relevant elements according to the methods for the Attestation of Conformity (see Annex III of the CPD).*
- Due to the testing hierarchy of initial type testing methods (ITT) and simpler test methods (FPC), the testing efforts of concerned producers can be kept limited or be reduced.
- For conformity testing with previous ITT and for factory production control, simplified versions of the recommended ITT- level tests are recommended as far as this guarantees justifiable correlation between ITT and FPC testing. In addition, need for validation is reduced, when the simplified procedure is a part of the ITT procedure.
- The horizontal concept applies to all construction for which product mandates related to ER3 are given. When an intermediate product is subject to a regulation, the product ought to be tested within an end-use product representative of intended use in order to give meaningful results. The reference product will be specified by defining its formulation (e.g. cement tested within a mortar mix in accordance with EN 196 – 1).

*Recommendations regarding bringing together available information and databases*
For many products in the past 20-30 years, lots of research and development has been done by institutes and many tests have been done by producers. Generally, only a small part of this information is publicly available in reports, and sometimes in (better accessible) databases. For all parties concerned it would helpful to develop databases containing past and/or current release/ emission data on the construction products currently on the European market and to make (part of) the available information and data accessible. It is therefore strongly recommended to develop a database, which includes release data and other characteristics of a wide range of products. Such a database would facilitate characterization of a product and in assessing possible "band widths" of product characteristics. Such a database should be accessible for all parties concerned.

# PART 4. EVALUATION OF A HORIZONTAL APPROACH TO ASSESS THE POSSIBLE RELEASE OF DANGEROUS SUBSTANCES FROM CONSTRUCTION PRODUCTS TO SOIL, SURFACE WATER AND GROUNDWATER

# 1. Introduction

This part addresses the development of a horizontal testing concept to evaluate the release/emission of dangerous substances from building products to soil, surface water and groundwater.

# 2. Common release mechanisms as a basis for test development for S&GW

In a recent report on the subject of environmental impact assessment in the construction sector [1], it is postulated that for a number of widely different construction products (e.g., wood, concrete, metal roof products etc.) the number of chemical and physical factors that control the release from construction products is limited. Also, the release mechanisms of mineral construction products (concrete, brick, asphalt, aggregates, sand) are the same as those in other products (synthetic, wood, metal) or alternative products. The dominant factors can be identified and quantified in a limited number of initial type testing methods. This similarity allows the use of similar approaches and similar test methods for these construction products.

An important physical factor that determines the release from a product is its structure: granular or monolithic. Equilibrium (solubility controlled) release by percolation is characteristic for granular materials and non-equilibrium (diffusion- controlled) release for monolithic products. Important chemical factors include the pH, redox and acid/base buffering capacity of the product and its environment, and the chemical composition of the surrounding solution, in particular the presence of natural organic matter. These chemical factors may strongly accelerate or retard the release compared to non-reactive substances. Natural organic matter in dissolved form may form strong complexes with many organic and inorganic substances (e.g. heavy metals, organic micro pollutants) and accelerate their release. Some construction materials contain significant concentrations of organic matter (examples are MSWI bottom ash, soil, recycled construction debris) and thus may release substances in an already complexed form. The factor of time is important as it determines the extent to which a substance is released and subsequently spread in the environment. The dominant chemical and physical factors are explained in more detail in refs [2] and [19] and are summarized in Table 1.1 below.

Table 1.1: Dominant chemical and physical factors that control release of substances from construction products [1, 19]. See also the table in Part 2.

| Chemical factors | Physical factors |
|---|---|
| • Intrinsic water solubility of substances (e.g., metal oxides)<br>• "Self" pH of the product and of its surroundings<br>• Acid/base buffer capacity of the product and its surroundings<br>• Speciation (chemical form of the substance in the product)<br>• Total amount of the substance in the product (relevant for non-reactive, soluble salts)<br>• “Availability” of substances in the product (relevant for most other substances, maximum leachable amount is usually lower than total amount) | • Percolation rate (in particular relevant for granular products)<br>• Diffusion rate (in particular relevant for monolithic products)<br>• Surface runoff rate (in particular relevant for monolithic and plate products)<br>• Geometry and size of the product<br>• Porosity (volume of pores)<br>• Tortuosity (shape factor of pores)<br>• Water permeability<br>• Sensitivity for erosion<br>• Temperature<br>• Time |

| Chemical factors | Physical factors |
|---|---|
| • Type and amount of organic ligands (e.g., dissolved organic matter, DOM) to which substances can bind (facilitated release)<br>• Type and amount of reactive surfaces (clays, oxides) to which substances can bind<br>• Redox potential in the product and of its surroundings<br>• Redox buffer capacity<br>• Reaction kinetics | |

The predominance of common release mechanisms in different products makes it possible to answer questions of both regulators and producers with a limited number of test methods, for a wide range of (construction) products and a wide range of exposure conditions. Suitable test methods allow insight into the factors that influence reproducibility, in how to improve the environmental quality of products, to make reliable predictions of the environmental behaviour of products in the environment, and finally, the development of consistent criteria for assessing release of substances from construction products.

For more detail on leaching mechanisms as they appear in a wide range of products see e.g. Van der Sloot and Dijkstra [1], Dijkstra et al. [2]; Guyonnet et al [34], Tiruta-Barna et al., [35], Cornelis [36], Kalbe [37] de Windt et al. [38].

For a general description on how test results can be translated to environmental impact reference should be made to Part 2 of this report; a more detailed description for impact on soil and groundwater is provided in the paragraphs below.

# 3. Selection of CEN technical committees for product standardisation

## *3.1 The questionnaire (evaluation sheet): aim and approach*

To make a first step towards development and standardization of test methods to assess impact to soil, surface water, groundwater and indoor air, the main questions to ask include:

- For which products are measurement/test schemes relevant in regard to indoor air, soil, surface water or groundwater?
- How to define clusters of products that behave similarly in release tests (release scenario)?
- For which substances or products is the measurement/test of the content relevant?
- How to combine individual measurement and test methods to an appropriate test program to allow the determination of the relevant properties and to allow the assessment of the results?

The questions above need to be answered for all different construction products or product groups. This is an action of the project consortium in close cooperation with CEN/TC 351 and the respective construction TCs.

The authors of this Technical Report have expertise on testing and test interpretation, but need input on specific products/product groups. The chosen approach was to consult the different CEN Technical Committee's in construction (about 60 in number). For this purpose, an "evaluation sheet" was developed, which in the first instance wasfilled by the project team and then the different TCs were consulted to provide comments and amendments. This approach aimed to ensure a similar interpretation of the different questions by the different consulted TCs.

## 3.2 For which product TCs is release to soil, surface water and groundwater relevant?

When judging the relevance of construction products for environment and health it was not possible to investigate in detail all currently applicable regulations for ER3 in the member states for this report. Therefore the assessment of the relevance of products has been carried out on technical grounds (see Chapter 1.2). While preparing the questionnaires, the insight developed that not all of the product groups covered by 60 construction TCs are of equal relevance to *potential* soil, surface water and groundwater impact. Therefore, a preliminary assessment was made whether products may potentially release substances to soil, surface water and groundwater based on a number of technical considerations listed below, being the most important whether the intended use of the product is outdoors, and so in (in)direct contact with soil, surface water and/or groundwater. The goal of the assessment was to judge the relevance of the products in regard to impacts on soil and groundwater on technical and not on regulatory grounds (therefore not all products deemed relevant here may necessarily need to implement ER3 in the future). The assessment was made for products covered by the 60 different CEN/TCs in construction that are mandated with respect to ER3 of the CPD, as well as for the list of EOTA WGs. The reason for this assessment was that for some product TCs, impact on soil, surface water and groundwater is very unlikely during intended use (e.g., used indoors), and further consideration in this respect may possibly not be needed (for instance, fire-fighting equipment, anti-seismic devices). The assessment was made by the authors based on the information on each CEN/TC found on the internet (scope, intended use, quantities produced, etc.). The results of this pre-assessment are given in Tables 1.2 (CEN/TCs) and 1.3 (EOTA WGs) and are open for discussions and amendments by the different TCs based on their expertise.

**Criteria used for this preliminary assessment were:**

1. Does the TC cover products that are in contact with soil, surface water and groundwater (i.e. their intended use is outdoors)? Only these products may potentially release substances to soil, surface water and groundwater.
2. Does the TC cover only intermediate products? In the sense of the CPD even final products are considered intermediates as the essential requirements do not concern products as such but construction works. For practical reasons products are tested instead of construction works. The CPD requires also the intermediate products to be fit for their intended use, where regulations exist, if they are placed on the market as intermediates. Thus an intermediate product needs to show that it will satisfy the regulatory requirements in its end use. Intermediate products can be tested as a part of a final product manufactured only for test purposes and consisting besides the intermediate product under scrutiny of constituents whose contribution to leaching is known.
3. Is the recycling stage of the products relevant? Some products are re-used in unbound applications, such as construction debris recycled as unbound aggregate. Such applications

may be relevant to soil, surface water and groundwater impact. Although the "recycling stage" is not addressed under the CPD, there are construction products that are in fact recycled construction products, such as certain unbound aggregates.

4. Annex D of this report addresses aspects on the building cycle, including intermediate and recycled products. These products are not in all cases covered by the ER3 of the CPD, but may in special cases nevertheless be of relevance to judge potential release of substances from final products during intended use. Recycled aggregates are an example of such as "special" case which is discussed in more detail in Annex D.
5. Based on common sense, there are product groups in construction that are not relevant with respect to soil, surface water and groundwater impact. Examples of such product groups are those not in contact with soil, surface water and groundwater neither during service life nor in the recycling stage (e.g., fire fighting systems).

In the EOTA WG list is referred to the CEN/TCs that cover the same or similar product groups.

**Table 1.2: Preliminary assessment based on technical considerations of which CEN/TCs cover products that (1) may potentially release substances to soil, surface water and groundwater quality (column 1); (2) are constituents /intermediate (half)products (column 2), (3) that are products only used indoor and do not release substances during service life (column 3) and (4) products that are not relevant with respect to potential release to soil, surface water and groundwater (column 4).**

| **CEN/TC** | **TITLE** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| 33 | "Doors, windows, shutters and building hardware" | X | | | |
| 46 | "Oil stoves" | | | | x [1)] |
| 50 | "Lighting columns and spigots" | | | | x [1)] |
| 51 | "Cement and building limes" | | x | | |
| 67 | "Ceramic tiles" | X | | | |
| 69 | "Industrial valves" | | | | x [1,2)] |
| 72 | "Automatic fire detection systems" | | | | x [1)] |
| 88 | "Thermal insulating materials and products" | | | x | |

| **CEN/TC** | **TITLE** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| 92 | "Water meters" | | | | x [1)] |
| 99 | "Wall coverings" | | | x | |
| 104 | "Concrete" | X | | | |
| 112 | "Wood-based panels" | | | x | |
| 121 | "Welding" | | | | x [2)] |
| 124 | "Timber structures" | X | | | |
| 125 | "Masonry" | X | | | |
| 128 | "Roof covering products for discontinuous laying and products for wall cladding" | X | | | |
| 129 | "Glass in buildings" | x | | | |
| 130 | "Space heating appliances without integral heat sources" | | | | x [1)] |
| 132 | "Aluminium and aluminium alloys" | | x | | |
| 133 | "Copper and copper | | x | | |

| CEN/TC | TITLE | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| | alloys” | | | | |
| 134 | “Resilient, textile and laminate floor coverings” | | | | x [1)] |
| 135 | “Execution of steel structures and aluminium structures” | | | | x |
| 154/ SC1 | “Aggregates for mortar” | | x | | |
| 154/ SC2 | “Aggregates for concrete” | | x | | |
| 154/ SC3 | “Aggregates for bituminous materials” | | x | | |
| 154/ SC4 | “Aggregates for unbound and hydraulically bound materials” | X | | | |
| 154/ SC5 | “Lightweight aggregates” | X | | | |
| 155 | "Plastic piping systems and ducting systems” | X | | | |
| 163 | "Sanitary appliances” | | | | x [1)] |
| 164 | “Water supply” | X | | | |

| **CEN/TC** | **TITLE** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| 165 | "Waste water engineering" | X | | | |
| 166 | "Chimneys, flues and specific products" | x | | | |
| 167 | "Structural bearings" | X | | | |
| 175 | "Round and sawn timber" | X | | | |
| 177 | "Prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure" | x | | | |
| 178 | "Paving units and curbs" | X | | | |
| 185 | "Threaded and non-threaded mechanical fasteners and accessories" | | | | x [2)] |
| 189 | "Geotextiles and geotextile-related | x | | | |

| CEN/TC | TITLE | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| | products" | | | | |
| 191 | "Fixed fire fighting systems" | | | | x [1)] |
| 192 | "Fire service equipment" | | | | x [1)] |
| 193 | "Adhesives" | | | | x [2)] |
| 203 | "Cast iron pipes, fittings and their joints" | X | | | |
| 208 | "Elastomeric seals for joints in pipework and pipelines" | | | | x [2)] |
| 217 | "Surfaces for sports areas" | x | | | |
| 221 | "Shop fabricated metallic tanks and equipment for storage and for service stations" | X | | | |
| 226 | "Road equipment" | X | | | |
| 227 | "Road materials" | X | | | |

| CEN/TC | TITLE | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| 229 | “Pre-cast concrete products” | X | | | |
| 235 | “Gas pressure regulators and associated safety shut-off devices for use in gas transmission and distribution” | | | | x [1)] |
| 236 | “Non-industrial manually operated shut-off valves for gas and particular combinations valves-other products” | | | | x [2)] |
| 241 | "Gypsum and gypsum based products” | | | x | |
| 246 | "Natural stones” | X | | | |
| 249 | “Plastics” | X | | | |
| 254 | "Flexible sheets for waterproofing” | x | | | |

| **CEN/TC** | **TITLE** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| 266 | "Thermoplastic static tanks" | X | | | |
| 277 | "Suspended ceilings" | | | x [3)] | |
| 295 | "Residential solid fuel burning appliances" | | | | x [1)] |
| 297 | "Free-standing industrial chimneys" | X | | | |
| 298 | "Pigments and extenders" | | x | | |
| 323 | "Raised access floors" | | | x [3)] | |
| 336 | "Bituminous binders" | | x | | |
| 340 | "Anti-seismic devices" | | | | x [1)] |
| BT/TF/119 | "Stretched ceilings" | | | x [3)] | |
| ECISS/TC 10 | "Structural steels - Qualities" | | x | | |
| ECISS/TC 13 | "Flat products for cold working - Qualities, dimensions, tolerances and specific tests" | | x | | |

| **CEN/TC** | **TITLE** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|
| ECISS/TC 19 | "Concrete reinforcing steel -Qualities, dimensions and tolerances” | | x | | |
| ECISS/TC 23 | "Steels for heat treatment, alloy steels and free-cutting steels-qualities” | | x | | |
| ECISS/TC 29 | "Steel tubes and fittings for steel tubes” | | x | | |
| ECISS/TC 31 | "Steel castings” | | x | | |

1. Indoor use, no impact on soil and groundwater during service life. In addition, the apparatus/device(s) will be removed after service life and/or upon demolition of the construction application, and is therefore not found in demolition waste/aggregate that can pose environmental impact in the recycle stage.
2. Nature of product present in construction application is thought to be insignificant with respect to impact on soil,surface water and groundwater quality (i.e. no dangerous substances are anticipated) and/or relative exposed surface of product present in construction application is thought to be insignificant with respect to impact on soil, surface water and groundwater quality (i.e. dangerous substances may be anticipated, but released amount in final application is anticipated negligibly low)
3. No information found on the CEN website.

**Table 1.3: Preliminary assessment based on technical considerations of which EOTA WGs cover products that (1) may potentially release substances to soil, surface water and groundwater quality (column 1); (2) are constituents /intermediate (half)products (column 2), (3) that are products only used indoor and do not release substances during service life (column 3) and (4) products that are not relevant with respect to potential release to soil, surface water and groundwater (column 4).**
**id**

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| 1 | Metal anchors for use in concrete<br>Part 1: Anchors in general<br>Part 2: Torque-controlled expansion anchors<br>Part 3: Undercut anchors<br>Part 4: Deformation-controlled anchors<br>Part 5: Bonded anchors | <br>Endorsed<br>Endorsed<br>Endorsed<br>Endorsed<br>Endorsed | | x | | |
| 2 | Part 6: Metal anchors for use in concrete for fixing lightweight systems | Endorsed | | x | | |
| 3 | Plastic anchors for use in concrete and masonry<br>Part 1: General<br>Part 2: For use in normal weight concrete<br>Part 3: For use in solid masonry materials | Endorsed<br>Endorsed<br>Endorsed<br>Endorsed | | x | | |

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| | Part 4: For use in hollow or perforated masonry<br>Part 5: For use in autoclaved aerated concrete<br>Part: For use in lightweight aggregated concrete<br>Part: For ETICS | Endorsed<br>On hold<br>Endorsed | | | | |
| 4 | Metal injection anchors for use in masonry | Finalized | | x | | |
| 5 | Structural Sealant Glazing Systems<br>Part 1: Supported and Unsupported Systems<br>Part 2: Coated Aluminium<br>Part 3: Thermal Breaks<br>Part 4: Opacified Glazings | <br>Endorsed<br>Endorsed<br>Endorsed<br>On hold | X | | | |
| 6 | External Thermal Insulation Composite Systems/kits with rendering | Endorsed | X | | | |

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| 7 | Non-load bearing permanent shuttering systems based on hollow blocks or panels of insulating materials and, sometimes, concrete | Endorsed | X | | | |
| 8 | Systems of mechanically fastened flexible roof waterproofing membranes | Endorsed | X -> see CEN/TC 128 | | | |
| 9 | Liquid applied roof waterproofing kits | Endorsed | X | | | |
| 10 | Internal partition kits | Endorsed | | | X | |
| 11 | Self-supporting translucent roof kits (except glass-based kits) | Endorsed | X -> see CEN/TC 128 | | | |
| 12 | Prefabricated stair kits | Endorsed | | | X | |
| 13 | Post-tensioning kits for the pre-stressing of structures | Endorsed | | | | X |
| 14 | Light composite wood-based beams and columns | Endorsed | | | x | |
| 15 | Timber Frame Building Kits | Endorsed | X | | | |
| 16 | Log Building kits | Endorsed | X | | | |
| 17 | Fire Stopping, Fire sealing and Fire | | | | | x |

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| | Protective products<br>a. Fire stopping, Fire Sealing Products<br>- part 1: General<br>- part 2: Cable and Pipe Penetration Seals<br>- part 3: Linear Joint Seals/Gap Seals<br>- part 4: Air Transfer Grilles<br>- part 5: Cavity Barriers<br>b. Fire protective products<br>- part 1: General<br>- part 2: Reactive Coatings<br>- part 3: Renderings<br>- part 4: Fire protective Board, Slab and Mat Products and Kits | Finalized<br>Finalized<br>Finalized<br>Dec. 2006<br>Dec. 2006<br><br>Endorsed<br>Endorsed<br>Endorsed<br>Endorsed | | | | |
| 18 | Pre-fabricated wood-based load bearing stressed skin panels | Endorsed | | | x | |
| 19 | Self-supporting composite light-weight | | X -> see | | | |

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| | panels<br>Part 1: General<br>Part 2: For use in Roofs<br>Part 3: For use in External Walls and Claddings<br>Part 4: For use in internal walls and ceilings | Endorsed<br>Endorsed<br>Endorsed<br>Endorsed | CEN/TC128 | | | |
| 20 | Expansion joints for road bridges<br>Part 1: General | <br>Finalized | X | | | |
| 21 | Three-dimensional nailing plates | Endorsed | | | x | |
| 22 | Ventures (prefabricated) insulation Kits and Cladding Kits<br>a. Ventures<br>b. Cladding Kits<br>Part 1: Cladding Elements and Associated Fixing Devices | Endorsed<br>Dec. 2006<br>Dec. 2006 | X | | | |

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| | Part 2: Cladding Elements, Associated Fixing Devices, Sub frame and Insulation Layer<br>Part 3: Glued exterior wall Cladding | Dec. 2006 | | | | |
| 23 | Falling Rock Protection Kits | Finalized | | | | X |
| 24 | Prefabricated Building Units | Endorsed | X | | | |
| 25 | Liquid Applied Bridge deck Waterproof Systems | Oct. 2006 | | | X -> CEN/TC 254 | |
| 26 | Concrete and Metal Frame Building Kits<br>a. Concrete Frame Building Kits<br>b. Metal Frame Building Kits | <br>Endorsed<br>Endorsed | X -> CEN/TC 104 (concrete) | | | |
| 27 | Cold Storage Rooms and Building Kits<br>a. Kits for prefabricated Cold Storage Rooms<br>b. Kits for prefabricated Cold Storage Buildings | <br>Endorsed<br>Endorsed | | | | X |
| 28 | Pins for Structural Joints | Apr. 2006 | | | | X |
| 29 | Watertight coverings for bathroom walls | | | | x | |

| **EOTA WG#** | **TITLE** | **status** | Cover final products including those that may potentially release contaminants to S&GW during intended use (i.e. outdoor use) | Cover only constituents and/or intermediate products, potential release to S&GW only of the final product | Cover only final products used indoor, potential release to S&GW only in recycling stage | Cover only final products without potential release to S&GW |
|---|---|---|---|---|---|---|
| | and floors<br>Self-supporting composite light-weight panels<br>- part 1: Liquid applied waterproofing kits<br>- part 2: Kits with flexible sheets with welded joints<br>- part 3: Kits of inherently watertight boards | Finalized<br>Finalized<br>Dec. 2006 | | | | |
| 30 | Ultra Thin Layer Asphalt Concrete | June 2006 | X -> CEN/TC227 | | | |
| 31 | Inverted Roof Kits<br>Part 1: General<br>Part 2: Rendered Insulation Products for Inverted Roofs | Finalized<br>Dec. 2006 | X -> CEN/TC 88 | | | |
| 32 | Fire Retardant Products | Finalized | | | x | |

### 3.3 Results from the questionnaires

In total, 66 CEN/TCs and 32 EOTA TCs were asked for consultation using the questionnaires. Of the CEN/TCs, a total of 28 cover products that are considered potentially of direct relevance for soil, surface water and groundwater impact (these are marked in column 1, Table 1.2 and 1.3). Of the EOTA TCs, 20 cover products that are considered potentially of direct relevance for soil, surface water and groundwater impact, but many of these are with respect to their scope “covered” by CEN/TCs.

- A total of 27 responses were received on the questionnaires on soil, surface water and groundwater impact. These include 18 completed questionnaires; 16 of these were formally agreed by the respective TCs and 2 were at the time of writing (04-02-08) still in draft. The 9 other responses included TCs and/or branch organizations that made comments to the questionnaire and/or decided that release of substances to soil and groundwater is not relevant for their products.
- Of the 28 CEN/TCs that are considered to cover products that are potentially of direct relevance for soil, surface water and groundwater impact, **10** have responded altogether by 17 completed questionnaires. This means that some TCs have returned more than one questionnaire, namely by different working groups covering different products.
- The overall conclusion that can be drawn from the returned questionnaires is that most TCs see the proposed test methods (see below) as “suitable” for their product. Some remark that more experience should be gained with the proposed methods. One TC in the metal sector considered the proposed testing methods as “unsuitable”, but the criticism has been constructively used to modify the standard to make it suitable for metal construction products (see discussion TS14429/14997 below). A number of possible alternative test protocols are discussed below.
- It appears that there are very little test methods available that specifically aim at release of substances to soil, surface water and groundwater other than the ones proposed and listed in the present report. Some methods need to be compared with the proposed methods. Some sectors have proposed slight modifications to existing tests; e.g. sector on metals have indicated in discussions that the proposed pH dependence test needs modification. Work is in progress to slightly adapt the TS14429 protocol to become suitable for metal plate products. See also Annex E.
- There is much more data on release of substances already available than many TCs had ever anticipated, e.g. due to the Dutch Building materials Decree.

# 4. Recommended test methods

## *4.1 Methods for ITT*

A preferred approach for assessing release of substances is to use a generally applicable set of leaching tests, which define and quantify the underlying mechanisms of release under a wide range of environmental exposure conditions. Through this approach, a common set of test results can be used to assess product performance under a range of use, recycling and disposal conditions and thus facilitating life-cycle evaluations (although the assessment currently required under the CPD only concerns the period of use). In addition, this information facilitates improvement of products and uniform comparison of products within and between different categories and under varying use and management conditions. For instance, the release behaviour of Zn is not as much dependent on a specific product, as it is on release controlling parameters associated with a specific product in terms of pH, redox, dissolved organic carbon (DOC), sorption processes, etc. Below, we will introduce three generally applicable initial type test methods that have proven their suitability to cover the field of all granular and monolithic products [1, 19]. These test methods are recommended to be part of the CEN/TC 351 work. Suitable methods for FT as needed under FPC are presented in section 4.5.

In CEN/TC 292 (Characterization of waste) and in ISO/TC 190 (Soil quality) test methods have been and are still being developed for characterization of the leaching behaviour of granular and monolithic products with a more general applicability than just waste or soil and soil like products [5, 6, 7, 8]. This standardisation work provides the basis for the standards to be adopted or amended by CEN TC 351 "Construction Products: Assessment of Release of Dangerous Substances". The advantage of a horizontal (defined as covering different fields which in CEN until now have seen independent development of tools) approach in testing to assess a time dependent source term is that no double testing is needed when a product switches categories (i.e. changes from a waste into a product and vice versa) or is used for other purposes, i.e. another intended use condition. The most important tests used for ITT-level that cover the field of monolithic and granular products are briefly described below. The test methods proposed are adequate as they properly represent key release factors or they provide a basis to derive such properties. In addition, repeatability has been shown to be quite satisfactory for each of these methods, but reproducibility as obtained from a European validation study is still needed.

*1. <u>pH dependence leaching test</u>*

Based on a comparison of methods and test data the pH dependence test (CEN/TS14429, CEN/TS14997, ISO/TS 21268-4 [6, 7, 8]) has been identified as a method that allows mutual comparison of several different test methods [5]. The CEN/TS14429 and CEN/TS14997 are technically somewhat different, but for most applications the results can be treated as equivalent as long as compared at the same pH value. The tests are developed for inorganic substances (metals, oxyanions). ISO/TS21268-4 is a similar protocol, but its applicability extends to organic substances (such as PAH) as well, but not to substances that are volatile under ambient conditions. US EPA-is adopting a very similar pH dependence test protocol for inclusion in SW 846 (reference book of EPA test methods).

The objectives of this method are to quantify the leaching in different pH-regimes (different environments), the acid neutralisation capacity, and the ability to use the data for geochemical speciation modelling. Different pH regimes may for instance occur through the uptake of $CO_2$ by alkaline products (e.g. concrete) which will result in release properties that change as a function of time. The resulting pH change will affect release properties, which can be estimated by the pH-dependence test. The element specific leaching curve (metals, oxy-anions, major and minor elements) obtained with the pH dependence test can be seen as a product characteristic, a "geochemical fingerprint" of the product under study (figure 4.1).

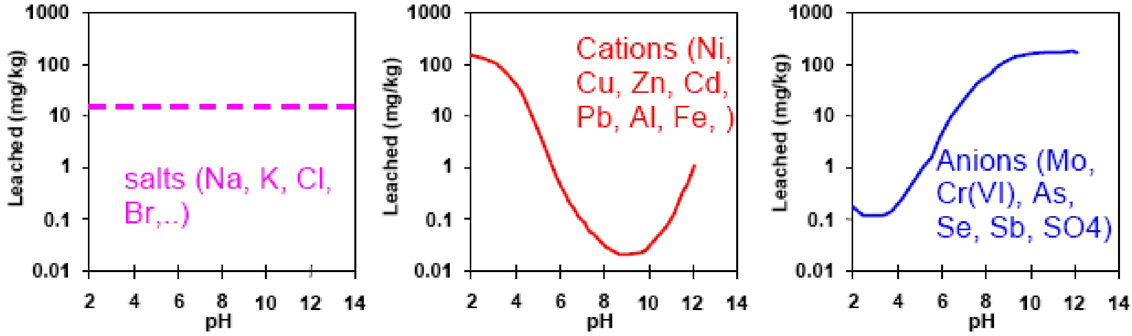



*Figure 4.1: Typical (schematized) result of a pH-static leaching test, which show pH dependent release of substances of different chemical nature. Released concentrations generally vary over orders of magnitude as a function of pH. Also, results of single batch tests can be better interpreted when such data is plotted in a pH-dependence diagram. For instance, apparent "bad reproducibility" can often be explained as batch tests are conducted at steep pH-concentration gradients.*

*Features of the pH dependence leaching test (TS14429/TS14997 [6, 7]):*

- Applicable to almost any (granular or size-reduced monolithic) product
- Examples of granular products: natural, synthetic and recycled aggregates, soil, debris, crushed (size reduced) concrete
- In initial acid base addition mode very easy to perform anywhere
- Identification of sensitivity of release to small pH changes
- Provides acid neutralization capacity information
- Provides information on release under pH conditions imposed by external influences (acid, neutral, alkaline)
- Basis for comparison of many existing international leaching tests
- Basis for geochemical speciation and transport modelling
- Mutual comparison of widely different products to assess similarities in leaching behaviour
- Tool for recognition of factors controlling release (figure 4.2)
- Identification of solubility limitation in a tank test (see below) or DMLT-PLR (dynamic monolith leaching test; see below) by comparing eluate data with pH dependence test data
- Measurement of chemical species that are non-reactive (e.g. chloride) can be used as "tracer" species to assess variability/standard deviations caused in the chain: sampling-test performance
- Much experience with this test has been gained, a lot of data is available from a very wide range of products (see e.g., www.leaching.net).

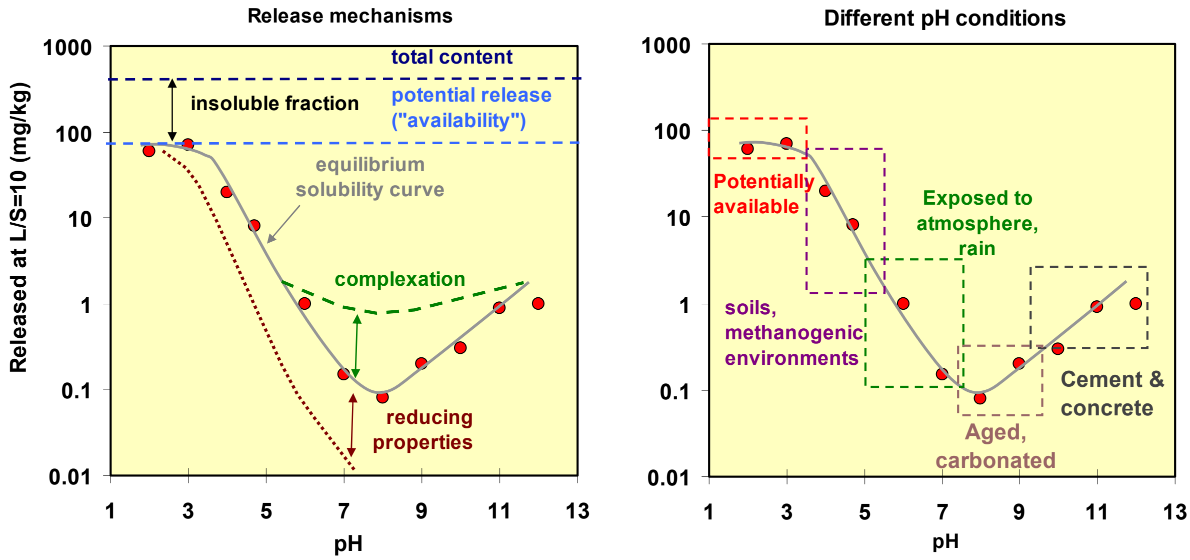



*Figure 4.2: Left: data from a pH-dependence test can be indicative for release mechanisms in individual product samples and substances can form a "fingerprint" of the mechanism that controls release under different conditions (example for a cationic metal, principles also apply to other substances). The effect of (changes in) chemical conditions that can be met in practice on the release of substances from construction products can be assessed (Figure right).*

*2. Percolation test*

The release from granular products occurs mainly through percolation of water through the product and subsequent uptake of substances (CEN/ TS 14405, ISO/TS21268-3 (9, 10). CEN/TS14405 and ISO/TS21268-3 are very similar, but the ISO/TS21268-3 focuses on organic substances (such as PAH) as well, but not on substances that are volatile under ambient conditions. An advantage of these recommended test methods is that there is much (worldwide) experience with test methods based on similar principles for many different construction products. E.g.,  the percolation test NEN7373 (successor from NEN7343) is based on the same principles as TS14405 and is a validated test method directly referenced in Dutch construction products regulation since 1999 (Building Materials Decree, Soil Quality Decree). US-EPA is adopting a very similar percolation test in SW 846. (reference book of test methods)

For the percolation behaviour of granular products the presentation of release and concentration as a function of the liquid to solid (L/S) ratio is the most suitable form of data presentation [5], as it allows comparison with data from larger scale experiments (e.g. lysimeter) and field data [8] (figure 4.3). The latter does require an estimate on the amount of liquid that has passed through the product. A particular feature is that the combination of the before named pH dependence test and a percolation test provides a strong combination for the assessment of release under a range of environmental conditions (as a function of pH and L/S ratio) and provides the necessary input for geochemical speciation and transport modelling. TS14405, contrary to other percolation tests such as NEN7373, prescribes an initial equilibration period after saturation of the column with water in order to attain (near-) local equilibrium conditions in the first few leachate fractions (L/S 0.1 – 0.2 l/kg). It has been argued that the initial equilibration period is functional for establishing lab – field relationships; in addition, it has been shown that even for a heterogeneous granular product TS14405 is rather insensitive to flow velocity [40].

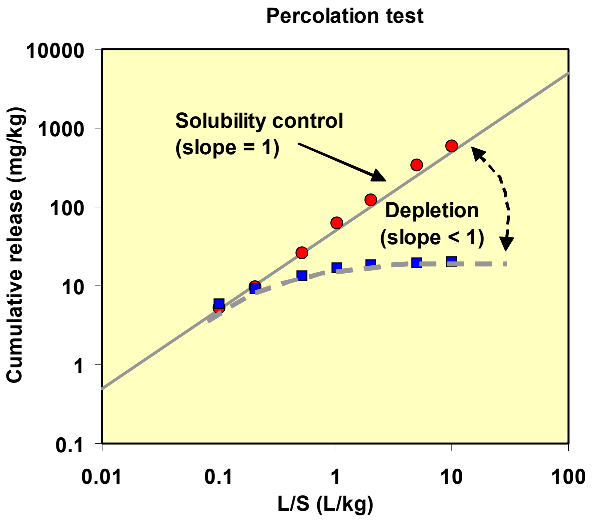



Figure 4.3: Typical (schematized) result of a percolation test. The shape of the curve is indicative for different release mechanisms, such as solubility control (invariable concentrations) or depletion (wash-out of soluble salts). The L/S scale (l/kg) can be translated to a time scale in practice based on precipitation rate (mm/y, l/m$^2$.y), bulk density (kg/m$^3$) and application height (m).

*Features of the percolation test (CEN/TS14405, ISO TS 21268-3 [9, 10]):*
- Applicable to many products, in particular relevant for granular products.
- examples of granular products: natural, synthetic and recycled aggregates, soil, slags
- Identification of release controlling process (solubility control versus wash-out)
- Quantification of pore water concentrations relevant to field leachate from low L/S data
- Basis for geochemical speciation and transport modelling and prediction towards long-term behaviour
- Allows comparison with lysimeter and field data (provided L/S value can be obtained from such measurements)
- Limited or not applicable to low-permeable products (see below for alternative test).
- Much experience has been gained with TS14405 and similar test methods NEN7373/NEN7383, of which the latter have been called-up by Dutch construction regulations since 1999. A vast amount of data for a wide range of products is available (see e.g. reports on the monitoring of the environmental quality of construction products, [39]).

<u>3. Tank leaching test</u>
The release from monolithic products is mainly limited by diffusion from the internal matrix to the surrounding water phase, and is thus related to the exposed surface area of the product. In the tank test, the release is related to the surface area of the specimen to be tested. A tank test is at present under development in TC292, the DMLT-PLR (Dynamic Monolith Leaching Test – Periodic Leachant Renewal) [16]. This protocol is quite similar to the Dutch standard tank leaching test (NEN 7375, [11], formerly NEN7345), which is a validated test method directly referenced in Dutch construction products regulation since 1999 (Building Materials Decree, Soil Quality Decree). In the DMLT-PLR, the specimen is subjected to leaching in a closed tank. The leachant is renewed after regular time intervals roughly related to the square root of time and generally up to around 64 days at a specified leachant to product volume ratio (L/V). The results are expressed in mg released/m$^2$.(figure 4.4) This method can be applied as long as the product maintains its integrity.

The DMLT has slightly different renewal times compared to NEN7375 to better discriminate between diffusion-dominated release and solubility-controlled release. The DMLT method is developed for inorganic substances, but with relatively minor technical modifications (based on differences between CEN/TS14429 and ISO21268-4) it will be suitable for organic substances as well. US-EPA is now adopting a method for testing monoliths very similar to the DMLT-PLR for inclusion in SW846 (reference book of EPA test methods).

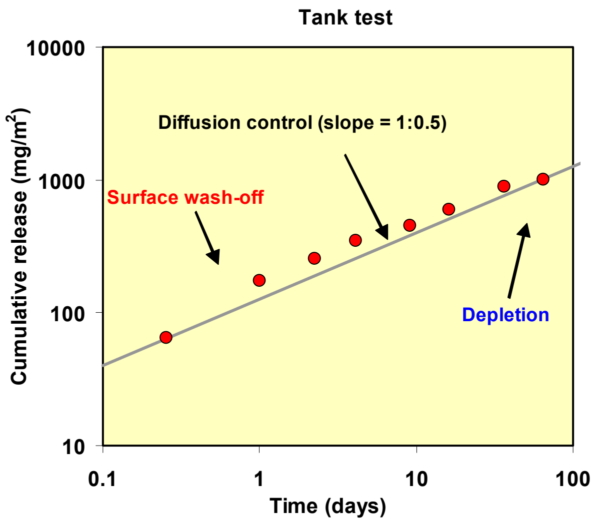



*Figure 4.4: Typical (schematized) possible results of a tank test. The slope of the cumulative release curve is indicative for the mechanism that controls the release, such as pure diffusion, depletion, or surface wash-off. The slope of the curve can be used to estimate effective diffusion coefficients that can be used in modelling of release scenarios.*

The CMLT (Continuous Monolithic Leaching Test), being developed in CEN/TC292, is a method based on the same principles as DMLT-PLR (i.e. surface related release) but with a slightly different technical procedure based on continous recirculation of the leachant. Although the CMLT method has been shown to allow mechanistic interpretation and a start for modelling leaching scenarios [35], at present more experience is available with methods based on periodic leachant renewal (see e.g. ref 39).

The leaching procedure referred to in CEN/TC 104 work [12] is based on the NEN7375 protocol. For assessing the release of biocides from treated wood EN 1250-2 [13] has been developed with similarities to the DMLT-PLR tests as the monolithic character and surface area related release from the product is the basis of the test. One of the OECD protocols [14] is very similar to this method and is the preferred testing approach in view of the possibility to use the test results for release scenario evaluation [15].
The OECD protocols have recently been standardized by CEN/TC 38 (Wood preservatives), prCEN/TS15119-1 [24] and prCEN/TS15119-2 [25]. Both standards are developed to "simulate" a specific scenario, such as in intermittent wetting (TS15119-1) or in permanent contact with water or soil (TS15119-2). Disadvantages of test methods that try to simulate specific scenarios have been discussed elsewhere in this report. One of the requirements for the development of horizontal test methods should be to provide the information by which test results can be translated to other or different exposure scenarios. This means that the test should provide results that enable the determination of the basic release mechanisms (e.g.,

equilibrium solubility, diffusion) and quantitative release properties (e.g. an effective diffusion coefficient).
The procedure of TS15119-2 is almost the same as the DMLT-PLR (the recommended horizontal test method for monolithic products), which could mean that TS15119-2 for wood products may fit well in a horizontal testing framework. However, although the test procedure is similar, the treatment of the results may need some adaptation for this purpose (e.g. determination of the dominant release process, estimation of effective diffusion coefficient). The TS15119-1 protocol is less suitable for this purpose, because the intermittent-wetting test protocol does not allow a straightforward determination of mechanistic release properties.

Test methods used to test the migration of substances from cementitious materials in contact with drinking water [prEN 14944] are to some extent different from the NEN7375 standard as shown by van der Sloot and Dijkstra [1] and are less likely to be suitable for general application to all monolithic construction products.
The combination of a tank test/pH dependence test can be used to assess the release behaviour of a product after disintegration or demolition, as in this situation the pH is likely to change from strongly alkaline to more neutral conditions.

*Features of dynamic monolith leach test DMLT-PLR [16] (in development):*
- Relevant for products with monolithic character (durable products) such as concrete or products behaving as a monolith (low permeable products)
- Examples of "monolithic" products: concrete, masonry, plastics, wood, rubber
- Identification of solubility control versus dynamic leaching possible
- Identification and quantification of surface wash-off effects
- Quantification of intrinsic release parameters (e.g. effective diffusion coefficient)
- Basis for reactive/transport modelling
- Prediction towards long term behaviour possible.
- Much experience has been gained with NEN7375 of which the results are quite comparable with those from DMLT-PLR, and which is referenced in Dutch construction products regulations since 1999 (Building Materials Decree, Soil Quality Decree). A vast amount of data for a wide range of products is available (see e.g., reports on the monitoring of the environmental quality of construction products, [39]).

The above three release tests cover the field of practically all granular and monolithic products (apart from exceptions, see below). As such, these test methods form the basis for product characterization and are recommended for standardization as reference test methods for construction products in CEN/TC351 that also can be used at ITT level. More detailed technical information on these test methods and their application to various products is referred to Dijkstra et al. [19] and references therein.

4 <u>Special considerations</u>
Although the vast majority of products can be categorized on the basis of granular/monolithic and testing by the (one of) the above (reference) tests is straightforward, there are some exceptions:

*Granular products with a low permeability.* Some granular products exhibit a very low permeability (hydraulic conductivity < $10^{-8}$ m/s), such as clayey products and products that become physically and/or chemically compacted (some slag and ash types). With respect to their release properties, these products may act as a "monolith" in practice and should be judged accordingly. A suitable test method for such low-permeable products, that cannot be tested by a regular percolation test and/or tank test, is the Dutch standard NEN 7347 [20] internationally also known as the Compacted Granular Leach Test (CGLT). The test is conducted with compacted granular products, and closely resembles the tank leach test for monolithic materials in the way it is carried out and the data are handled. DIN developed and validated a percolation upflow test - DIN 19528 [30]. According to DIN 19528 low permeable granular materials can be percolated as aggregates or by mixing them with inert quartz sand to increase permeability. As such, this test provides L/S - concentration information for low-permeable materials that can be useful for investigating mechanisms that control leaching..

*Metal products.* Metal products (such as zinc slabs in roof construction, plumbing works, metals with surface treatments such as galvanization, powder coating) may be classified as “monolithic” on first sight. However, when the release of metals from these products is to be tested, the release process is likely to be solubility-controlled (of metal phases, corrosion products) rather than diffusion-controlled. Release tests strongly suggested that the release from new and old zinc slabs is indeed governed by solubility control, and a pH dependence test provides in this case more useful information (see Annex E: Release from construction metals (example for zinc roof materials).
The test method pr ISO/WD156 N 1086: *“Corrosion of metals and alloys - Procedure to determine runoff rates of metals from materials as a result of atmospheric corrosion*” may be relevant to simulate and quantify runoff rates. As the basic mechanisms of release are the same in TS14429/TS14997 and/or in DMLT-PLR [16] the relationship between pr ISO/WD156 N 1086 and the proposed test methods needs to be established.
The present test protocol for the pH dependence test TS14429/TS14997 is designed for granular materials and not for e.g. plate-shaped metal products. Size reduction of metal products is certainly not the way to handle these types of products. For these products, it is preferable to fix a test piece with certain dimensions in an inert frame that covers the (cut or broken) edges. In addition, it will be sufficient to cover only a narrow range of pH values that can be found in practice under intended use conditions (e.g. pH 5-8) with the purpose to identify the controlling mineral phase on the metal surface (i.e. it is not the purpose to determine the maximum amount that can be released, which would result in complete dissolution of the metal at low pH). Most other conditions of the test protocol will be similar to the present protocol.

*Low-porous, plate-shaped products.* These products, such as tiles, but also plastic or PVC, can be viewed as monolithic, as release will be predominantly surface related (these products generally feature a low porosity). The products meant here are usually too thin to be tested with the standard DMLT-PLR, as this test method requires minimum dimensions of the samples used in the test. However, for these products it is fairly straightforward to make provisions in the test method such that they can be tested with the recommended DMLT-PLR method.

*Coatings, paints and color agents*

Final product with a surface coating should in principle be tested as used. These coatings and paints can be tested using 1) a standard or reference surface on which these products are to be applied, or 2) a specific surface for which they are specifically developed. For instance, as far as the intended use of certain paints or coatings is the general application on “concrete” surfaces, a standard mortar can be used to make a reference concrete for application of the product. As far as a specific coating is developed for a specific (type of) concrete, this specific type of concrete should be used. Next, the standard and/or specific mortar recipe, including the surface treatment, can be tested using the regular test methods for monolithic products. The same approach can be followed for other type of surfaces such as metals, wood or granular products such as specific types of aggregates. Pigments or color agents, for instance as used in (colored) concrete, are an *ingredient* of a final product and do not need to be tested separately. Only the final product as used during intended used is subject to testing.

*Reducing properties*. Some products have intrinsically reducing properties (e.g. slags from iron production) or bear enough reducing capacity to develop reducing properties in their specific application scenario. Reducing conditions may significantly change the release of substances in comparison with oxidised conditions. Therefore, testing these materials by the reference tests above could lead to an over- or underestimate of the release in the application scenario. A test to determine the reducing capacity of a product, in order to determine whether adapted test methods are needed, is NEN 7348 (NEN, 2006a). In this test method, the reducing capacity of a material or its eluates is determined by carrying out a redox titration with Ce(IV). The reducing capacity is expressed in mmol $O_2$/kg dry matter. The explanatory notes in NEN 7348 (NEN, 2006a describe the threshold values of the reducing capacity above which an adapted protocol should be followed, and products/application scenarios for which reducing conditions can be expected.

*Ecotoxicity testing*. EN 14735 “Characterization of waste – Preparation of waste samples for ecotoxicity tests”, which was developed in CEN/TC 292, has been validated with support from UBA and JRC. The characterisation leaching tests (pH dependence TS 14429 and column TS 14405) provide options for chemical speciation modelling to determine the bioavailable fraction (“free” unbound concentrations of substances in solution) under varying conditions in the test methodology. This has been shown for aquatic organisms to relate rather well with measured ecotoxicity (Cu in waste wood). This implies these methods have potential for construction products as well. This is an area where still pre-normative work is needed to determine the relationship between relevant ecotoxicity testing and release measurement to cover the regulatory requirements currently valid in Germany.

## *4.2 Evaluating release in intended use;*

### 4.2.1 Introduction

The relationship between a test result and the (expected) impact on the environment is made through model calculations based on insight into the dominant release mechanism; see Part 2 for a general description of this relationship. In short, it is not practical to perform predictions and evaluations for each individual use of a product in different types of constructions. However, it is possible to schematise the use options of products under one or more “intended use conditions”. These schematizations are called the “release scenarios”……………….. and usually involve a modelling step based on the dominant release mechanisms. The reference test methods provide the necessary information for the models necessary to determine the source term in the release scenarios and to model the path and target impact.

It should be noted that the actual performance of such path-target calculations is the responsibility of the national or EU regulators, and does not fall under the obligations of the product TCs or the producers. The Ad hoc group of WG1 is concerned with establishing generalized release scenarios.

### 4.2.2 Release scenarios

The translation of test results to actual emissions of the product under intended use conditions requires a modelling step. It is emphasized that scenarios are not linked to individual products, but to general characteristics which have been shown to be important for their release behaviour (e.g., monolithic products, granular products, etc.). At present 3 basic release scenarios are discussed in the Ad hoc group of WG 1 based on product characteristics and resulting differences in release mechanism:

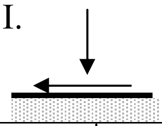
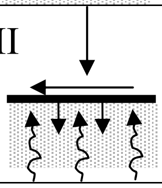
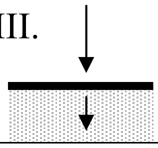
- Scenario I: Impermeable product. Water is redirected at the surface of the product. For products used above ground this is surface runoff. For example, sheet metal, surface coating, glazed tiles, glass surfaces etc. The scenario is also relevant for products used underground, or submerged into water. For example: Foundations such as steel piles (a cover of polythene, epoxy, zinc are commonly used as corrosion protection) used in ground or in water.

- Scenario II: Low permeable product. Water is transported into the matrix by capillary forces, and a fraction may be redirected at the surface of the product. In the matrix the capillary force is considered to be significant and the water movement is slow. Dissolved substances are transported out of the matrix by (capillary driven-) advection and diffusion. At the surface substances may dissolve and precipitate. This scenario is relevant for typical monolithic products used above ground, under ground, or submerged into water. For example, tiles (non-glazed), bricks, concrete, and pipes. A special case is permeable compacted granular material used in constructions partially sealed by impermeable layers, for example a paved construction. The physical properties of the pavement structure influence the way and the extent to which the construction materials become exposed to water, here different zones develop dominated by gravity flow and capillary flow and diffusion, respectively.

- Scenario III: Permeable product. Water may infiltrate into the matrix driven by gravity (pressure head gradient). A fraction of the water may be redirected at the surface of the product. The main transport process is advection through the matrix with the gravity driven flow. Transport with any water that is redirected at the surface is considered to be negligible (for this reason the horizontal arrow has been omitted in table Y). For example, granular products, building debris, soil, etc, used above ground or underground, or submerged into water.

Note that all three scenarios are relevant for products used above ground, under ground, or submerged into water. Both the construction product and the specific use of that product will influence what category of scenario that is relevant. Table Y also indicates which of the source scenarios in table Y (see below) are associated with which of the general scenarios, and it indicates which test methods may be appropriate for determination of the release for each of the general scenarios. Based on subsequent discussions, it may prove necessary to reduce or expand the above number of release scenarios; see therefore the activities in WG1

Table Y. Water contact and leaching scenarios.

| General scenario | Ref to source scenarios in table Z | ¤Relevant test methods |
|---|---|---|
| I.  | 5,7 | Tank test (DMLT) |
| II  | 2, 3, 5, 6, 4 | Tank test (DMLT) alt.<br>Compacted granular tank test |
| III.  | 1, 4 | Column test (CEN/TS 14405)<br>Batch test (EN 12457) |

.

It should be noted, however, as explained in detail in Part 2, that for judgement of environmental impact in a release scenario, a “source term” needs to be coupled to a “pathway” that describes the processes that substances undergo between the construction works and the ”point of compliance”, that is, a certain point at which quality criteria with respect to soil, surface water and/or groundwater criteria are met (e.g., the concentration of a substance in groundwater at a given distance downstream of an application, the concentration at the soil-groundwater interface or even directly below the application in the unsaturated zone) [3, 4]. In principle each of the AH1 scenarios above can be coupled to a “pathway” such as “soil” or “in water”. See also Part 2 for a general description of “source term” and “pathway”.

In previous work a number of model schematizations consisting of a combination of release scenario and source-pathway-target for construction products have been identified [2]. The number of these model schematizations (Table 1.4), is determined by the amount of situations for which a (fundamentally) different model setup is required to relate test results to environmental impact. These schematizations are largely consistent with the release scenarios so far identified by AH1, except for no.4, unbound aggregate (varying particle size). The latter scenario is a combination of surface related release (large particles) and percolation related release (small particles).
It is obvious that for one product (group) more than one model schematization of Table 1.4 may apply (combinations release scenario – product - pathway - target). Also, parameters for further modelling/evaluation within a the release scenario may be different even when the intended use scenario is essentially the same (e.g., parameters such as climate conditions, degree of water exposure, soil type, combination product source term/pathway)

*Table 1.4: short description of model schematizations from [2] consisting of basic release scenarios. For more detailed information is referred to Dijkstra et al. [2].*

| no. | Scenario description |
|---|---|
| 1 | Granular products placed on soil |
| 2 | Monolithic products placed on soil |

| | |
|---|---|
| 3 | Runoff (wet/dry) from monolithic product |
| 4 | Unbound aggregate (varying particle size) |
| 5 | Pipes (e.g. drinking water pipes)[7] |
| 6 | Monolithic products in water (e.g., coastal works) |
| 7 | Runoff from metal plates |

In Dijkstra et al. [2], each construction product and/or product group (as covered by the different CEN TCs) was connected with one or more of these model schematizations based on their predominant intended use. For instance, a certain type of brick should be allocated to one of the 'monolithic' basic release scenarios (2, 3 or 6 in the table). In this example, the brick can be used either above the ground, exposed to rain (in that case, 'runoff' and wet/drying cycles are important, basic release scenario 3) and/or directly in contact with soil (basic release scenario 2). For more detail on the scenarios and how these can be linked to different products see Dijkstra et al. [2].

#### 4.2.3 Development of a consistent set of assessment criteria for release of substances from construction products

As outlined in general terms in Part 2, the modelling approach sketched above can also be used in "reverse mode" to develop a consistent set of maximum allowable release criteria (pass/fail values) in a standard leaching test that are fully consistent with a certain level of protection (e.g., limit values) in soil, surface water and groundwater (e.g., groundwater quality values). Assessment criteria can be developed through an impact assessment procedure using again a generic 'basic scenario description [2]. This route was followed by the TAC (Technical Adaptation Committee with representatives from EU Member states) to develop the European leaching limit values for acceptance of waste at various types of landfills in accordance with the EU Landfill Directive (1999/31/EC and 2003/33/EC) [22, 23]. The scenario approach focuses on the main release mechanisms from the product under consideration and uses test results to derive relevant parameters for a model description of release over a relevant time scale of the intended use. This approach will allow future improvement as new and better information becomes available. The "reverse mode" is schematically sketched in figure 4.5 (in this case for a road construction product, basic release scenario 1). A more detailed description of the approach to translate test results to environmental impact is provided elsewhere [2, 19, 22, 23].

[7] The release to the inside (e.g. to drinking water) is covered in other fields. As for release to the outside, pipes can be considered as monolithic products

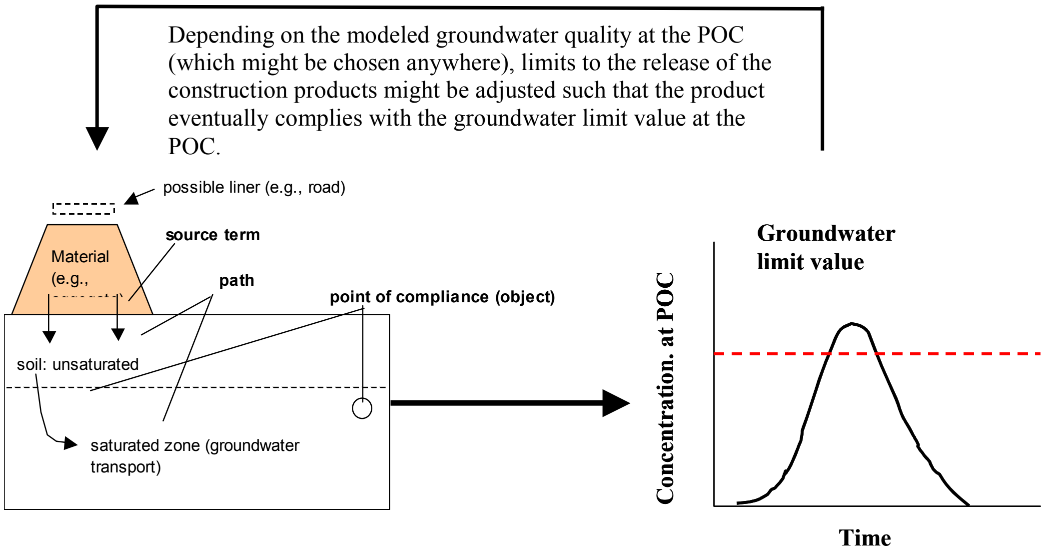



*Figure 4.5. Illustration of the 'reverse mode' for the step-wise impact procedure. Test results are related to a certain impact (concentration at a chosen point of compliance, POC) by modelling. The result of the exercise can be used in return to set limits to the release of the product (mg/kg or mg/m$^2$) in a standard leaching test such that the quality objective will not be exceeded.*

In the Netherlands, a similar combination of testing and modelling has been used to establish release criteria for construction products in the revised Dutch Building Materials Decree (DBMD), now part of the Dutch Soil Quality Decree, effective January 2008. The maximum allowed release is now such that both soil- and groundwater ecotoxicological limit values at the chosen POC (in this specific case, the average concentration in the upper 1 metre of the groundwater) are not exceeded, according to Figure 4.5 (step-wise impact procedure, reverse mode).
The technical background of an approach developed in Germany to relate results from testing to environmental impact is described in Susset and Leuchs [33].

### *4.3 Relation with content as prepared in TR 5*

For construction products release is the main aspect to focus on, rather than content. However, in some cases it may be relevant to address content. This may apply in case of substance restrictions and bans (then used both in ITT and FPC) or in case content can provide a quick means of assessing conformity (may be used in FPC, e.g. if content levels are relatively low.) Below an example is given for the relationship between total content and release of chromium at pH 10 from Ordinary Portland Cement (OPC) mortar, fly ash, lime and Cr reduced mortar, slag and blended cement mortar. For OPC mortar a fairly good correlation is found between total Cr content and leachable Cr at liquid to solid ratio 10 (figure 4.6). For blended cements no clear cut relation, but leachability in all cases lower than OPC mortar. This illustrates that determination of content can in some cases be used to assess conformity.

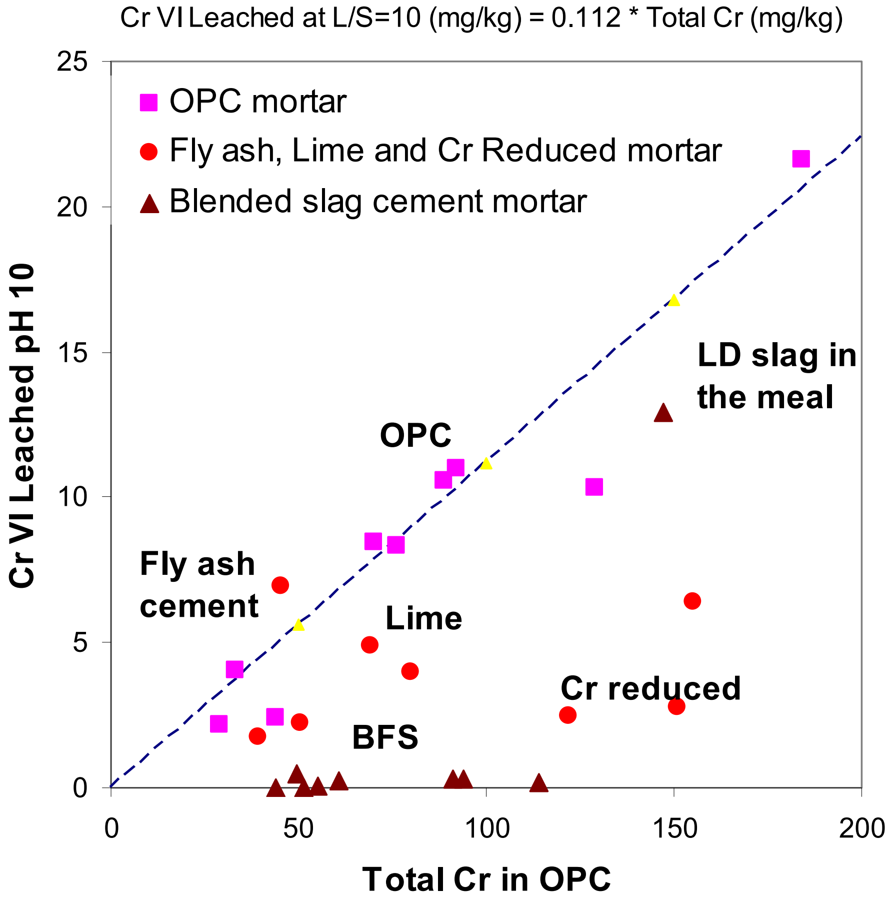



*Figure 4.6: relationship between total content and release of Cr VI (leached concentrations at pH 10) from Ordinary Portland Cement (OPC) and blended cement mortars (Fly ash, BFS, Lime and Cr reduced mortar; additions in the mortar blend identified in the graph), BFS = Blast Furnace Slag.*

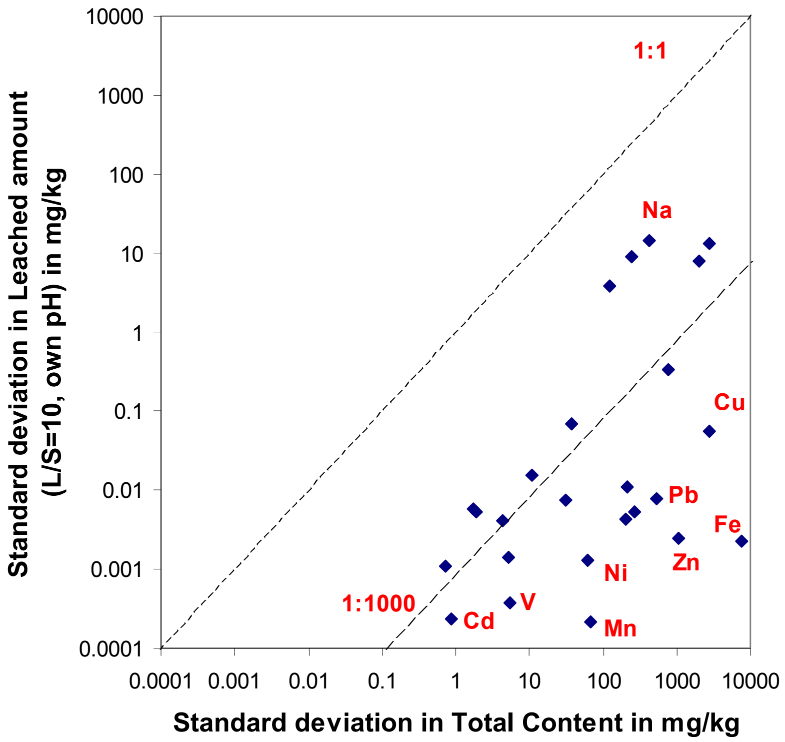



*Figure 4.7. Comparison of absolute uncertainty in analysis based on total composition and release (MSWI Bottom ash, n=15). Data from ECN report ECN-C-01--0117 on validation of EN 12457.*

It should be noted that the uncertainty (in mg/kg) about a possible environmental effect hidden in the analysis of content is a multiple of the uncertainty obtained by a leaching test, as there is generally no *a priori* knowledge of the fraction of the total content that is potentially available for release (Figure 4.7). This is also shown in different projects of the German joint research project "Sickerwasserprognose" (e.g. [32] and [33]). In addition, from a sampling point of view, release tests are expected to be less sensitive for sampling heterogeneity as larger quantities of material can be used in the test (less stringent sample pre-treatment).

Finally, carrying out a leaching test is not more complex, although more time-consuming, than carrying out a content analysis, as both methods are in fact a form of extraction.

## *4.4 Methods for FPC*

### 4.4.1 Introduction

Simplified methods for FPC linked to the listed ITT tests are partly still under development in CEN/TC292 and other standardization bodies (e.g., ISO TC 190 "Soil Quality"). However, below a number of suitable test methods with a proven general applicability will be discussed, or propose test methods suitable for this purpose. It should be noted that at the FPC level more product-specific test methods can be used allowing more flexibility to the end-users (manufacturers), as long as the results are compatible with the generic ITT-tests.

### 4.4.2 Granular products

Given the constraints of a short duration, simplicity and cost-efficiency of FPC tests, there are generally three options for FPC testing of granular materials, i) by comparing the release from a batch test directly with the release in the pH dependence test at the same pH value; ii) by comparing the release from a batch test directly with the release in the percolation test; iii) comparing the release from a shortened percolation test (e.g., only the first 2 fractions) with that of a full percolation test.

*Ad i. pH dependence test for FPC.* The most preferable approach for pH-dependence tests for FPC is a much simplified version of the full pH dependence test TS14497/TS14997 (or similar method ISO PRF TS12168-4). There are instances for which it is relevant to perform a batch test at a specific pH value, e.g., when a product is to be used under specific conditions or in cases where alterations of the product's intrinsic pH over time are anticipated. In such cases an FPC test can be performed at a specific pH value by adding (predetermined) quantities of acid/base; a suitable protocol for a single step FPC test is that of the pH dependence test protocols (TS14427, TS14997) but reduced to one single (pH) data point. The results of the simplified pH-dependence test can be compared directly with the result of a full pH dependence test at similar pH value. A simplified version of the pH-dependence test has not been standardized yet, but as it would essentially be an element from the complete pH dependence test (TS14429, TS14997), the protocols are already available and no further validation is necessary.
Besides the pH-dependence test and its possible simplified version referred to above, the test methods EN12457 1-4 [26-29] are suitable for this purpose; the four protocols differ with respect to the amount of steps (1 or 2 step procedures), the final cumulative L/S ratio (L/S 2 and/or L/S 10) and the nature of the product (particle size, solid content). In Germany a batch test at L/S 2 for the investigation of coarse grained materials up to 32 mm grain size was developed and validated (tol be published soon as DIN 19529 [31]). Other similar methods standardised at the EU level to be mentioned are those developed for soil (ISO/TS21268-1 and TS21268-2, batch tests at L/S 2 and L/S 10 respectively, ISO/TC190 Soil Quality). The tests methods have in common that they are performed without addition of acids or bases, so that the final pH is dictated by the properties of the product itself.

*Ad i, ii) Batch tests to compare with percolation test data*. Results from batch tests (for instance a pH-dependence test) allow a direct comparison with the complete ITT data of the latter test method, as long as the results are compared in the same L/S and pH region.

*Ad iii). percolation test for FPC.* As outlined above, a simplified version of the pH-dependence test and the methods EN12457 1-4 can be used for FPC purposes for the percolation test, but a more preferable approach is a much simplified version of the full percolation test TS14405 or similar method for inorganic/organic substances (ISO/TS21268-3). For instance, a suitable simplified test could be the percolation test limited to the first few fractions (e.g., up to L/S 0,3 instead of L/S 10). The duration of the test would be limited to within a day, and the collected fraction can be directly compared to the low L/S value in the regular percolation test. One could also choose a different cumulative L/S value. Such a FPC-version of the percolation test has not been standardized, but as it would essentially be an element from the complete percolation test (TS14405), the protocol is already available and a separate validation is not necessary. In Germany a short column test up to L/S 2 for grain sizes up to 32 mm was developed and validated (will be published soon as DIN 19528 [30]). NEN7383 is a validated, simplified version of the full percolation test NEN7373 and consists of two steps, with a final L/S ratio of 10 l/kg. Although it is cheaper with respect to chemical analysis (less fractions), the duration of the test is the same as NEN7373 (about 16 days).

**4.4.3. Monolithic products**

There are no standardized simplified test methods available for FPC monolithic products. However, in the case of a monolithic product a suitable option is to perform a simplified version of the tank test, e.g., only the first few steps of the recommended procedure DMLT-PLR [16]. This approach reduces the duration of the test to within a day. Like the simplified percolation test (see above), the results are directly comparable to that of the complete tank test. Part of the proposed monolith compliance test in CEN TC292 (WI292010) is based on this concept. As this test could essentially be an element from the complete tank test, no new protocol would need to be developed and additional validation would then not be necessary, as the short test is then an integral part of the complete test (a similar approach to the 28 day compressive strength test compared to the longer 56 or 90 day compressive strength test).

# 5. Validation

A separate document is in preparation by the Ad hoc group Validation of CEN TC 351 to describe validation work needed in relation to impact to soil, surface water and groundwater, indoor air, content, radioactivity and sampling. This will cover the rationale of product selection, sampling, pre-treatment, number of products to be selected and ruggedness testing needs. Particularly related to the latter aspect already a large amount of information on sensitivity to parameters in release testing is available from previous ruggedness work on similar tests, published research on parameter sensitivity and available test data on construction products. Bringing this information together in a Technical report would reduce cost for ruggedness testing considerably.

# 6. Recommendations and conclusions

- Based on research and consultation of the construction sector, the generally applicable test methods for construction products as listed in tables 6.1 and 6.2 are recommended.
- A good and constructive response was obtained from the questionnaires, by which the various construction TCs were consulted. It is estimated that from the 66 construction-TCs, a minority of 28 will deal with testing release of dangerous substances to soil, surface water and groundwater. For the other, testing on release will be less relevant as there is no direct or indirect possibility for release to soil, surface water and groundwater, or the TC only deals with half products.

| **Table 6.1 - ITT level test methods** | | | | |
|---|---|---|---|---|
| **Product** | **Substances** | **Test reference** | **Test name** | **Status** |
| Granular | Inorganic | CEN/TS14405:2004 | Characterization of waste - Leaching behaviour tests - Up-flow percolation test (under specified conditions) | published |
| | Inorganic + non-volatile organic | ISO-21268-3:2007 | Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials -- Part 3: | published |

| | | | | |
|---|---|---|---|---|
| | | | Up-flow percolation test | |
| | inorganic | CEN/TS14429:2005 / CEN/TS14997:2006 | Characterization of waste - Leaching behaviour tests - Influence of pH on leaching with continuous pH control (TS14997) / initial acid/base addition (TS14429) – provide equivalent results | published |
| | Inorganic + non-volatile organic | ISO/TS21268-4:2007 | Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials -- Part 4: Influence of pH on leaching with initial acid/base addition | published |
| Monolithic | Inorganic | "DMLT-PLR" | Dynamic Monolith Leaching Test – Periodic Leachant Renewal (DMLT-PLR) | In development (Work Item 292010 of CEN/TC 292) |
| | Inorganic + non-volatile organic | prCEN/TS15119-2:2007 | Wood tank test | |
| Compacted granular | Inorganic | NEN7347:2006 | Leaching characteristics of solid earthy and stony building and waste materials - Leaching tests - Determination of the leaching of inorganic components from compacted granular materials. | Published (national standard) |
| Solid metal products | Inorganic | CEN/TS14429:2005 | Modified for plate products; | To be developed |

| **Table 6.2 - Conformity assessment methods/factory production control** | | | | |
|---|---|---|---|---|
| **Product** | **Substances** | **Test reference** | **Test name** | **Status** |
| Granular | Inorganic | CEN/TS 14405:2004* | *=Simplified version up to L/S 2 | To be developed |
| | Inorganic + non-volatile organic | ISO 21268-3:2007* | *=Reduced version up to L/S 2 | To be developed |
| | | EN 12357 1-4:2002 | CEN/TC292. Characterisation of waste - Leaching - Compliance test for leaching of granular waste materials and sludges - Part 1 - 4 | published |
| | | CEN/TS 14429:2005* / CEN/TS 14997:2006* | *=Simplified version (single point) | To be developed |
| | Inorganic + non-volatile organic | ISO/TS 21268-4:2007* | *=Simplified version (single point) | To be developed |
| | Inorganic + non-volatile organic | ISO/TS 21268-1:2007 | Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials -- Part 1: Batch test using a liquid to solid ratio of 2 l/kg dry matter | published |
| | Inorganic + non-volatile organic | ISO/TS 21268-2:2007 | Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials -- Part 2: Batch test using a liquid to solid ratio of 10 l/kg dry matter | published |
| Monolithic | Inorganic + non-volatile organic | "DMLT-PLR"* | *=Simplified version (first two steps) | To be developed |
| | Inorganic + non-volatile organic | prCEN/TS15119-2:2007 * | Wood tank test - OECD 2 *=Simplified version (first two steps) | |
| Compacted granular | Inorganic | NEN 7347* | *=Simplified version (first two steps) | To be developed |
| Coarse granular | Inorganic | EN 1744-3 | * | |
| Solid metal products | Inorganic | CEN/TS 14429:2005* | *modified for plate products/Simplified version | In development |

* suitability for regulatory purposes and relationship with other tests to be verified.

# References

[1] Van der Sloot, H.A. & J.J. Dijkstra (2004): Development of horizontally standardized leaching tests for construction materials: a material based or released based approach? ECN-C--04-060, Energy Research Centre of the Netherlands (ECN): Petten, The Netherlands.

[2] Dijkstra, J. J. (ECN) van der Sloot, H. A. (ECN) Spanka, G. (VDZ) Thielen, G. (VDZ). How to judge release of dangerous substances from construction products to soil and groundwater - CPD Topic 1 - Soil and groundwater impact - CPD Topic 2 - Hierarchy in testing: Characterisation, initial type testing, further testing and selection of tests in specific stages of material judgement - CPD Topic 3 – Proposal for reference to ER 3 aspects in product standards and in CE marking. ECN-C--05-045.

[3] Principles for the assessment of the effects of construction products on soil and groundwater, Part I. German Institute of Structural Engineering – DIBt – Berlin, Germany (Draft April 2005). English version: http://europa.eu.int/comm/enterprise/tris/index_en.htm

[4] Principles for the assessment of the effects of construction products on soil and groundwater, Part II: Assessment concepts for particular construction products "Concrete starting materials and concrete". German Institute of Structural Engineering – DIBt – Berlin, Germany (Draft April 2005). The English version is available under: http://europa.eu.int/comm/enterprise/tris/index_en.htm

[5] Van der Sloot, H.A, L. Heasman, Ph Quevauviller, Eds. (1997). Harmonization of leaching/extraction tests. Studies in Environmental Science, Volume 70, Elsevier Science, Amsterdam, 292 pp.

[6] CEN/TC292 (2005). Characterization of waste - Leaching behaviour tests - Influence of pH on leaching with initial acid/base addition. CEN/TS 14429

[7] CEN/TC292 (2005). Characterization of waste - Leaching behaviour tests - Influence of pH on leaching with continuous pH control. CEN/TS 14997

[8] ISO TS 21268-4 Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of materials -- Part 4: Influence of pH on leaching with initial acid/base addition. (To be adopted in CEN/TC 345)

[9] ISO TS 21268-3 Soil quality — Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials — Part 3: Up-flow percolation test. (To be adopted in CEN/TC 345)

[10] CEN/TC292 (2005): Characterization of waste - Leaching behaviour tests - Up-flow percolation test (under specified conditions), CEN/TS 14405

[11] NEN (2003). Leaching characteristics - Determination of the leaching of inorganic components from moulded or monolithic materials with a diffusion test - Solid earthy and stony materials – NEN7375:2003.

[12] Groot, G.J. de, I. Hohberg, F.J.M. Lamers, A.M.H. van der Veen, W. Wassing, Ph. Quevauviller, Development of a Leaching Method for the Determination of the Environmental Quality of Concrete, bcr information EUR17869, 1997

[13] ENV 1250-2 (1994) Wood preservatives – Methods for measuring losses of active ingredients and other preservative ingredients from treated timber – Part 2: Laboratory method for obtaining samples for analysis to measure losses by leaching into water or synthetic sea water

[14] OECD guideline 2: Estimation of Emissions from Preservative - Treated Wood to the Environment: Laboratory Method for Wooden Commodities that are not Covered and are in Contact with Ground, Fresh Water or Seawater, version from February 2003.

[15] U. Schoknecht, H. Mathies, N. Morsing, B. Lindegaard, H.A. van der Sloot, A. van Zomeren, G. Deroubaix, S. Legay, J.L. Tadeo, A.I. García-Valcárcel, G. Gigliotti, C. Zadra, J. Hajšlová, M. Tomaniová, R. Wegner, C. Bornkessel, C. Fürhapper, Inter-laboratory Evaluation of Laboratory Test Methods to estimate the Leaching from Treated Wood. EU DG ENV project 04/375757/C4, BAM, Germany, April 2005

[16] CEN/TC292 (2005). Characterization of waste - Leaching behaviour tests – DMLT-PLR (dynamic monolith leaching test – periodic leachant renewal), under development.

[17] Sloot, H.A. van der, D. Hoede, R.P.J.J. Rietra, R. Stenger, Th. Lang, M. Schneider, G. Spanka, E. Stoltenberg-Hansson, A. Lerat, Environmental criteria for cement based products, ECRICEM I, ECN C--01-069

[18] EN1744-3. Test for chemical properties of aggregates – Part 3: Preparation of eluates by leaching of aggregates, CEN TC 154 Aggregates, 1999.

[19] Dijkstra, J.J., Van der Sloot, H.A., Comans, R.N.J., Kosson, D A, Hjelmar, O. An approach for environmental impact assessment of contaminated materials based on horizontal test methods for measuring release of substances in combination with associated modelling instruments. To be submitted to *Environmental Science and Policy.*

[20] NEN, 2006. Leaching characteristics of solid earthy and stony building and waste materials - Leaching tests - Determination of the leaching of inorganic components from compacted granular materials. NEN 7347:2006.

[21] NEN, 2006. Leaching characteristics - Determination of the reducing character and the reducing capacity - solid earthy and stony materials. NEN 7348:2006.

[22] Hjelmar, O., H.A. van der Sloot, D. Guyonnet, R.P.J.J. Rietra, A. Brun & D. Hall: Development of acceptance criteria for landfilling of waste: An approach based on impact modelling and scenario calculations. In: T.H. Christensen, R. Cossu and R. Stegmann (eds.): Sardinia 2001, Proceedings of the Eigth International Waste Management and Landfill Symposium, S. Margharita di Pula, Cagliari, CISA , Vol. III, pp. 712-721, CISA, 2001.

[23] Hjelmar, O.: Environmental performance of waste materials. In Dhir, R.K, Newlands, M.D. & Halliday, J.E. (eds.): Recycling and Reuse of Waste Materials. Proceedings of the

International Symposium held at University of Dundee, Scotland, UK on 9-11 September 2003, Thomas Thelford, London, 2003, pp. 653-668.

[24] prCEN/TS15119-1:2007. Durability of wood and wood-based products - Determination of emissions from preservative treated wood to the environment - Part 1: Wood held in the storage yard after treatment and wooden commodities exposed in Use Class 3 (not covered, not in contact with the ground) - Laboratory method.

[25] prCEN/TS15119-2:2007. Durability of wood and wood-based products - Determination of emissions from preservative treated wood to the environment - Part 2: Wooden commodities exposed in Use Class 4 or 5 (in contact with the ground , fresh water or sea water) – Laboratory Method.

[26] EN 12457-1:2002. Characterisation of waste - Leaching - Compliance test for leaching of granular waste materials and sludges - Part 1: One stage batch test at a liquid to solid ratio of 2 l/kg for materials with high solid content and with particle size below 4 mm (without or with size reduction).

[27] EN 12457-2:2002. Characterisation of waste - Leaching - Compliance test for leaching of granular waste materials and sludges - Part 2: One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 4 mm (without or with size reduction).

[28] EN 12457-3:2002. Characterisation of waste — Leaching - Compliance test for leaching of granular waste materials and sludges — Part 3: Two stage batch test at a liquid to solid ratio of 2 l/kg and 8 l/kg for materials with high solid content and with particle size below 4 mm (without or with size reduction).

[29] EN 12457-4:2002. Characterisation of waste — Leaching - Compliance test for leaching of granular waste materials and sludges — Part 4: One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 10 mm (without or with size reduction).

[30] DIN 19528 (2008): Elution von Feststoffen - Perkolationsverfahren zur gemeinsamen Un-tersuchung des Elutionsverhaltens von organischen und anorganischen Stoffen für Materialien mit einer Korngröße bis 32 mm – Grundlegende Charakterisierung mit einem ausführlichen Säulenversuch und Übereinstimmungsuntersuchung mit einem Säulenschnelltest', Ausgabe Juli 2007.- Beuth Verlag, Berlin

[31] DIN 19529 (2008): Elution von Feststoffen - Schüttelverfahren mit einem Wasser/Feststoffverhältnis von 2 l/kg zur Untersuchung der Elution von anorganischen Stoffen für Materialien mit einer Korngröße bis 32 mm - Übereinstimmungsuntersuchung, Ausgabe Juli 2007.- Beuth Verlag, Berlin

[32] Susset, B., Leuchs, W (2008): "Stofffreisetzung aus mineralischen Ersatzbaustoffen und Böden - Ermittlung der Quellstärke-Entwicklung und des Rückhalte- und/oder Abbaupotentials mittels Freilandlysimetern und Laborelutionsmethoden".- Abschlussbericht des Landesamt für Natur Umwelt und Verbraucherschutz Nordrhein-Westfalen (LA-NUV NRW) zum Teilprojekt 02WP0286 im BMBF- F&E-Vorhaben „Sickerwasser-prognose", vorgelegt am 20.06.2008 beim Forschungszentrum Karlsruhe GmbH, Projektträger Forschungszentrum Karlsruhe, Bereich Wassertechnologie und Entsorgung (PTKA-WTE), Koordination: Heinrich-Sontheimer-Laboratorium für Wassertechnolo-gie (HSL) im Technologiezentrum

Wasser (TZW), 286 S. (+212 S. Anhang), Technische Informationsbibliothek, Universitätsbibliothek Hannover (TIB/UB), http://www.tib.uni-hannover.de

[33] Susset, B., Leuchs, W. (2008): „Umsetzung der Ergebnisse des BMBF-Verbundes Sickerwasserprognose in konkrete Vorschläge zur Harmonisierung von Methoden“ - Ableitung von Materialwerten im Eluat und Einbaumöglichkeiten mineralischer Ersatzbaustoffe.- Fachbericht zum UBA-UFOPLAN-Vorhaben FKZ:20574251, www.uba.de, 117 S., Anhang 93 S.

[34] Guyonnet,D., Bod□nan,F., Brons-Laot,G., Burnol,A., Chateau,L., Crest,M., M□hu,J., Moszkowicz,P. & Piantone,P. 2008. Multiple-scale dynamic leaching of a municipal solid waste incineration ash. Waste Management, 28, 1963-1976.

[35] Tiruta-Barna,L. 2008. Using PHREEQC for modelling and simulation of dynamic leaching tests and scenarios. Journal of Hazardous Materials, 157, 525-533.

[36] Cornelis,G., Johnson,C.A., Gerven,T.V. & Vandecasteele,C. 2008. Leaching mechanisms of oxyanionic metalloid and metal species in alkaline solid wastes: A review. Applied Geochemistry, 23, 955-976.

[37] Kalbe,U., Berger,W., Simon,F.-G., Eckardt,J. & Christoph,G. 2007. Results of interlaboratory comparisons of column percolation tests. Journal of Hazardous Materials, 148, 714-720.

[38] de Windt,L., Badreddine,R. & Lagneau,V. 2007. Long-term reactive transport modelling of stabilized/solidified waste: from dynamic leaching tests to disposal scenarios. Journal of Hazardous Materials, 139, 529-536.

[39] De Wijs, J. Cleven, R., 2008. Monitoring environmental quality of stony construction materials 2003-2006. RIVM report number 711701066/2007, www.rivm.nl.

[40] Dijkstra, J. J., Meeussen,J. C. L., van der Sloot, H. A. & Comans, R. N. J. 2008. A consistent geochemical modelling approach for the leaching and reactive transport of major and trace elements in MSWI bottom ash. Applied Geochemistry, 23, 1544-1562.

**Further reading:**

Kosson, D.S., van der Sloot, H.A., Sanchez, F., and Garrabrants, A.C., 2002. An integrated framework for evaluating leaching in waste management and utilization of secondary materials. Environmental Engineering Science (19) 3, 159-204.

Van der Sloot, H.A., van Zomeren, A., Meeussen, J.C.L., Seignette, P., Bleijerveld, R. Interpretation of test method selection, validation against field data, and predictive modelling for impact evaluation of stabilised waste disposal Journal of Hazardous Materials (2006), 141, 2007, 354-369.

# PART 5. EVALUATION OF A HORIZONTAL APPROACH TO ASSESS THE POSSIBLE RELEASE OF DANGEROUS SUBSTANCES FROM CONSTRUCTION PRODUCTS TO INDOOR AIR

# 1. Requirements of the horizontal approach for indoor air

The general requirements for a horizontal approach that can be used to test/evaluate construction products on their emission of dangerous substances to indoor air in their *intended conditions of use* under the CPD are the following:

- Integrates the requirements of the currently valid, notified regulations on the emission of dangerous substances (formaldehyde, VOC) into indoor air and for the indoor air quality in buildings in the different member states (e.g. notifications 2005-255-D, 2005-592-S, 2007-372-FIN, 2007-0090-DK) and of the relevant notified regulations restricting the content of dangerous substances for construction products used in indoor spaces).
- Makes use of the existing test methods for emissions of construction products to indoor air.
- Is efficient, precise enough and applicable for the products to be tested, both for ITT and FPC.
- Takes into account current developments on legislation and on evaluation of emissions to indoor air as far as they are robust enough to be included, without extra development time.
- Fits in the general structure, under development now in CEN/TC 351, for the evaluation of dangerous substances released from construction products.

A standardised assessment method needs to fulfil in addition the following technical requirements:

- An adequate precision of test results is required to make an evaluation of the product possible and reliable.
- The relation between generation of emission from the product produced / placed on the market and the emissions from the product in its intended use situation is well understood: the outcome of the test provides data with which the product can be evaluated in its intended use.
- A “hierarchy of testing” as foreseen for the attestation of conformity according to Annex III of the CPD is integrated, comprising a characterisation test for ITT and a simplified testing procedure for FPC.

New technical developments related to emissions of dangerous substances from construction products are likely to be taken into account in future regulations. Therefore, the recommended conceptual approach for assessing construction products on their emission of dangerous substances to indoor air should be adaptable to these future regulations.

Construction products for indoor air environment that fall under the CPD can comprise of the following group of products:

- Construction products[8] such as a wall, ceiling or floor coverings and sealants
- Heating, ventilating and air conditioning (HVAC) products such as a radiator (in the occupied space) or a filter or ductwork (out of the occupied) space).

---

[8] According to the Interpretative Document 3 of the CPD the following product families are involved in the control of indoor air quality, bcause emissions of pollutants from the product to the indoor air are possible: materials used for flooring, partitions, walls and wall linings, ceilings, insulating materials, paints and varnishes, timber preservatives, adhesives, fillers, damp-proof membranes, electric cables and fittings, coatings for floor screeds, masonry, putties, installations.

- Intermediate products: Products that are added to another product, e.g. aggregates, pigments, and fillers and cannot be used in buildings independently. These are only used in combination with other products.

National building regulations normally require for a healthy indoor environment to be maintained in buildings for daily occupancy. For HVAC systems no detailed notified regulations in regard to dangerous substances are presently in use, but because of the expectation that future regulations will also concern HVAC products, the available information with respect to the emission of dangerous substances from HVAC products will be presented under pre-normative work. The same can be said for susceptibility to growth of harmful micro-organisms as well as sensory testing methods. For the recommended harmonised approach, pre-normative work will be recommended on this issue. When other ISO or CEN TCs develop suitable methods, e.g. for sensory evaluation work has started, these can be overtaken and adapted if neededv by CEN/TC 351 in the future.

In general a test can comprise of different steps, all introducing some sort of uncertainty (variation) on the results:

- Sampling of material or product
- Transport of sample
- Storage of sample before testing
- Test specimen preparation (age and conditioning of test specimen)
- Chamber test
- Air sample collection and analyses
- Translation to in-use situation

An ITT could include all of these steps while an FPC test perhaps consists of only some of them.

# 2. Emission mechanisms

## 2.1 Introduction

A construction product in use can emit substances (particles and/or gases) to the indoor air that originate from the product itself (primary emission), that are caused by coming into contact with other products (ozone or water) (see e.g. Aoki and Tanabe, 2007; Uhde and Salthammer, 2007; Nicolas et al, 2007) or arise/develop during the in use phase of the product (secondary emission). The latter can be associated with the building products' exposure to gaseous compounds in indoor air, to cleaning agents or with their ageing. In this report, secondary emissions are only considered if they arise from maintenance activities deemed necessary by the product manufacturer.

Examples of emissions that originate from the product itself (primary emission) are:
- Organic compounds VVOC, VOC, and SVOC e.g. phthalates from PVC products, formaldehyde from wood based boards (a long term continuous emission from a dry product), VOC from non-water carrying paints (a short term high emission from a wet product), and solvents of coatings and adhesives.
- Airborne particles: if the product is mechanically impaired during normal maintenance during the in-use phase, or damaged by aging, also airborne particles can be given off e.g. fibres from certain types of insulation products and wool.

## 2.2 Emission patterns

A pollutant present in a building material can diffuse through the material, reach the laminar layer, and influenced by the convection mass transfer coefficient reach the buffer layer, in which it is be transported by air to the turbulent region and by the motions of ventilation into the space. This process is presented in Figure 5.1.

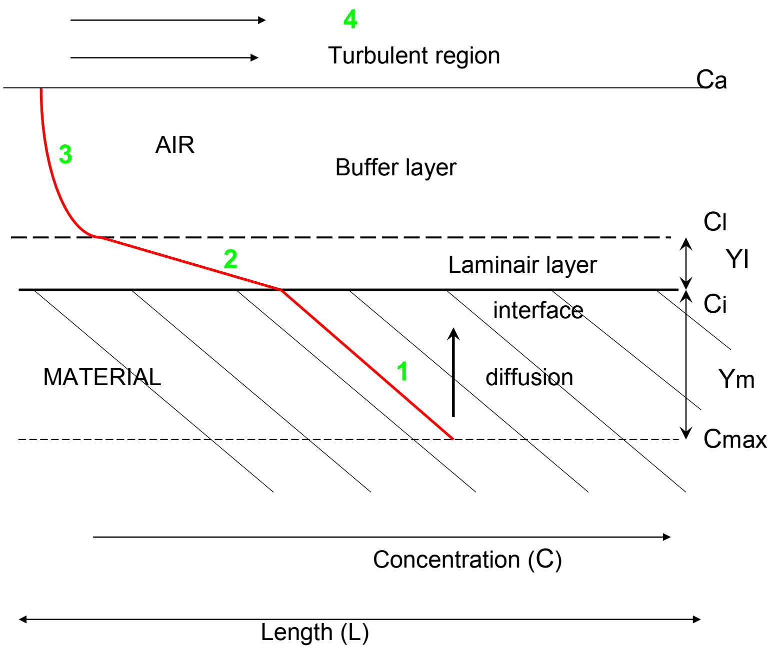



*Figure 5.1 Emission of a pollutant via diffusion through material (Bluyssen, 2008).*

For each of the transports an equation can be set up in the form of:

$$\Phi_{ij} = h_{ij}\, A\, (C_j - C_i) \qquad (2.1)$$

With:

$\Phi_{ij}$ = mass transport between i and j [kg/s]
A = surface are [$m^2$]
C = concentration of pollutant in point i and j [$kg/m^3$]
$h_{ij}$ = mass transfer coefficient in layer between i and j [m/s]

For each of the mechanisms, the mass transfer coefficient is different. Important parameters are type of pollutant (polarity, volatility, vapour pressure), type of material/product (porosity, roughness and specific area) and the surrounding conditions (temperature, humidity, air velocity).
Considering the number of pollutants in the air and the number of different materials present in the indoor environment, it is difficult to determine for each combination of material and pollutant, the mass transfer coefficients. And above all, it is likely that slightly different conditions influence these transfer coefficients.

For a pollutant present at the surface of the product (secondary emissions or for example paints or varnishes), the emission mechanism can be slow evaporation of substances with low volatility or slow desorption from the surface.

Emission of substances is often controlled by diffusion; this implies that emission will not reach a plateau, but keeps on decreasing with time. If diffusion is assumed, an effective diffusion coefficient can be obtained from measurements, which allow more accurate predictions of emission.

Determining the emission mechanisms may help judging, whether any particular release pattern can be considered 'normal'. Knowledge of the release mechanism may also help to find simple and quick FPC-test procedures or to decide, whether anomalies in the emission pattern need further attention.

Different substances are emitted in different ways, as illustrated in Figure 5.2.

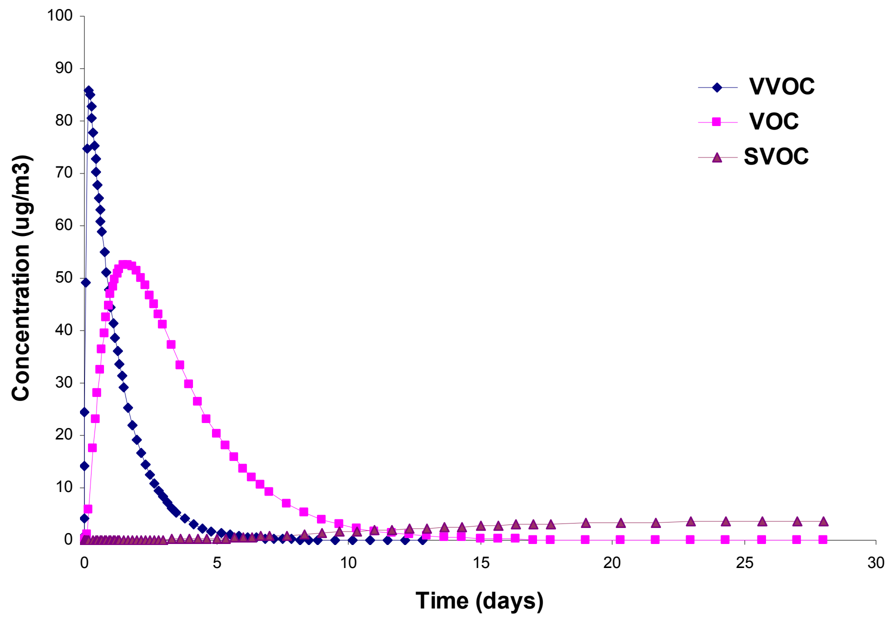



Figure 5.2 Illustration of different emission patterns over time for VVOC, VOC and SVOC.

This implies that given the complex emission patterns that may occur, proper understanding of the emission pattern of dangerous substances from a construction product is crucial in ITT to make adequate choices of test conditions for FPC.

Depending on the substance emitted, a different pattern of primary emission over time can occur. For new materials, the emission of VOC in general starts high and decreases over time until a seemingly steady state emission rate. VVOC emissions are very high in the beginning and decrease until almost zero (for example evaporation controlled emissions), although depending on the thickness of source, from certain products also long-term VVOC emissions have been measured. SVOC (the more involatile compounds) might have the opposite behaviour to VVOC and start their emission much later in time (for example some sealants) (Wilke et al., 2004). Over a long time, also those emissions will in general decrease eventually (although exceptions have been encountered). And last but not least, some emissions may show an intermittent release due to the conditions in the indoor space (temperature and humidity variations) influencing the emission rate, or due to recurrent (maintenance and cleaning) activities related to the product. The latter are called secondary emissions.

Products, built up in different layers, e.g. with glue between the layers containing solvents, may start to emit substances with some delay due to slow diffusion processes. The delays are not shown in Figure 5.2, but they feature an emission curve like the SVOC curve. An understanding of the mechanisms and the properties of the materials used in the product, enables predictions and explanation on the expected behaviour (level and time frame of release).

## *2.3 Influence of several emission controlling factors*

Various factors control the concentrations observed in test chambers: e.g. temperature, loading (changing the amount of product per $m^2$), effective diffusion of different substances from construction products, thickness of product, chamber size, ventilation rate (flow) and moisture content.

Understanding the emission behaviour of dangerous substances from construction products is crucial for making choices on test conditions for a horizontal standard to assess impacts to indoor air quality.

### 2.3.1 Temperature

Experiments on the effect of temperature performed by Bluyssen et al. (1996) show that temperature may have a significant influence on the emission rate, depending however on the material or source tested. Figure 5.3 shows an example of the TVOC concentration ($\mu g/m^3$) measured in a desiccator as well as in a 15 $m^3$ chamber over time as a result of the emission of a piece of carpet, under different temperature conditions.

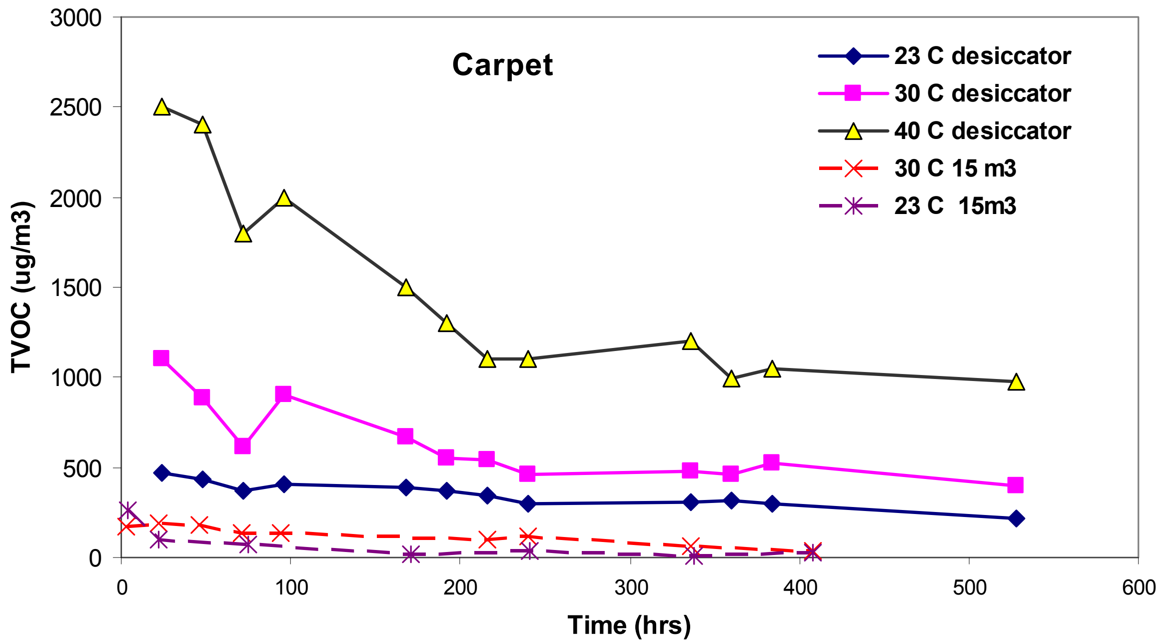



Figure 5.3 Influence of temperature on emission of dangerous substances (Bluyssen et al., 1996)

### 2.3.2 Effective diffusion of substances

Substances are emitted from products by processes governed by physical and chemical proceeses. This is reflected in the effective diffusion coefficient. Normally, the spectrum of substances emitted leads to a resultant emission curve for the mixture, which is composed of the sum of individual released substances. Figure 5.4 calculated by using different release rates due to difference in effective diffusion in the construction product and the resultant sum of VOC (TVOC) as the mixture of substances emitted, illustrates this.

From Figure 5.5 it is clear that a real plateau is not reached at 28 days nor at any point in time. The emission shows a continuous decrease provided release is limited by a surface coating or the emission is delayed due the slow rate of emission as in the case of SVOC's. But also in the latter case, the emission will decrease after the peak in the emission has been reached.
In Figure 5.6 the cumulative emission is given for the substances with different effective diffusion coefficients. It shows that very volatile species are depleted within a relatively short time scale, while slow released substances contribute more to the 28 day emission.

In a project performed by BAM (2003), it was also found that: "in the case of SVOC, a test period of a minimum of 100 days was necessary to achieve equilibrium".
On the other hand for VOC emissions a shorter test period is adequate as concluded by Hodgson and Alevantis (2004): "For most solid materials, the contributions of VOC emissions to such exposure burdens can be estimated from measurements of long-term diffusion-controlled emission rates. These emission rates are best obtained after the materials have been exposed for a period of one week or longer. Thus, many widely recognized European test protocols have agreed upon a 28-day measurement point. However, considerable experimental data, as well as diffusion theory, suggest that a shorter period of 7 to 14 days will provide nearly equivalent data."

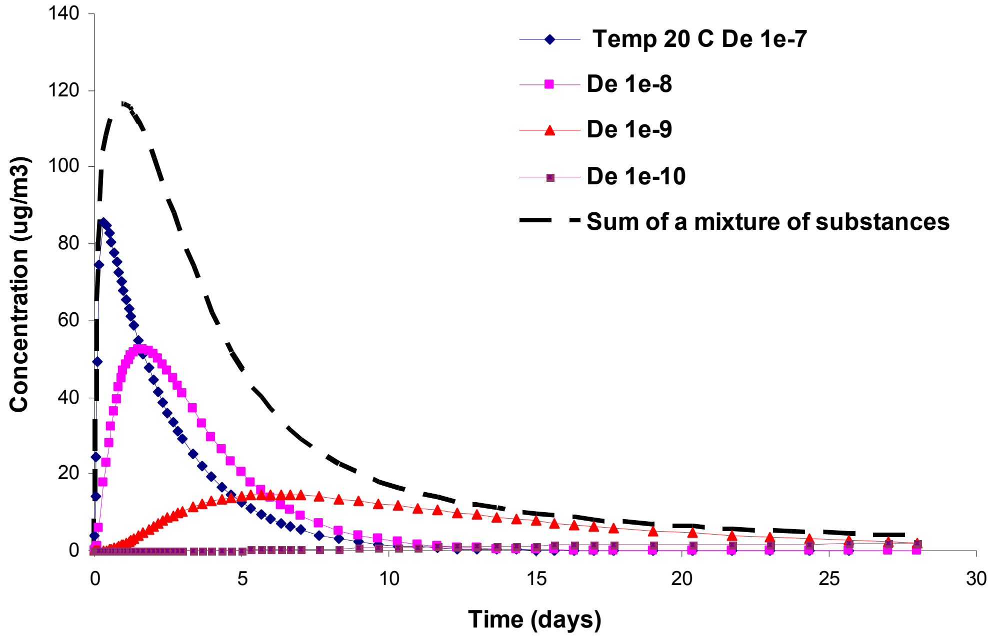



*Figure 5.4 Model description of emission of substances with different release rates due to difference in effective diffusion in the construction product and the resultant sum of VOC (TVOC) as the mixture of substances emitted. (Legend: De 1e-8 (= $10^{-8}$ $m^2/s$) is the effective diffusion coefficient, specific for the rate at which a substance can be transported in the product to the surface)*

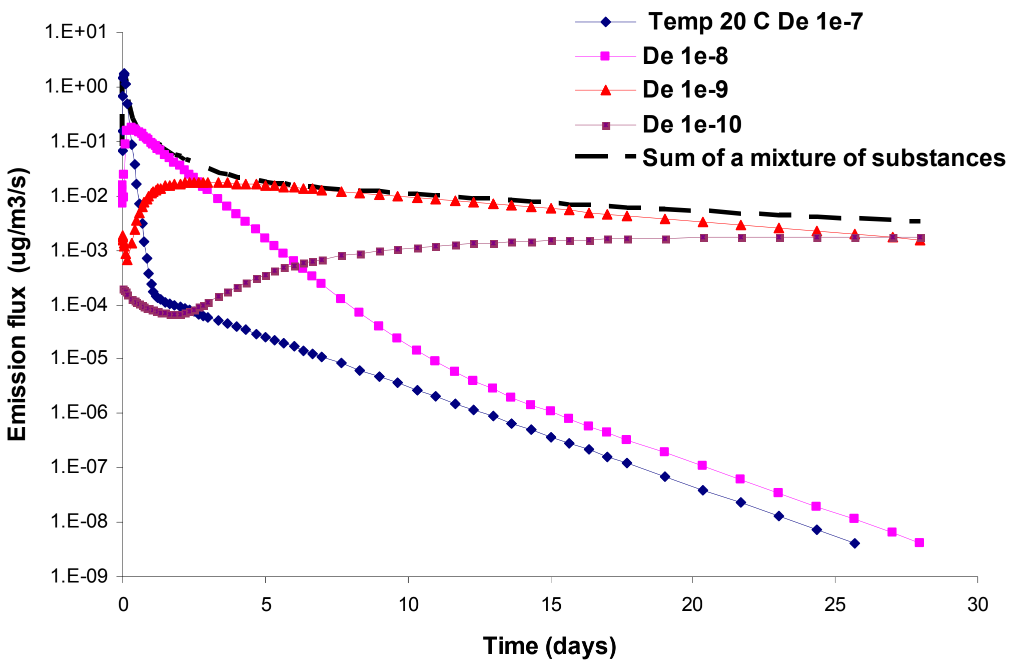



*Figure 5.5 Modelled emission flux of substances with different release rates due to difference in effective diffusion in the construction product and the resultant sum of VOC (TVOC) as the mixture of substances emitted.*

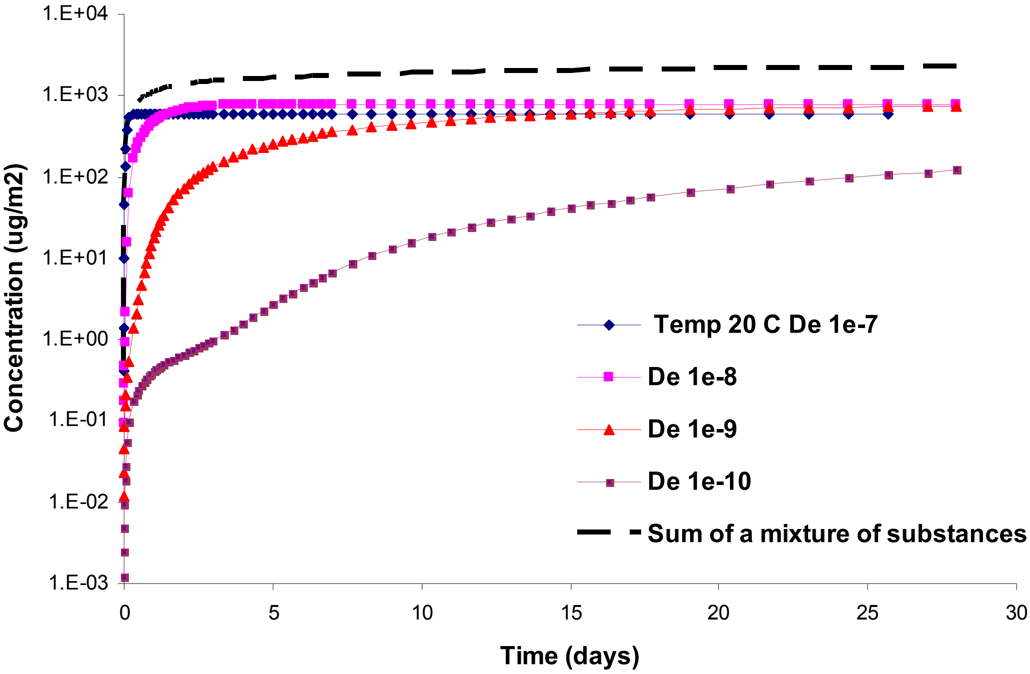



*Figure 5.6 Modelled cumulative emission of substances with different release rates due to difference in effective diffusion in the construction product and the resultant sum of VOC (TVOC) as the mixture of substances emitted.*

### 2.3.3 Chamber size

For chamber size, several studies indicate that the emission rate of a product, whether evaporation based (paint) or diffusion based, does not differ when tested in for example a 15 $m^3$ or 1 $m^3$ chamber (see Figure 5.7). On the other hand for very small test chambers (micro chambers) differences have been reported (see Chapter 3.5.3 and 3.5.4). Less volatile VOC and SVOC show lower emission rates in larger than in smaller test chambers (Oppl, 2008, personal communication).

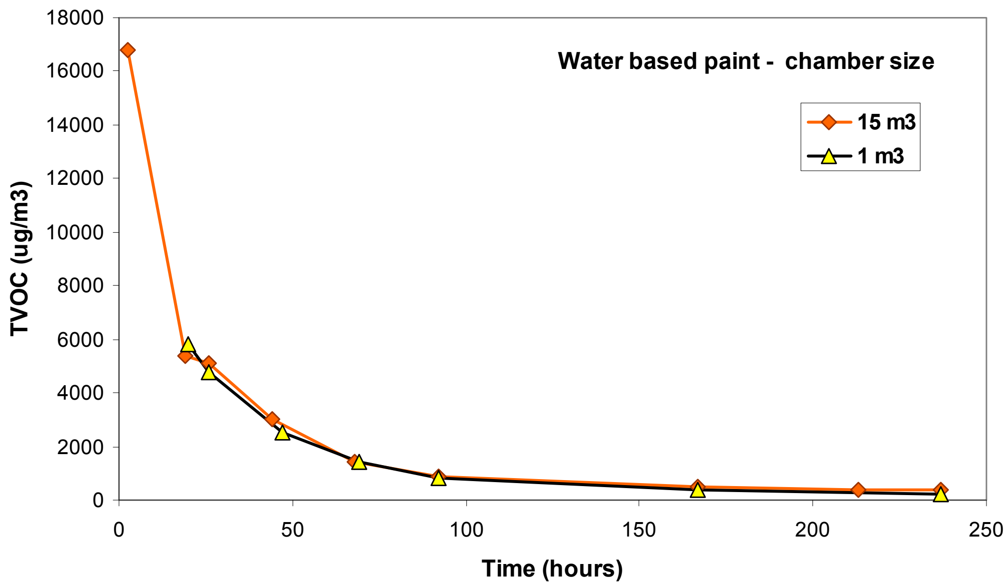



Figure 5.7 TVOC concentration (μg/$m^3$) over time caused by a water-based paint on an aluminium plate tested in 1 $m^3$ and 15 $m^3$ chamber using the same loading factor (Bluyssen et al., 1996).

### 2.3.4 Loading

The loading of a product in a test chamber has a significant effect on the emission rate. In Figure 5.8 the loading was changed by increasing the test chamber volume, but keeping all other factors constant. The decrease in concentration is caused by the depletion of the substance from the product.

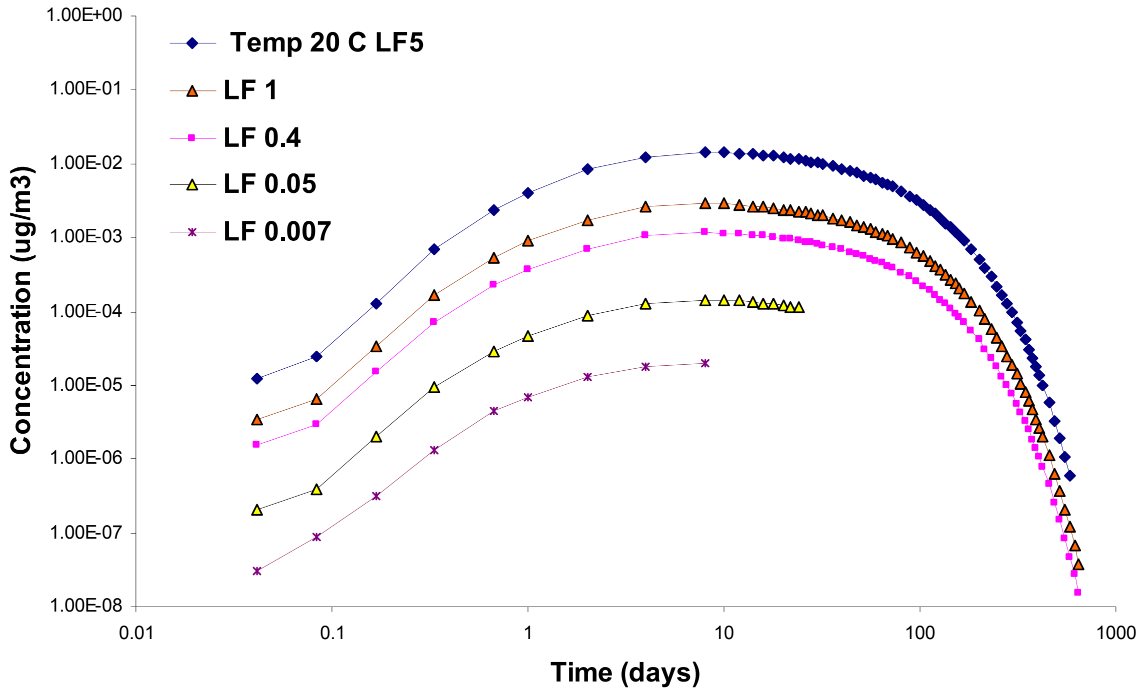



Figure 5.8 Modelled effect of different loading for equal exposure conditions in terms of temperature, flow rate, product area. Chamber volume has been varied to change loading. (x and y axis logarithmic).

### 2.3.5 Product thickness

In Figure 5.9 the effect of product thickness on emission is given as concentration versus time. These results are for a porous material with the same properties when the thickness is varied. Other products, like wood or flooring, may behave differently. A material with a dense internal structure that emits by surface evaporation mainly will show a different release behaviour, but again classifying emission behaviour will highlight such typical material properties.

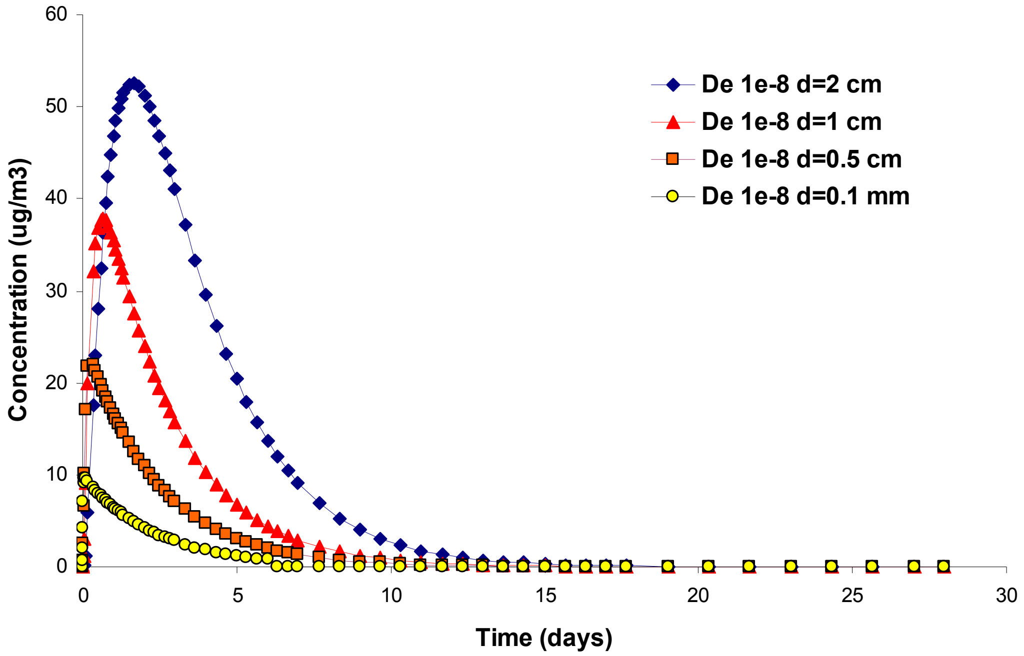



Figure 5.9 Modelled effect of product thickness on the concentration in a test chamber as a function of time (only diffusion assumed).

## *2.4 Recommendations*

Considering the above, the following aspects are deemed important in the test procedure:

- Number of measurement points required as a minimum to determine a characteristic emission pattern: testing after 3 and 28 days is the current convention (supported by current regulations). However, to decrease the burden of testing, it might be possible for some products to shorten the test duration depending on the emission pattern.
- the most efficient testing times (days from the start of testing), knowing the emission patterns can be different for different groups of substances (two points over time do not always seem sufficient )
- to differentiate between well known product/substance combinations that emit rather quickly and product/substance combinations that need more time for determining the characteristic behaviour over time, if possible

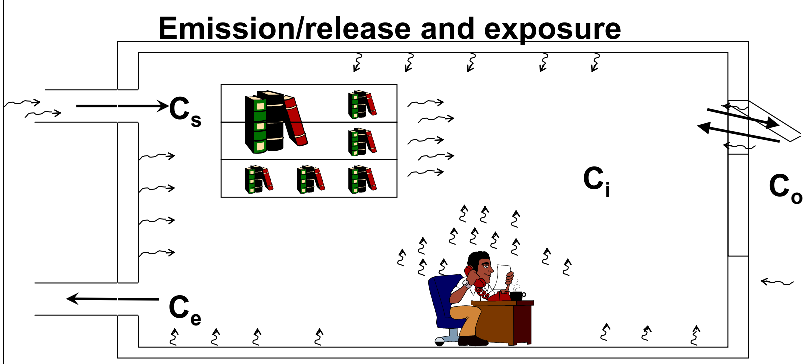
An ITT needs to ensure that sufficient measurement points are taken for a proper release curve to be established for a given product. This can be seen as a material characteristic or product reference against which conformity test data can be placed for judgment. Adequate ITT testing should provide a basis for efficient FPC testing. Experiences with different kinds of products and different release patterns can be used to enable the choice of simple and acceptable tests for FPC.

Additionally, it is seen that factors such as temperature (and most likely also humidity for substances such as formaldehyde), loading and thickness of product, may have a significant impact on the emission. The size of test chamber doesn't seem to have the same effect, except for micro chambers. Fixing the factors of influence is therefore important when comparing test results from different testing environments.The best basis for comparison of test data for different types of chambers is on the basis of emission rate rather than concentration in the test chamber. However, very different ventilation rates and loading factors may influence the emission rate itself.

# 3. Intended use conditions and release scenarios

## 3.1 Introduction

The exposure to indoor air pollutants, emitted by construction products, is influenced by the indoor environmental parameters such as ventilation rate, air velocity, temperature, relative humidity, the activities taking place in that indoor environment resulting in introduction or removal of the same or other pollutants, and the time (age of product) and duration of the exposure. Small variations in the indoor environmental parameters, activities or just the introduction of another source make the prediction of emissions of products complicated. Figure 5.10 shows the relationship between the emission of pollutants and the processes of removal by ventilation and sorption to surfaces. The pollutant concentration ($C_i$) in the air in a room and the exposure of occupants depends on the emission and removal processes and the concentration of pollutants in the air entering from outside ($C_o$). This is a dynamic situation as the rates of emission and the other parameters vary over time. It should be noted that the actual indoor air quality does not depend on a single product, but is a function of input from many sources and ventilation. The concentration of indoor air pollutants may vary widely as a function of both time and space.




The concentration of pollutants in the indoor air, Ci, depends on the emissions from sources in the room, concentration in the ventilation supply air, Cs, concentration in the outdoor air, Co, ventilation rate and ventilation efficiency.

Figure 5.10 The actual indoor air quality does not depend on a single product, but is a function of input from many sources.

## 3.2 Products and their Intended use

Before construction products can influence the indoor air quality, the compounds emitted or released from the installed product need to be transported in some manner to the indoor air. In general, construction products for indoor environments can be allocated to one of the following categories:

1. *In direct contact with indoor air:* Products/components that are applied in such a manner that they are in direct contact with the indoor air, e.g. the finishing products of floor, wall

and ceiling (flooring, wallpaper, plasters and paint[9]). These products can emit or release substances directly into the indoor air.
2. *Not in direct contact with indoor air, possible impact on indoor air:* Products/components that are covered by other products and have no direct contact with the indoor air. These may be part of the floor, wall and ceiling construction (e.g. concrete, bricks, glass, steel, different materials for thermal insulation, wood and wood-based-products). Substances may reach the surface by diffusion or other mechanisms through the covering product or by cracks in covering product.
3. *Not in direct contact with indoor air, impact on indoor air impossible:* Products/components that are part of the construction but separated from the indoor air in such a way that transfer of any emitted substances to the indoor air is virtually impossible[10]. These may include products covered by several layers of other products, or impermeable products as well as products applied e.g. on the outside of the building.

In the case of intermediate products, the most relevant for their possible impact on indoor air are thermoset products produced from monomers, oligomers or other low molecular weight reactive organic compounds through curing processes such as cross linking, vulcanization or oxidation. These products may emit residues of unreacted monomers, accelerators, curing agents and in between substances from the reaction phase. Water borne systems as paints and adhesives require intermediate products to attain and retain the emulsion. Most synthetic construction products contain additives such as plasticizers, and surface treating agents to reach the desired processing and mechanical properties, antioxidants and stabilisers to retain their mechanical properties through their intended service life and pigments and colorants, to be attractive.

## *3.3 Substances and exposure*

Some national building regulations require that buildings must be designed and constructed so that the indoor air does neither contain any gases, particles or microbes in such quantities that will be harmful to health, nor any odours that would reduce comfort. Even though available evidence on VOCs causing health effects in indoor environments is not conclusive (EU, 2007 report; Carslaw, 2007; NRC 2005) exposure levels have been related to certain effects (Annex K). More precisely, carcinogens have been identified and more recently it has been shown that a much broader analytical window of organic compounds than the classic VOC window (as defined by the World Health Organisation) should be used to explain the effects. In Figure 5.11 this broader window is presented schematically. Intermediary species (e.g. radicals, hydroperoxides and ionic compounds like detergents) as well as species deposited onto particles are included. The latter mentioned species cannot be considered when testing construction products for their emission of dangerous substances. However, it is possible to link the expected organic compounds to exposure effects and not only to the small window of VOC. This is reflected in the list of dangerous substances that CEN has received from the expert group on dangerous substances.

[9] Paints are by definition chemical products rather than construction products. However, their impact on the indoor air can be rather large which is why the group is included in this report anyway. Several categories of paints and coatings fall under the CPD –ETA route (intumescent paints-ETAG 018; concrete repairing coatings…).
[10] According to several experts, this category of products doesn't exist: all substances released by products, covered or not, will eventually reach the indoor environment.

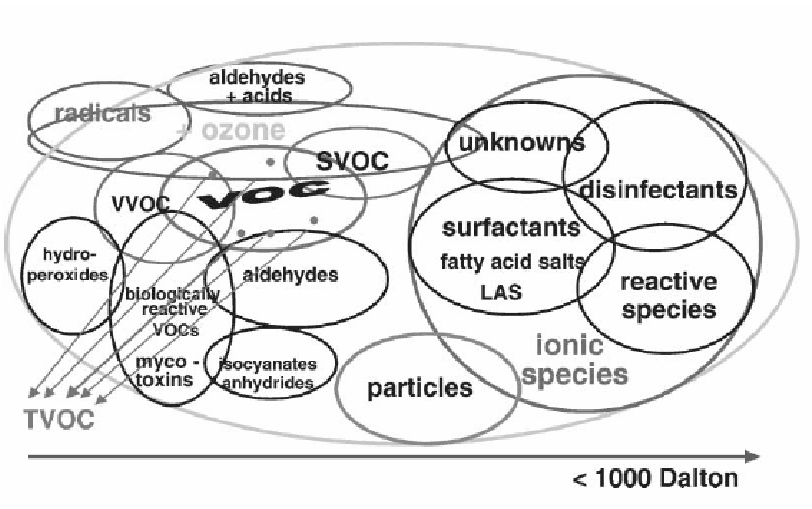



*Figure 5.11 Schematic presentation of the organic compounds in indoor air (Wolkoff and Nielsen, 2001).*

The measurement of emissions from construction products can in principle be approached in three ways:

- *The source*: identify the contents of the potential source (product characteristics) and predict what might be emitted.
- *The air nearby the source*: identify the substances emitted under intended use conditions in a standard test chamber and predict the indoor air concentration for the intended use situation by modelling.
- *The effect*: by exposing people and observing/monitoring the effect (for example smell, irritation of skin, allergic reactions, etc.)

Besides the ethical issues, the last approach is very time-consuming and most likely no one on one exposure-effect relations will be found. Some data are available, for example for carcinogenic compounds such as asbestos, but they are mostly based on experience in practice (people getting sick) and not acquired in a laboratory set-up.
The first approach would have been a good way if the compounds of concern would only comprise a handful. Instead we are dealing with more than a thousand substances, most of them behaving differently from each other. For certain banned or restricted substances however, it is a good way[11].
Therefore, up to now the second approach has been the preferred methodology. Although the translation to practice (the in-use situation) with modelling is still too complex, the current methods provide information to at least compare some of the applied construction products based on their emission patterns of a specified group of substances.
The substances emitted from construction products have different characteristics and therefore require also different methods of detection. The large group of volatile organic compounds are normally divided into subgroups depending on their respective boiling points, each group requiring different methods of detection.
To be pragmatic, the TVOC concept was introduced some decades ago, to cover a broad range of volatile organic compounds. Although in the mean time, there is a wide consensus that TVOC is not a very good measurement for health impacts, indications from Finland where it's been used for a number of years within the voluntary M1 system, show that the TVOC approach does decrease adverse health effects of construction products in real life.

[11] In this report, the content approach will not be dealt with; TG5 of CEN TC 351 is given this task.

Chemical analysis often does not correlate with odour assessments made by humans: for most pollutants the nose has a much lower detection limit than most chemical instruments and the interpretation capabilities of the human brain (giving an integrated evaluation of a mixture of pollutants) are superior. Therefore sensory evaluation using human panels have been introduced and are now used for labeling for example in Denmark and in Finland. Both trained and untrained panel methods have been developed (Bluyssen, 2007; ECA, 1999). The Finnish M1 (Saarela and Tirkkonen, 2004) and the Danish Indoor Climate labelling scheme (DICL) (Wolkoff and Nielsen, 1996) both comprise value judgements of indoor air quality and make use of the so-called continuous acceptability scale.
A screening of the available standards (CEN, 2007) for testing emission of construction products to indoor air shows that several are available. The available standards are focused mainly on products in direct contact with indoor air. For the category not in direct contact to indoor air it is assumed as a worst case approach that they also fall into the category in direct contact to indoor air. In current testing no difference is made between products in direct contact and products not in direct contact with indoor air.

Substances under a restriction or a ban such as asbestos, PCB, certain metals and flame retardants, shall not be put in new products at all. However, it is becoming more and more common to recycle old materials and mix virgin materials with recycled material in the process of making new products. This may cause unintentional contamination of new products by substances now under ban, and an unspecified dilution of dangerous substances throughout. The solution could be a) to verify the material to be recycled is "clean" when it comes to banned or restricted substances or b) to verify that the performance of the finished product is below any limit values.

For fibres some standards are available, but they are mainly concerned with an analytical procedure for fibres in air, not with the emission of fibres from products (see Annex K). It is not very likely that fibres suddenly are released into the indoor air, if no mechanical actions are involved. However, when maintenance work is involved (even cleaning of for example ceiling panels), fibres can be released. Maintenance work is covered by the CPD ("the essential requirements must, subject to normal maintenance, be satisfied for an economically reasonable working life". Annex I, CPD). For now, fibres from products are not considered relevant for an emission test of products in the in-use conditions of construction and finishing products. However, both the EU and several Member States (Denmark, Germany) have regulations on the structure of the mineral wool permitted. The structure can be verified by microscopic methods.

## 3.4 Linking emission rates to exposure

Regulatory criteria for air quality are not a concern of CEN, but linking chamber test results to relevant concentrations in a reference room or an actual indoor situation is of relevance, since test results should provide relevant data for assessing exposure concentrations. (The assessment can be based on simple or more complex modelling depending on the underlying regulations and their requirements).

Different member states have chosen different ways of implementing essential requirement 3 in regard to indoor air quality. Some regulate on the building level (indoor air quality in new buildings) and other on the product level (emissions from products). The tools provided by CEN are expected to accommodate all national approaches. Apart from the notified German regulation on emission rates of dangerous substances into indoor air by construction products

(DiBT, 2005), other notified regulations on indoor air quality in buildings are concerned with exposure levels (concentration in μg/$m^3$, 2007-372-FIN,) or do not give limit values for either emission rates or exposure levels but oblige the use of products with low emissions (2007-0090-DK, 2005-592-S). In order to fulfil the regulations that are based on the assessment of exposure levels, the emission rates of the products (e.g. expressed in ug/$m^2$.hr) used in a space where exposure limits are set, must be transferred to a concentration or an exposure value. This exposure can be defined as the concentration of the substances over time expressed in μg/$m^3$.

The concentration of substances in a reference room depends on several parameters:
- The emission of the substances in the space expressed with the emission rate of a substance in μg/h or μg/h per $m^2$ surface area of source (one or more sources).
- The ventilation rate of the space in which the substances are produced, expressed in $m^3$/h or l/s.
- The concentration of the substances in the ventilation air, expressed in μg/$m^3$.

Assuming the following conditions in the 'basic release scenario Indoor air' can be chosen with:
- No sorption and no cleaning
- No other source of a certain substance than the source of concern
- Ventilation efficiency of 1 (same concentration of substance at each point in the space)
- A fixed ventilation rate
- Fixed climate conditions (temperature and humidity)
- Homogeneous emission of source
- No covering layer on product

Under the assumption that the emission flux is constant after a given time, a steady state concentration of a substance emitted by a certain surface area can be expressed as:

$$C = E/Q$$

with: C = concentration (g/$m^3$);
E = emission (g/h);
Q = ventilation rate ($m^3$/h)

With this equation it is possible to give an indication of a concentration to be expected. In practice, the above assumed conditions do not of course occur: emission of the source of concern changes in time due to the emission process and under influence of changing climate conditions, ventilation rates and other (internal chemical) processes. These conditions represent therefore a simplified scenario.

More detailed approaches are possible by deriving intrinsic parameters from the test data and using these to assess emission from multiple sources under varying exposure conditions (temperature, ventilation, loading, chemical reaction, etc). The simulation tool IA-QUEST from NRC-CNRC (irc.nrc-cnrc.gc.ca/ie/iaq/iaquest_e.html) is an example. The models require detailed input to allow a description of emission of substances from different construction products in a reference room. Additional parameters for models that take chemistry into account are the concentration of reactants and rate constants for hydrolysis reaction of polymers with water or the release of ammonia at high pH.

In principle the test development is independent of the model used provided sufficient information can be obtained from the test. This mainly relates to more than two measurement points from which to derive parameters relevant for modeling.

## 3.5 Intended use versus chamber testing

As was pointed out in the previous paragraph, there are several factors connected to the intended use situation that can lead to either underestimating or overestimating the measured emission rates in a test chamber, when applying the 'basic release scenario' as presented

### 3.5.1 Covered products

In case a construction product consists of a layer material with different porosities between a finishing cover and the matrix of the material the emission of substances from the more porous layer is delayed due to the larger diffusion resistance of the surface cover. If the surface is essentially non-porous then no emission is expected unless the covering is not complete (sides). In Figure 5.12 a comparison is given between a layer of a given material without and with a dense cover material with low porosity. The degree to which the emission is delayed is of course a function of the diffusion resistance of the protective layer. If such emission behaviour is observed, the magnitude of the diffusion resistance can possibly be quantified. It is an example of one specific situation as illustration of the effect a cover layer with different permeability has. Other situations and other layers could result in other curves.

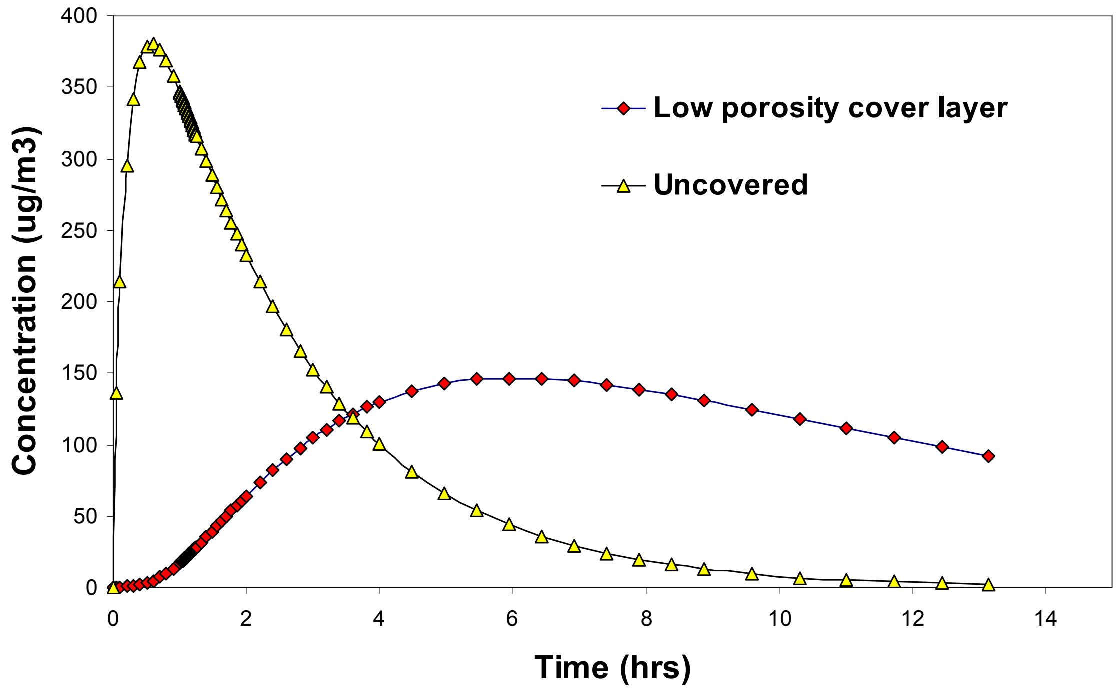



Figure 5.12. Example of a comparison of modeled emission from an uncovered product and a product with a surface cover with a substantially lower porosity than the underlying product resulting in a delayed emission.

In a study performed by Barry (2007) on the effectiveness of barriers to minimize VOC emissions, VOC emissions of 50 finished and unfinished products samples of different wood composite products were evaluated for more than 200 days. Although different in the beginning, finished products didn't show any difference with unfinished products in the long term: both reached a slightly different plateau at around 45-50 days.

### 3.5.2 Product systems (structures)

Indoor air concentrations and emissions from structures and interior materials were investigated in eight residential building during the time of construction and the first year of occupancy (Järnström, 2007). Contributions to concentration levels were highest for ceiling and lowest for walls. Significantly higher emissions were measured on site from the complete floor structure than from the single materials (PVC and adhesive) measured in the laboratory. The impact of adhesives on VOC emissions was clearly seen. Hydrolysis reactions in the floor structure (PVC/adhesive/casein containing levelling agents) can produce 2-ethylhexanol, butanol and ammonia). Predicted indoor air concentrations based on the on site measured emissions (floor, walls, ceiling) and air exchange rates were in general lower than the measured indoor air concentrations.
From the results, Järnström advised to test complete structures instead of single components of those structures. Furthermore, she advised to test adhesives 24-72 hours after spreading and preferably with the structure it is applied on. Under the CPD the manufacturer will, however, be able to test complete structures only rarely. This could perhaps be the case for certain kits in the sphere of EOTA. Due to practical considerations products normally need to be tested under the CPD as manufactured and not as used.

### 3.5.3 Scale of testing

From tests performed (see Figure 5.13 and Figure 5.7), it is clear that for most substances, the number of substances identified, doesn't differ when different testing chambers are applied. However, the quantity (concentration of substance in sampled air) can differ. The most obvious difference being found between a micro chamber and other chambers (note difference in scale of Y-axis).

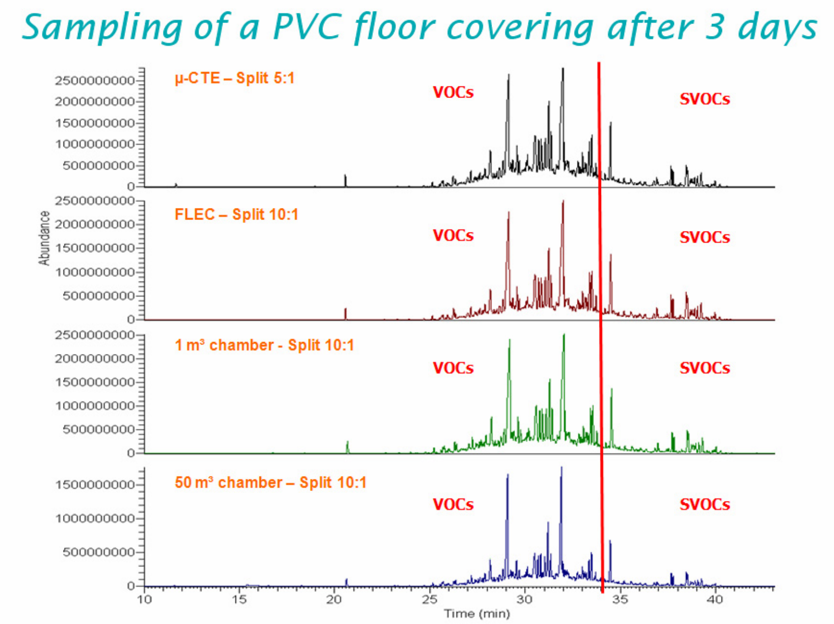



*Figure 5.13 Comparisons of chromatograms obtained with the micro-chamber, FLEC, 1 $m^3$ and 50,5 $m^3$ chambers after 3 days. (de Lor et al., 2008).*

This would imply that it should be possible to relate test results for different chambers to one another, if the loading and the ventilation is the same. Changing the amount of product per $m^3$ (loading) and the loading ($m^3$/h) will change the concentration of the pollutants emitted, depending of course on the product and conditions of the room.

Due to the higher ventilation rate applied in an emission cell (FLEC), a difference may occur between chamber tests and FLEC (Uhde et al., 1998). However, there are indications that test results can be correlated fairly well. In a recent publication it is stated that the FLEC is unsuitable for evaporation type materials in which the mass transfer of the surface controls the emission rate and not the internal transport (diffusion) (Zhu et al., 2007). Wolkoff et al (2005) report that when the emission process is dominated by internal diffusion within the material, the results from cells and small chambers are satisfactory.

#### 3.5.4 Micro chamber

It seems that high boiling compounds (SVOC) reveal a higher sensitivity in the measurements with micro chamber compared to the emission test chamber at ambient temperature (Hughes et al. 2006, Schripp et al, 2006). This may in part be attributed to the higher temperature in the microchamber, by which SVOCs are easier volatilised.

## *3.6 Recommendations*

The intended conditions of use of construction products to indoor air can be divided into:

1. In direct contact with indoor air: for example a textile flooring product
2. Not in direct contact with indoor air, possible emission to indoor air: for example of the strand board covered with a gypsum board.

A single "harmonized" horizontal approach for testing construction products is applied for two intended-uses.

It is recommended to test a product as it is normally applied in the in-use situation as far as practicable and reasonable. This is especially important for products expected to react or behave differently in the test system as compared to the naked situation (i.e. emitting different substances). For products which may be combined with very many different products into composite structures (e.g. adhesives used with carpets, laminates, PVC or rubber flooring), and not expected to behave differently, a simplified scenario (e.g. naked product) may be chosen to avoid repeated tests. Covering factors should not be considered.

With regard to the substances to be tested chemically, it is recommended to include the following groups: VVOC, VOC and SVOC.

It is important to emphasize that the "indicative list" of substances from the Commission (document CEN/TC 351 N 0054 "Indicative list of regulated dangerous substances") will be updated regularly in order to take account of notified regulations. Both the commission and the Member states may introduce new regulation or update existing regulation, if they deem it necessary on the basis of new scientific evidence to protect human health or the environment. Such scientific evidence may be produced for a large number of substances in the course of implementation of the REACH regulation. This may have consequences for the harmonised method to be recommended but also for the approach that is chosen now and in the future. In other words, the chosen approach has to be flexible enough in order to integrate for example new substances later.

If comparability between different sizes of chambers could be achieved by scaling the relevant controlling factors proportionally, that would be highly advantageous as it would improve comparability of test results. In this case temperature and moisture content would

have to be the same. The ventilation rate should be the same. Equal loading would be the main factor for comparability between products. The basis for comparison should be emission rate and after that the somewhat less sensitive parameters loading and ventilation rate. The allowed variability in these parameters needs to be assessed by robustness validation.
For the microchamber, which can be applied as an accelerated test, rapid release in high temperature, a correlation with chamber tests could be achieved, provided that the temperature increase does not lead to a significantly different substance spectrum being emitted (see figure 5.13). When the microchamber is operated at 23 °C, the results are better comparable, but the sensitivity may be low due to the concentration level in the chamber.

# 4. CEN technical committees for indoor air relevant construction product standardisation

## *4.1 Selection of relevant products TCs*

Considering the scopes of the products TCs that fall under the CPD (Annex A), and based on a first criterion “the product is normally used to build an indoor environment or is present in an indoor environment and has the possibility to release substances to the indoor air”, a selection was made. Furthermore it was identified whether the product TCs are concerned with intermediate products or final products.

In a second step, each selected product TC in the first step was analysed and categorised on its intended use:

A Finishing and construction products:

1. In direct contact with indoor air
2. Not in direct contact with indoor air, possible impact on indoor air
3. Not in direct contact with indoor air, impact on indoor air impossible

B Heating, Ventilation and Air Conditioning (HVAC) system components:

1. In occupied space (e.g. radiator): behave similar to the products in direct contact with air as above.
2. Not in occupied space, ventilated air passes through the component and transfer to air passing through possible.
3. Not in occupied space, ventilated air passes through the component and transfer to air passing through not possible.

No standard seems to be available for the B2 category in-use condition (HVAC systems not in occupied space but air passes through to occupied space). Therefore, those product TCS are omitted in the next step. Product TCs categorised as mainly A3 (finishing and construction products not likely to come in contact with indoor air during intended use) are also omitted.

After the first two screenings, the products covered by 21 product TCs remain to be further investigated with regards to their emission of dangerous substances to indoor air. The products groups and substances possibly emitted are described below (representatives of the actual product groups have been asked to update the properties).

Table 4.1 presents the outcome of the different steps.

## *4.2 Grouping of product TCs and EOTA groups according to their relevance for indoor air*

Table 4.2 shows the grouping of product TCs and EOTA groups and their relation with mandates under the CPD and possible relevant standards produced under those mandates and groups.

The grouping is based on the construction of spaces, namely for furnishing and construction products: walls, ceilings, floorings, panels and others. This grouping considers the in-use situation: ventilation pattern, activity patterns and maintenance (cleaning) (in general from flooring most emission will reach the person in the space, while from the ceiling the least; walls are known to absorb and desorb). In principle they can all be tested partly (i.e. as test specimens cut out from the product and smaller than the product placed on the market), except perhaps doors, windows and shutters. For those it could also be considered to test them in full scale, since they comprise of several parts or it could be decided to test the parts separately.

For HVAC systems only one category is considered: products in space. These products need to be tested full scale.

Table 4.1 Selection of relevant Products TCs and EOTA WGs (highlighted is selected).

| CEN/TC | TITLE | Step 1 Indoor use | Step 2 In-use condition 1 | In-use condition 2 | Step 3 Substances of interest | Step 4 Type of test |
|---|---|---|---|---|---|---|
| 33 | Doors, windows, shutters and building hardware | Yes | A1 | | Yes | Full? |
| 46 | Oil stoves | Yes | B1 | | Yes | Full |
| 50 | Lighting columns and spigots | No | | | | |
| 51 | Cement and building limes | Yes | | | | |
| 67 | Ceramic tiles | Yes | A1 | | no | |
| 69 | Industrial valves | No | | | | |
| 72 | Automatic fire detection systems | Yes | A1 | | no | |
| 88 | Thermal insulating materials and products | Yes | A2 | A3 | Yes | Partly |
| 92 | Water meters | No | | | | |
| 99 | Wall coverings | Yes | A1 | | Yes | Partly |
| 104 | Concrete | Yes | A3 | A1/A2 | | |
| 112 | Wood-based panels | Yes | A1 | A2 | Yes | Partly |
| 121 | Welding | No | | | | |
| 124 | Timber structures | Yes | A3 | A1/A2 | | |
| 125 | Masonry | Yes | A3 | A1/A2 | | |
| 128 | Roof covering products for discontinuous laying and products for wall cladding | Yes | A3 | | | |
| 129 | Glass in buildings | Yes | A1 | | No | |
| 130 | Space heating appliances without integral heat sources | Yes | B1 | | Yes | Full |
| 132 | Aluminium and aluminium alloys | Yes | | | | |
| 133 | Copper and copper alloys | No | | | | |
| 134 | Resilient, textile and laminate floor coverings | Yes | A1 | | Yes | Partly |
| 135 | Execution of steel structures and aluminium structures | Yes | A3 | | | |
| 154 | Aggregates | Yes | | | | |
| 155 | Plastic piping systems and ducting systems | Yes | B2 | | | |
| 163 | Sanitary appliances | Yes | A1 | | No | |
| 164 | Water supply | No | | | | |
| 165 | Waste water engineering | No | | | | |
| 166 | Chimneys, flues and specific products | No | | | | |
| 167 | Structural bearings | No | | | | |
| 175 | Round and sawn timber | Yes | A2 | A1/A3 | yes | Partly |
| 177 | Prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure | Yes | A3 | | | |
| 178 | Paving units and curbs | No | | | | |
| 185 | Threaded and non-threaded mechanical fasteners and accessories | No | | | | |
| 189 | Geotextiles and geotextile-related products | No | | | | |
| 191 | Fixed fire fighting systems | No | | | | |
| 192 | Fire service equipment | No | | | | |

| CEN/TC | TITLE | Step 1<br>Indoor use | Step 2<br>In-use condition 1 | In-use condition 2 | Step 3<br>Substances of interest | Step 4<br>Type of test |
|---|---|---|---|---|---|---|
| 193 | Adhesives # | Yes | | | | |
| 203 | Cast iron pipes, fittings and their joints | No | | | | |
| 208 | Elastomeric seals for joints in pipework and pipelines | No | | | | |
| 217 | Surfaces for sports areas | Yes | A1 | | Yes | Partly |
| 221 | Shop fabricated metallic tanks and equipment for storage and for service stations | No | | | | |
| 226 | Road equipment | No | | | | |
| 227 | Road materials | No | | | | |
| 229 | Precast concrete products | Yes | A3 | A1/A2 | | |
| 235 | Gas pressure regulators and associated safety shut-off devices for use in gas transmission and distribution | No | | | | |
| 236 | Non-ind. man. operated shut-off valves for gas and other products | No | | | | |
| 241 | Gypsum and gypsum based products | Yes | A2 | A1 | Yes | Partly |
| 246 | Natural stones | Yes | A1 | A2/A3 | No | |
| 249 | Plastics | Yes | A1 | | Yes | Partly |
| 254 | Flexible sheets for waterproofing | No | | | | |
| 266 | Thermoplastic static tanks | No | | | | |
| 277 | Suspended ceilings | Yes | A1 | | Yes | Partly |
| 295 | Residential solid fuel burning appliances | Yes | B1 | | No | |
| 297 | Free-standing industrial chimneys | No | | | | |
| 298 | Pigments and extenders | Yes | | | | |
| *303* | *Floor screeds and in-situ floorings in buildings* | Yes | A1 | A2 | Yes | Partly |
| 323 | Raised access floors | No | | | | |
| 336 | Bituminous binders | No | | | | |
| 340 | Anti-seismic devices | No | | | | |
| *349* | *Sealants for joints in building construction* | Yes | A1 | | Yes | Partly |
| BT/TF/119 | Stretched ceilings | Yes | A1 | | Yes | Partly |
| ECISS/TC 10 | Structural steels – Qualities | No | | | | |
| ECISS/TC 13 | Flat products for cold working – Qualities, dimensions, tolerances and specific tests | No | | | | |
| ECISS/TC 19 | Concrete reinforcing steel –Qualities, dimensions and tolerances | No | | | | |
| ECISS/TC 23 | Steels for heat treatment, alloy steels and free-cutting steels-qualities | No | | | | |
| ECISS/TC 29 | Steel tubes and fittings for steel tubes | No | | | | |
| ECISS/TC 31 | Steel castings | No | | | | |

*Italic: added # For adhesives for floor coverings no mandate exists yet. As emission is not negligible, it is expected that mandated work will be likely.*

| | | Step 1 | Step 2 | | Step 3 | Step 4 |
|---|---|---|---|---|---|---|
| EOTA WG# | TITLE | Indoor use | In-use condition 1 | In-use condition 2 | Substances of interest | Type of test |
| 1 | Metal anchors for use in concrete | Yes | | | | |
| 2 | Metal anchors for use in concrete for fixing lightweight systems | Yes | | | | |
| 3 | Plastic anchors for use in concrete and masonry | Yes | | | | |
| 4 | Metal injection anchors for use in masonry | Yes | | | | |
| 5 | Structural Sealant Glazing Systems | Yes | A1 | | Yes | Full |
| 6 | External Thermal Insulation Composite Systems/kits with rendering | No | | | | |
| 7 | Non-load bearing permanent shuttering systems | No | | | | |
| 8 | Systems of mechanically fastened flexible roof waterproofing membranes | No | | | | |
| 9 | Liquid applied roof waterproofing kits | No | | | | |
| 10 | Internal partition kits | Yes | A2 | | Yes | Partly |
| 11 | Self-supporting translucent roof kits (except glass-based kits) | No | | | | |
| 12 | Prefabricated stair kits | Yes | A1 | A2/A3 | Yes | Partly |
| 13 | Post-tensioning kits for the pre-stressing of structures | Yes | | | | |
| 14 | Light composite wood-based beams and columns | see TC 175 | | | | |
| 15 | Timber Frame Building Kits | see TC 175 | | | | |
| 16 | Log Building kits | No | | | | |
| 17 | Fire Stopping, Fire sealing and Fire Protective products | Yes | A1 | | Yes | Partly |
| 18 | Pre-fabricated wood-based load bearing stressed skin panels | See TC 175 | | | | |
| 19 | Self-supporting composite light-weight panels | Yes | A1 | A2 | Yes | Partly |
| 20 | Expansion joints for road bridges | No | | | | |
| 21 | Three-dimensional nailing plates | no | | | | |
| 22 | Ventures (prefabricated) insulation Kits and Cladding Kits | No | | | | |
| 23 | Falling Rock Protection Kits | No | | | | |
| 24 | Prefabricated Building Units | No | | | | |
| 25 | Liquid Applied Bridge deck Waterproof Systems | No | | | | |
| 26 | Concrete and Metal Frame Building Kits | see TC 104 | | | | |
| 27 | Cold Storage Rooms and Building Kits | Yes | A1 | A2 | Yes | Partly |
| 28 | Pins for Structural Joints | Yes | | | | |
| 29 | Watertight coverings for bathroom walls, floors /Self-supporting composite light-weight panels | Yes | A1 | | Yes | Partly |
| 30 | Ultra Thin Layer Asphalt Concrete | No | | | | |
| 31 | Inverted Roof Kits | No | | | | |
| 32 | Fire Retardant Products | Yes | | | | |

Table 2.2 Categorised relevant Product TCs and their mandates and possible relevant standards (the ones marked with an * should be tested in full scale and not as a test specimen)

| **Categorised Product TCs** | | **Mandates** | **Products covered** | **Possible relevant standards** |
|---|---|---|---|---|
| **Construction and furnishing products** | | | | |
| **Flooring** | TC 134 resilient, textile and laminate floor coverings | M/119 | Floorings | EN 14041 Resilient textile and laminate floor coverings<br>*DIN ISO 2424, ISO 16000 series*<br>*prENV 15052???* |
| | TC 175 Round and sawn timber | M/119 | Floorings | EN 14342 Wood flooring |
| | TC 217 Surfaces for sports areas | M/119 | Floorings | EN 14904 Surfaces for sports areas |
| | TC 303 Floor screeds and in-situ floorings in buildings | M/132 | Floor screeds | - |
| **Walls** | TC 99 Wall coverings | M/121 | Wall and ceiling finishes | EN 438-7 High-pressure decorative laminates<br>EN 14915 Solid wood panelling and cladding<br>EN 15102 Decorative wall-coverings |
| * | TC 33 Doors, windows, shutters and building hardware | M/101<br><br>M/108 | Doors, windows<br><br>Curtain walling | prEN 14351 Windows and doors (part 3)<br>EN 13830 curtain walling |
| | TC 175 Round and sawn timber | M/121 | Wall and ceiling finishes | |
| | TC 241 Gypsum and gypsum based products | M/106<br><br>M/139 | Gypsum products<br><br>Amendment to M/106, M/109, M/110 and M/125 | EN 12859 Gypsum blocks<br>EN 13950 Gypsum plasterboard thermal/acoustic insulation composite panels<br>EN 520 Gypsum plasterboards<br>EN 14246 Gypsum elements for suspended ceilings<br>prEN 152283-1 Gypsum boards with mat reinforcement<br>prEN 15283-2 Gypsum boards with fibrous reinforcement |
| * | EOTA WG 5 Structural Sealant Glazing Systems | | | |
| | EOTA WG 29 Watertight coverings for bathroom walls and floors | | | |
| **Ceiling** | TC 277 suspended ceilings | M/121 | Wall and ceiling finishes | EN 13964 Suspended ceilings |
| | TC BT/TF/119 stretched ceilings | M/121 | Wall and ceiling finishes | EN 14716 Stretched ceilings |
| **Sealants** | TC 349 Sealants for joints in building construction | | | |
| | EOTA WG 10 Internal partition kits | | | |
| | EOTA WG 12 Prefabricated stair kits | | | |
| | EOTA WG 17 Fire Stopping, Fire sealing and Fire Protective products | | | |
| **Panels** | TC 112 wood-based panels | M/113 | Wood-based panels | EN 13986 Wood-based panels for use in construction<br>*EN 717, EN 120, EN 1250-1, ISO 16000 part 2 and ; TR 14823 Determination of content* |
| | EOTA WG 18 Pre-fabricated wood-based load bearing stressed skin panels | | | |
| | EOTA WG 19 Self-supporting composite light-weight | | | |

| Categorised Product TCs | | Mandates | Products covered | Possible relevant standards |
|---|---|---|---|---|
| **Construction and furnishing products** | | | | |
| | panels | | | |
| | EOTA WG 21 Three-dimensional nailing plates | | | |
| | EOTA WG 27 Cold Storage Rooms and Building Kits | | | |
| **Others** | TC 88 Thermal insulating materials and products | M/103<br><br>M/138<br>M/367 | Thermal insulation products<br><br>Amendment to M/103<br>Addendum to M/103 | EN 13163 to 13171, prENV 14303 to 14309 and 14313, EN 14933 and 14934 Different factory made products; *EN 13162* |
| | TC249 Plastics | M/121 | Wall and ceiling finishes | prEN 13245-2 Plastics – profiles for internal and external wall and ceiling finished |
| **HVAC components** | | | | |
| **In space**<br>* | TC 130 Space heating appliances | M/129 | Space heating appliances | EN 14037-1 Ceiling mounted radiant panels<br>EN 12809 Residential independent boilers fired by solid fuel<br>EN 13229 Inset appliances including open fires fired by solid fuels<br>EN 13240 Room heaters fired by solid fuel<br>EN 442-1 Radiators and convectors<br>EN 15250 Slow heat release appliances fired by solid fuel<br>WI 00295016 Sauna stoves fired by solid fuel |
| * | TC 46 Oil stoves | M/129 | Space heating appliances | EN 1:1998/prA1:2007 Fluid oil stoves with vaporizing burners |

## 4.3 Questionnaires for product TCs

A questionnaire for the product TCs was developed to record specific information per product group. This questionnaire was sent to several TCs in order to verify this information but also to get feed-back on the questions asked.

The first questionnaires sent can be found in Annex L-1. They were sent to the following that are also represented within TC351 as members or liaison members:
- TC88 Thermal insulating materials and products
- TC104 Concrete
- TC112 Wood-based panels
- TC134 Resilient, textile and laminate floor coverings
- TC349 Sealants for joints in building construction

The questionnaire for the second round evaluation comprised all product TCs and EOTA groups (Annex L-2) and was sent at the end of May, 2007. In short, the questionnaires ask for specifications on what products more specifically are dealt with by the group, the intended use of these products, any emissions of concern, and what standards are used today. Note: product TCs were not consulted in regard to the regulations applicable to their products as this issue was covered by TG 1 of CEN/TC 351.

Up to January 2008 answers have been received from the following TCs and groups:
On the list of relevant TCs and groups
- CEN TC 88 Thermal insulating materials and products
    - WG 4 Expanded polystyrene
    - WG 10 Flexible Elastomeric Foam Insulation
    - Mineral wool products
- CEN TC 112 Wood-based panels

Not found relevant (a first assessment):
- EXCA: Exca products do not have any influence on indoor air quality in their intended use
- ECISS/TC23 Steels for heat treatment, alloy steels and free-cutting steels: no emission
- CEN TC 10 Structural steels: no emission
- CEN TC 19 Concrete reinforcing and pre-stressing steels: no emission
- CEN TC 125 Masonry: no emission

The answers from the relevant groups and TCs are presented in Annex L-3.

## 4.4 Recommendations

It is recommended to choose a testing procedure for test specimens instead of for whole construction products (more detailed recommendations are expected from TG 4 on sampling). For thermal insulating materials and products (TC88), resilient, textile and laminate floor coverings (TC134) and wood-based panels (TC112) much experience and work on emissions to indoor air seems to be available. The other TCs are not so experienced and/or informative on this matter.

HVAC system products need to be tested full scale, but pre-normative work is required for this.

# 5. Methods and standards for testing primary emissions of construction products

## 5.1 Introduction

In this chapter the existing standards and regulations are described and discussed with respect to the measurement steps in a test procedure and the available information on. The outcome is used to indicate how these current standards and regulations can be applied in a harmonised testing method and what is still required to improve and to validate the method.
The steps related to sampling are not covered here to avoid duplication with TG4. The focus of the chapter will be mainly on the generation, collection and analyses steps. Content analyses of a product sample is expected to be covered by TG5.

## 5.2 Existing standards and regulations

In Annex M, a selection of existing and draft standards for emission of products to indoor air, based on the inventory made by AFNOR, is presented. It shows three categories of standards: 1) standards related to VOCs, VVOCs and SVOC of finishing and construction products, 2) standards on formaldehyde from wood-based panels and 3) other relevant standards.

Horizontal standardisation is defined as the development of test methods applicable to different materials (across the fields of different TCs (CEN, 2007b)). A horizontal approach is defined as an approach in which the use of single methods is made possible for as large a number of products or purposes as possible. A vertical approach is defined as sector specific standardization.

In Europe, the most widely applied standard series for testing VOC emissions of construction products is the EN ISO 16000 series, which is considered a horizontal standard. The German regulation (DIBT, 2005) based on the AgBB scheme (AgBB, 2005) and a number of voluntary labelling schemes in Europe make use of this series. However, some differences are identified (see Annex N).

The international standard EN ISO 16000 consists of several parts. Some have been elaborated by CEN/TC 264 and some by ISO/TC 146 and have been mutually accepted under the Vienna agreement. The series comprises standards for sampling of product, for simulating emissions in either a small scale emission test cell or a larger emission test chamber, and several different ways of sampling and analyzing the emitted substances:
In practice, the tester starts with sample handling (Part 11), then selects a test chamber (part 9 or 10) and finally performs the analysis of sampled air from the test chamber (part 6 for VOC and TVOC and part 3 for Aldehydes):

- Part 3: Determination of formaldehyde and other carbonyl compounds – Active sampling method
- Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID
- Part 9: Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber (earlier: ENV 13419-1)
- Part 10: Determination of the emission of volatile organic compounds from building products and furnishing – Emission test cell method (earlier: ENV 13419-2)

- Part 11: Determination of the emission of volatile organic compounds from building products and furnishing – Sampling, storage of samples and preparation of test specimens (earlier: ENV 13419-3)

Although the analytical parts (EN ISO 16000-3 and 6) are mainly for aldehydes and VOCs (TVOC)[12], the potential and intent is there to widen them for other analyses methods for other groups of substances.
The sampling and chamber methods prescribed in EN ISO 16000-9, 10 and 11 were originally developed for emission mechanisms of homogenous construction and furnishing products in direct contact with indoor air by evaporation and/or diffusion mechanisms. They are based on a release scenario for simulating the impact of product emission (mainly emission from surface products) on indoor air quality using a model based on "European minimum room size " derived from European building regulations and "European minimum " ventilation rate. These simulations represent a worst case release scenario for buildings constructed according to regulations (e.g. supplied with a functioning ventilation) of the emissions' impacts on indoor air quality for relevant products. The scope of this emission testing standard can be widened to simulate offices, schools and other public spaces by taking into account the different ventilation requirements in the spaces. A higher ventilation rate could also be taken into account when defining technical specifications of products to be used in public spaces, if deemed practicable.
For extrapolation of test results to impact of product use under normal use conditions, one release scenario has been suggested in an informative annex of EN ISO 16000-9, -10. This so-called model room is an approximation of average European conditions, and is defined as follows:
- Floor area 7 $m^2$, Height 2.5 m
- Wall area 24 $m^2$, Sealant area 0.2 $m^2$
- 1/2 air exchange per hour (±3%), 23 °C (±2 °C), 50% relative humidity (±5 %) (ISO 554:1976)

The loading factor $m^2/m^3$ respectively area specific ventilation rate $m^3/m^2h$ (air exchange, divided by loading) are for:
- Flooring: 0.4 $m^2/m^3$ => 1.25 $m^3/m^2h$
- All walls: 1.4 $m^2/m^3$ => 0.4 $m^3/m^2h$
- Sealants: 0.012 $m^2/m^3$ => 44 $m^3/m^2h$

The emission tests are performed after 3 days (early exposure, renovation, gives an indication what to look for at later test) and after 28 days (long-term exposure). Samples can be taken as often as deemed helpful. (For example the German regulation allows for the test of floor coverings to be stopped after 7 days after loading the test chamber or the test cell, if the values determined are below 50 % of the 28-day-values and if no significant increase in the concentration of individual substances compared to the measurement on the third day is determined). The AgBB scheme and the regulation based on it have different conditions. The main parameter settings are subject to evaluation in the robustness validation work. To the extent the current German validation studies provide sufficient insight and clear conclusions already, the need for such work will be reduced.

[12] TVOC is the sum of VOCs sampled on Tenax TA® which elute between and including n-hexane and n-hexadecane, quantified by converting to toluene equivalents (ISO 16000-6). For definitions of VVOC, VOC and TVOC see ISO16000-6.

In EN ISO 16000-9 and 10 aspects such as adsorption effect of the surfaces in the chamber, ventilation rates, size of chambers, velocity nearby the sample, temperature and humidity of air in test chamber, are well defined. While in EN ISO 16000-11 the procedure from taking a sample of the product to be tested, transporting it and placing it in the test chamber is presented.

ISO 16017-1 provides guidance on measuring VVOC and SVOC.

For the measurement of aldehydes emitted from wood-based panels, a slightly different standard has been developed: EN 717-1, 2 and 3, The main difference is that the emissions are tested at a slightly different humidity and with different loading factor and ventilation, making direct comparisons of results achieved by EN 717 and EN ISO 16000 questionable.

Formaldehyde is the first dangerous substance emitting from building products regulated worldwide. For example in Japan and in California new standards allow only for a very low emission. In Europe, the regulation of formaldehyde emissions of wood-based panels – especially particle boards – started in 1980. The chamber test procedure was standardised as EN 717-1 in CEN/TC 112. The standard takes into consideration legislative regulations in Austria, Denmark, Germany and Sweden. EN 717-1 is applicable to products that, after an initial decay of emissions show a continuous steady-state emission of formaldehyde. This holds true for products with formaldehyde-urea-type bonding material that form and release formaldehyde when in contact with humidity from surrounding air. The harmonised product standard EN 13986 defines formaldehyde emission classes (E1 and E2) for wood based panels; this umbrella standard has been the model for E-classifications also in other related product standards.

The reference chamber test is complemented by three derived methods which are standardized as EN 717-2 (gas analysis method) EN 717-3 (flask method) and EN 120 (perforator method). The derived methods are used for external and internal production control of wood-based panels and many other building products and materials. A chamber test based on EN 717-1 principles is now an international standard (ISO 12460-1). The international harmonisation of formaldehyde emission testing is completed by the standardisation of the North American small chamber method as ISO/DIS 12460-2, the European gas analysis method as ISO 12460-3 and the Japanese desiccator JIS standard as ISO 12460-4. ISO/TC 89 has also initiated the international standardisation of the perforator method (ISO 12460-5).

CEN TC 112 was the first TC to start standardising test methods for emissions measurements in Europe. This has been a long process, however, and since 1995 there has been parallel standardisation by CEN TC 264 on VOC emissions from building products in general (not only wood based panels). Further CEN/TCs for construction products have also started work on VOC test standards (e.g. TC 134 (VOC standard for floor coverings - prEN15052) and TC 193 (VOC standard for adhesives - EN 13999 series). Another new test standard for VOC is currently being drafted in CEN/TC 112. Now that work on horizontal methods in CEN/TC 351 has started it would seem the most rational solution to concentrate work in this new CEN/TC. New vertical methods seem not worth developing unless the horizontal methods would turn out to be unsuitable for certain products.

## 5.3 Generation, collection and analyses

Table 5.3 presents an overview of the different steps of a test procedure and available methods, standards and regulations. As one can see, for VOC and formaldehyde, standards are available. For VVOC and SVOC suitable standards are partly missing.

In this chapter the focus will be on the steps generation, collection and analyses. The pros and cons of these different methods, standards and regulations will be discussed against what is required for a harmonized testing method.

**Table 5.3 Possible modules for testing construction products and available standards that might be used (input from experts sought)**

| | Substances | Phase | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Product tested | | Sampling of the product | Transport of sample | Storage of sample before test | Test specimen preparation | Testing age & conditioning | Chamber technique | Air sample collection | Analyses | Reporting |
| ITT # | | *TG4* | | | | | *Test chamber* | | | |
| | (T)VOC | *ISO 16000-11* | | | | *ISO 16000-9* | | *ISO 16000-6* | | *DIBT* |
| | Formaldehyde + aldehydes | *ISO 16000-11*<br>*EN 717-1* | | | | *ISO 16000-9*<br>*EN 717-1* | | *ISO 16000-3*<br>*EN 717-2and EN 717-3* | | |
| | VVOC | | | | | | | | | |
| | SVOC | | | | | | | *Content?*<br>*TG5* | | |
| | POM | | | | | | | | | |
| Partly (on site) FPC ? | | | | | | | *Micro chamber?* | | | |
| | (T)VOC | | | | | | | | | |
| | Formaldehyde + aldehydes | | | | | | | | | |
| | VVOC | | | | | | | | | |
| | SVOC | | | | | | | *Content?TG5* | | |
| | POM | | | | | | | | | |

# Full procedure for new or insufficiently characterised products (emission behaviour), simplified procedure in case sufficient knowledge on behaviour is available and tracable.

**Generation of emissions**

The main objective of this report is to recommend a harmonised testing procedure (standard/s) which is as horizontal as possible. The relation between generation of emission in a test and the real intended use situation should be well understood: in other words the outcome of the test should provide data with which the product can be evaluated (either directly related to the product or via limit values for indoor air quality and a tool to translate that to the product).

The ideal approach for fair testing would be to use a test that exactly mimics the in use situation. However this is neither realistic nor practical.

- The conditions in an in-use situation differ continuously. It is impossible to define uniform conditions in a test that exactly covers a specific in-use situation.
- The product will be used in different buildings with different conditions. -One single test for a type of product cannot exactly mimic each use situation.
- The number of tests for different use situations would be endless, and therefore impossible to execute, to report on and to work with in practice.

In general a producer wants to provide information on his product that guarantees a safe use in all situations within the scope of intended uses as defined for the specific product. For the designers, architects, contractors and users, it would be difficult to work with an approach that would include very detailed use specific differentiations. It is necessary to develop an approach that can be practical for all parties concerned. The approach should be based on the actual state of the art of knowledge and fulfil the requirements in current regulations.

Based on the state of the art four approaches could be combined:

1. Mimic one relevant selected reference situation (as in EN ISO 16000), but based on defined stable conditions.
2. Determine the ranges in emissions that can occur in other conditions than defined for the reference situation.
3. Determine specific properties of a product and properties of substances in the product; predict the behaviour of release in other situations than tested. (e.g. long term release, release at other ventilation rates, temperatures, humidity, combination with release from other products, etc).
4. Definition of worst case scenarios: determine the maximum emissions by testing and or modelling/predicting on the basis of the range of possible conditions in intended use and knowledge of properties of substances and release mechanisms of the product.

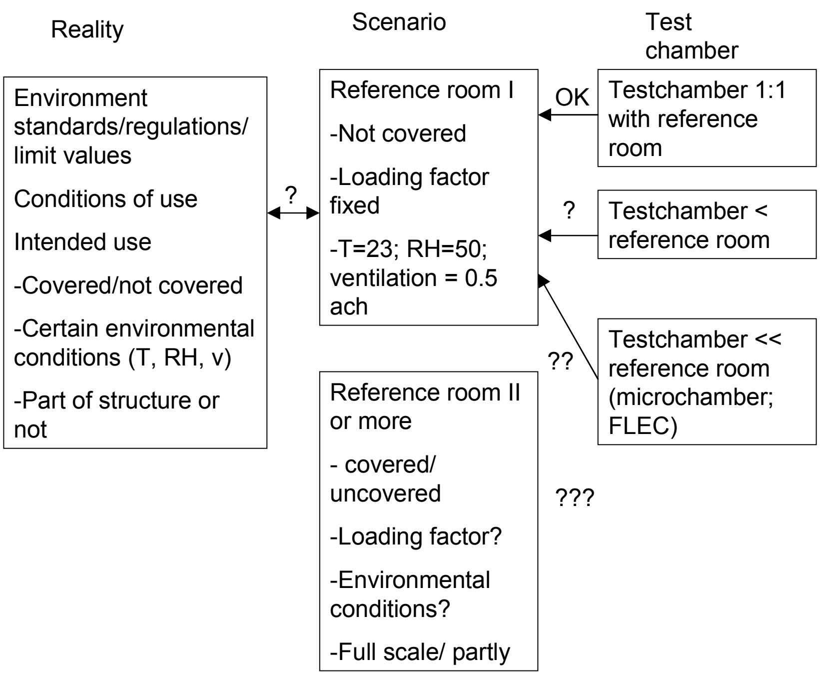
Available test procedures, as EN 717 and EN ISO 16000 follow approach 1, mimicking a specified reference situation with a specified stable situation. These tests base their evaluation on ranges and/or worst cases (approach 2 and 4). New information can be used for identification of specific risks and for identification of risks under specific (ranges of) conditions (approach 4). Approach 4 for is, however, not yet state of the art for all situations and caanot replace the approaches used now.

The great many individual substances that may be present, may emit and may react with each other is still too complicated and too unpredictable, to be able to calculate final emissions in detail on the basis of the composition of the product.

Regular testing as in the case of factory production control (FPC) should include the option to use more simplified tests. Such tests must be correlated for each product with the methods used in ITT to ensure a proper compatibility between the two types of tests.

The following schematic illustration shows possible ways to link the results from a chamber test to a model room or real use situation in a building. In this illustration the following definitions are applied:

- **Release scenario** = a schematization of release from a construction product in a (set of ways of) defined intended use situation(s), taking into account the main release mechanisms (e.g. diffusion, vapour pressure control, solubility control, percolation) and release controlling factors (e.g. temperature, humidity, type of water contact, wet/dry periods, pH, EC, DOC, redox)
- **Intended use** = a description of the intended applications of a construction product, as defined and specified in product standards or other relevant documents.
- **Intended use conditions** = range of conditions allowed in intended use of a product, which may affect the release of substances from a construction product (temperature, humidity, contact with water, pH of the environment, etc.)
- **Reference room** = Room with a specified shape and conditions, representing a worst case in the range of intended use condition situations For products intended to be used in interiors, a characteristic loading factor should be taken from a short list of default loading factors.
- **Loading factor** = The amount of a product that is supposed to be used in the release scenario 'reference room'.




With the horizontal test approach it should be possible to translate the results to the intended-use situations in order to make a valid evaluation of the product's influence on indoor air quality as far as this is required by regulations. For the generation of emissions this could either mean that the test situation is one to one to the in-use situation, or that the test results can be modelled in such a way that translation is possible. In the available standards the first option has been chosen due to the fact that little information is available to perform the second. Because it would be too complex to test each intended-use situation for each product, in the EN ISO 16000 series one situation (the model room) has been selected with one set of environmental conditions and one loading factor for three categories of products, simulating a worst case release scenario (not covered: i.e. a product is tested without a covering product although in its intended use it would always be covered) and always testing a single product using a test specimen (a part of the product).

The standards of the EN ISO 16000 series are therefore only valid for emission generation of:

- *A partial test specimen*: full scale testing, for example a door composed of different elements, is not included
- *A single product:* Whether the product is part of a structure, i.e. used in combination with other products (e.g. sealants or adhesives) or part of another product (intermediate products such as pigments) is not taken into account.
- *An uncovered product:* Even though a product is covered by another, substances will eventually be emitted, therefore all products are tested uncovered.
- *The product under "normal" environmental conditions* (e.g. RH=50%, T=23°C, air exchange 0.5 $h^{-1}$ as used in ISO16000): although the relation between emissions and different environmental conditions is not available for all substances, only one set of conditions is tested. Different conditions can lead to substantial different levels of release (for example in case of floor heating T=28°C).
- *A product with its peak emission before 28 days after production*: even though some products may reach the peak emission after that (for example the emissions from some flooring products increase when the top layer starts to wear). If SVOC are not taken into account adequately in the evaluation, this would let the products pass the test at 28 days but could cause long term adverse effects.
- *The amount of product that is applied in relation to the space is pre-set:* with the loading factors prescribed for flooring, wall and sealant. Flooring materials mostly cover the whole floor, but the use of sealants can depend for example on the number of windows in the space.
- *The sorption factor is fixed:* It is also a known fact, that adsorption to room surfaces reduces in the beginning the impact of product emissions on indoor air quality, but in the long run these surfaces become emitters. To contribute to cleaning indoor air is a subject for product development today e.g. for garages or other indoor spaces with high pollutant emissions. Standards for measuring sorption effect are developed in EN ISO 16000-series.
- *Quantifiable emissions without evaluation through sensory testing:* if sensory testing is required the generation conditions of the emission need to fulfil certain additional requirements, compared with the chemical evaluation according to e.g. EN ISO 16000 series.

The main difference between the EN 717 and the EN ISO 16000 series is that they use different testing climates, i.e. relative humidity and ventilation rates (loading) in the testing chambers. As relative humidity and loading may have an impact on the emissions of chemical substances from products this means results from using both standards might not be fully comparable. A comparison was made between EN 717-1 and EN ISO 16000-9 for VOC testing (see Annex O). From this comparison it is concluded that:

- the chamber sizes and materials recommended for the chambers differ in that EN 717-1 allows plexiglass, which is not acceptable for all VOC's and is definitely not allowed in ISO 16000-9. This issue can be resolved by specifying materials that are acceptable for all substances.
- the loading factors recommended by ISO 16000-9 are specified for sealants, wall and flooring, while for EN 717 only one loading factor is specified, indicating that the EN 717 is meant for wood-based panels only
- the climatic conditions for EN 717 and EN ISO 16000 differ in relative humidity and in air exchange
- the substance measured in EN 717 is only formaldehyde
- the steady state concentration of formaldehyde is measured in EN 717 while in EN ISO 16000 the specific emission rates for several VOCs are determined

Considering the test chambers in which the generation of emission is performed, for some substances there seems to be a difference between results from the emission chamber (EN ISO 16000-9) and the FLEC cells (EN ISO 16000-10). This can be explained considering the different micro climates occurring near the surface of the materials and resulting differences in diffusion and evaporation rates, depending on the pollutant of concern.

Beside the factors mentioned above, other factors such as the homogeneity of the material, other materials present (ad/ab- and desorption) and possible chemical reactions taking place in the material and at the surface, influence the emission rate (see chapters 2 and 3). Therefore, the assumption that measuring one situation in a so-called model room gives results that can be transferred to any other situation, is given the influencing factors not very straight forward. Using emission rates would give better comparability, as the emission is surface area related (concentration is not). The best that can be done is to test all products under similar conditions for comparison, but not for risk estimates or concentrations calculations in real life situations. This consideration has been taken into account in the German regulations, which define binding criteria for the product emission instead of the indoor air quality in buildings. In the Finnish regulations the binding limit values are defined for the indoor air quality in new buildings in six months after construction. In order to assess compatibility with this regulation a calculation method would be necessary.

The possibility has been raised to use micro-chambers for the FPC. In a micro-chamber, bulk thermal extraction of volatile or semi-volatile organic compounds, at temperatures up to 120˚C, is performed and seems suitable correlation with the reference test method. Some comparability of microchamber test results with chamber test results are given if also microchamber is operated at 23 °C. This may prove to be an important application of the microchamber (Oppl, 2008 , personalcommunication). This test should be possible to be applied in the factory as far as the correlation with the reference method is established.

**Collection and analysis of emissions**
Substances to be tested chemically comprise the following groups: VVOC, VOC and SVOC. Additionally it is still pending whether to test the products also on sensory aspects such as odour. When regulatory requirements appear and suitable standards become available, odour will need to be addressed in CEN/TC 351 at a later stage.

For the analysis of *VVOC, VOC and SVOC* emissions from construction products, again EN ISO 16000 can be applied. EN ISO 16000-6: -gives the procedure for detecting and reporting all VOC-emissions from one GC/MS –run and additionally defines how to report the VVOC- and SVOC-emissions detected outside the “VOC-window”. EN ISO 16000-6 also gives a calculation method for TVOC and requires reporting of the TVOC value. In EN ISO 16000-series there is a SVOC-measurement standard under development.
EN ISO 16000-3 can be used in detection and reporting formaldehyde and other aldehydes simultaneously with VOCs from emission chamber air operated according to EN ISO 16000 – 9 or 10.
The analytical method for VOC and formaldehyde, applied in the EN ISO 16000 series is **neither suitable for all VVOC** (e.g. acetone, dichloromethane, tetrahydrofurane) and **nor for very low volatile SVOC** with very high boiling points (e.g. PCP boiling point/decomposition 310 degrees, some Phthalates like DEHP, boiling point 385 degrees C). For the very low volatile SVOC and for the non-volatile organic compounds other methods of determination, i.e. extraction and content analysis are necessary, as far as regulatory requirements exist.

## *5.4 Uncertainties of the available test methods*

According to Saarela and Tirkkonen (2004), from error calculations and previous experience it is likely that results of the chemical measurements as defined in the EN ISO 16000 series will be reproducible for TVOC as follows:

± 10% on the same specimen by the same laboratory
± 20% between specimens within the same laboratory
± 30% between laboratories

There are however results presented by others that show a reproducibility far higher than those above and this could be due to heterogeneity of the test specimen, unpredictable behaviour of certain compounds to relative humidity as defined in the CEN-standards, interaction between chamber walls, etc…

From several inter-laboratory comparisons, four causes have been identified as key factors for the variability in measurements of emissions from products to indoor air:

- Homogeneity of test sample,
- Conditions of the test chamber: sink effects (interactions of measured compounds with chamber walls), unpredictable behaviour of certain compounds with variations in relative humidity or temperature
- The analytical procedure followed: for example the columns used in the gas chromatograph, whether these are polar or non polar, length of column, temperature programme, flow
- The person that is performing the analysis and the evaluation of the test results: interpretation of the chromatogram, regarding peak identity, peak integration and quantification/ calibration by the testing laboratory.

In 1999, the ECA reported on a European Inter-laboratory comparison on VOC emitted from building materials and products, in which 18 laboratories from 10 European countries participated (ECA, 1999b). The inter-laboratory comparison included the GC-MS determination of 5 target compounds from carpet, 8 from PVC cushion vinyl and 2 from paint; for the first time, chamber recovery (sinks), homogeneity of solid materials and possible contamination during transport were tested. The results show that the intra-laboratory variance (random errors) is much smaller than the inter-laboratory variance (systematic errors). Causes of the largest inter-laboratory discrepancies were: analytical errors, losses of heaviest compounds due to sorption on the chamber walls, non homogeneity of the materials.

- Non-homogeneity: difference from specimen to specimen is roughly 50% for carpet (with the exception for n-decane, for which it is 250%) and 20% for PVC. The smaller the area analysed, the larger the contribution to the overall variance of the results.
- Chemical analysis: incorrect integration of GC peaks has a substantial contribution to the variance of the results. For 5 of the 6 compounds tested the error was between 50 and 110%. The algebraic mean percent deviation compared to the median was 58% over the 12 cases.
- Sorption: from the sink tests performed it was concluded that either the sink test is not representative of losses occurring during the emission measurements or, more likely, other errors are overbalancing absorption losses.

The Association for the control of emissions in products for flooring installation (GEV) organised a second round-robin test in 2003 for assessing the GEV test protocol (Windhövel and Oppl, 2005). Twenty laboratories from seven countries followed a call for voluntary participation. The participants prepared a test specimen from a special model adhesive and stored it in a test chamber under well-defined conditions. Then they determined the TVOC and all individual VOC substances with more than 5 $\mu g/m^3$ after ten days. Besides that, each participant sent sampling tubes for analysis to a central laboratory. The results showed a variation of TVOC and individual VOC in the same order of magnitude, as did results in previous round-robin tests (largest results 10 to 15 times higher than lowest results and more than 40 % relative standard deviation around the mean value). Many technical parameters did not show any significant influence on the test result but analytical identification and quantification were shown to be the core problem. In particular the adequate precision and reproducibility was difficult to attain for sum parameters and individual substances with concentrations below 50 µg/m$^3$.

The expert group for building materials and construction of Nordtest, executed a round robin test in 1998-1999 with 9 laboratories, concentrated on chemical emission testing by use of the Field and Laboratory Emission Cell (FLEC) (Hansen et al., 1999), based on prENV 13419 Part 2 (now EN ISO 16000-10). The experimental part of the project comprised:

- Recovery determinations for decane and 2-(2-butoxyetoxy)ethanol, resulted in recoveries better than 90 % for both decane and the 2-(2-butoxyetoxy) ethanol (matching the criterion of prENV 13419-2).
- Analysis of spiked tubes with decane and 2-(2-buthoxyethoxy)ethanol, respectively, 1-butanol, butyl acetate and 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXiBTM): The analytical results from all the spiked tubes, compared to the true values target values) were within 5-10% for all the laboratories (except one). Based on this, it is concluded that the systematic errors are small for the analytical part of the method.
- Round Robin testing with nitro-cellulose lacquer applied on MDF-board. Based on the first chemical measurements it was decided that each laboratory at least determined the specific emission rate for the 3 substances: butyl acetate, 1-butanol and 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXiBTM). The statement of the variance analyse “all Lab-means are equal” tested on days 1, 3, 7 and 28 for all the compounds were not true (P-value = 0%). This implies that the laboratories measured differently and/or the test specimens were in-homogeneous. Since the laboratories generally showed a good performances with regard to the recovery tests (>90% recovery) and analyses of the spiked tubes (except one laboratory), it is considered that in-homogeneity of the test specimens is the main source for “ the laboratories not to be equal”. There were indications that long-term measurements beyond 14-28 days could give better results for comparison than early testing.

The Federal Institute for Materials research and testing (BAM) has currently the assignment to validate the procedures applied in the German regulation for VOC emissions from construction products. The report of thevalidation is expected to be completed soon.

The procedure as described in the EN ISO 16000 series for generation, collection and analysing, might be not detailed enough and would thus need to be specified further for the amended standard drafted in CEN/TC 351.

<u>Example 1</u>

It is seen in practice that in between the tests executed at 3 and 28 days, the product to be tested is taken out of the test chamber and put somewhere else until the next test. It is stated in EN ISO 16000-9 that “For periods when the test specimen is not in the chamber, it shall be stored at an average temperature of 23°C and a relative air humidity of 50 % RH. During this storage, the aging process of the test specimen shall be similar to that occurring in the test chamber. Any contamination by other stored test specimens has to be avoided. The test specimen shall then be re-introduced into the test chamber at least 72 h prior to air sampling. Each removal of the test specimen has to be documented in the test protocol.” However, it would probably be better for preventing additional uncertainties if it is specifically mentioned that when tests are performed for 28 days, the test specimen should stay in the test chamber under the conditions specified, i.e. not remove the sample at all.

Example 2
Another example is the collection duration of the test specimen to be analysed. In the EN ISO 16000-6 it is stated: "In general, the suitable sampling volumes, when sampling VOCs from non-industrial indoor air, is 1 l to 5 l for sampling tubes with 200 mg of Tenax TA. In material emission measurements, the material type and age, loading factor and air exchange rate in the chamber determine suitable sampling volumes. The recommended sampling volume, in general, is ≤5 l."
Furthermore it is stated that: "Appropriate sampling flow rate is in the range of 50 ml/min to 200 ml/min. When sampling from an emission chamber, the sampling flow shall not exceed 80 % of the air flow rate of the chamber".
First, from these instructions follows that the ranges of sampling volumes and flow rates are rather wide, it means that the total time of sampling can vary between 5 minutes and 100 minutes. But, it also shows that the sampling times are relatively very short (as compared to the 3 and 28 days testing times). A longer time of sampling is likely to lead to more accurate results.

## 5.5 Recommendations

For generation of emissions for ITT-procedures, test chamber and chamber conditions as described in EN ISO 16000-9 (and **not** EN ISO 16000-10) can be recommended. Translation of the results to other conditions or situations than referred to is not possible at the moment. The best that can be done is to test all products under similar conditions for comparison as required for example in the German regulation, but not for risk estimates or concentration calculations in real life situations as would be necessary for example for the Finnish regulation related to concentrations in the indoor air (2007-372-FIN). The procedures as described now in EN ISO 16000-9 are not specific or detailed enough to prevent unnecessary errors as explained in chapter 5.3. Therefore, it will be necessary in CEN/TC 351 to make the procedures more detailed and perhaps to decide to use sampling tubes that have a larger capacity and therefore can sample much more air with the emissions from the product tested.

For FPC testing it is advised to check the possibility to use micro-chambers for the generation of emissions. This test should be possible to be applied in the factory and needs to correlate with the tests used for ITT. Validation might be necessary.

For a WT dossier, it is advised to reconsider the testing points, i.e. the last point being 28 days after test begin as far as this is compatible with the current regulations. Especially when considering the possible SVOC emission pattern (emission peak beyond 28 days) or changes to the product in the in-use situation (for example the emissions from some flooring products increase when the top layer starts to wear).

With respect to the analytical part, both for ITT and FPC, the procedures need to be very clear and detailed enough to prevent unnecessary errors due to analytical procedure and equipment and due to interpretation of results.

Awaiting the outcome of the BAM validation programme, the recommendations above can be altered and/or elaborated on. If it turns out that for example homogeneity is the main cause of uncertainties in the testing procedure, as previous programmes have indicated, the sampling procedure (task of TG4) and interpretation of results need to be adapted to that.

If other standards or procedures are used for either generation, collection or analyses, such as EN 717, it is furthermore recommended to perform in the validation programme a comparison test. Here a transfer function needs to be developed in order to correlate the results or it needs to be proven that any differences are within the limits of accuracies requested.

# 6. Harmonised horizontal testing concept

## *6.1 Recommendations*

It is recommended to test the product as it is normally applied in the in-use situation as far as practicable and reasonable. This is especially important for products expected to react or behave differently in the test system as compared to the uncovered product (i.e. emitting different substances). For products which may be combined with very many different other products into composite structures and not expected to behave differently, a simplified scenario (e.g. uncovered product) may be chosen to avoid repeated tests. Covering factors should not be considered. Alternatively, a product used in combination with different other products may be tested in a standardised way and then declared suitable for use with all other related products (e.g. sealants used in windows and doors).

Products to be tested (as far as regulatory requirements apply)
The construction and furnishing products to be tested can be divided into the following groups:

| **Group** | **Product TCs** |
|---|---|
| **Flooring** | TC 134 resilient, textile and laminate floor coverings |
| | TC 175 Round and sawn timber |
| | TC 217 Surfaces for sports areas |
| | TC 303 Floor screeds and in-situ floorings in buildings |
| **Walls** | TC 99 Wall coverings |
| | TC 33 Doors, windows, shutters and building hardware |
| | TC 175 Round and sawn timber |
| | TC 241 Gypsum and gypsum based products |
| | EOTA WG 5 Structural Sealant Glazing Systems |
| | EOTA WG 29 Watertight coverings for bathroom walls and floors |
| **Ceiling** | TC 277 suspended ceilings |
| | TC BT/TF/119 stretched ceilings |
| **Sealants** | TC 349 Sealants for joints in building construction |
| | EOTA WG 10 Internal partition kits |
| | EOTA WG 12 Prefabricated stair kits |
| | EOTA WG 17 Fire Stopping, Fire sealing and Fire Protective products |
| | EOTA WG 27 Cold Storage Rooms and Building Kits |
| **Panels** | TC 112 wood-based panels |
| | EOTA WG 18 Pre-fabricated wood-based load bearing stressed skin panels |
| | EOTA WG 19 Self-supporting composite light-weight panels |
| | EOTA WG 21 Three-dimensional nailing plates |
| **Others** | TC 88 Thermal insulating materials and products |
| | TC249 Plastics |

A testing procedure for test specimens (detailed recommendations will follow from TG4 on sampling) is recommended. For products that comprise of several parts, it would be preferred to test them in the structure or system, but in most cases that will not be practicable and then these parts need to be tested separately.

Emission mechanisms

Understanding the emission behaviour of dangerous substances from construction products is crucial to making choices for test conditions for a horizontal standard to assess impacts to indoor air quality.

Emission over time and emission pattern

**A proper understanding of the emission of substances from construction products can not be obtained from one or two measurements.** How can one test a product as efficiently as possible but still consider the (major) emissions over time? The Finnish notified regulation for new buildings includes binding planning values for new buildings after 6 months from construction. Here standardisation is free to provide for the solution, how the products' conformity to the planning values can be tested with the least onerous solution. In order to conform to the German regulation the tests after 3 and 28 days are adequate. Additionally, the test for floor coverings can be stopped after 7 days, if the values determined are below 50 % of the 28-day-values and if no significant increase in the concentration of individual substances compared to the measurement on the third day is determined. Products that have their peak emission before 3 days (possibility to make tests shorter) or after 28 days can not be identified in this way.

There are several options:

1. Ignore the possible emissions at a later time than 28 days or the peak emissions before 3 days
2. A detailed test programme is performed to determine the emission pattern for the different substances of concern (once) and from that pattern or patterns, the testing procedure for the future is determined (i.e. 3 hours for short term emissions), 3, 28 and/or 120 days (or another maximum to be determined), etc.
3. Another method is applied to test the product on emissions that normally are emitted later than 28 days (such as several SVOC) (for example under elevated temperature conditions to speed-up the diffusion process).

The latter option seems to be a possibility worthwhile to investigate. When e.g. a new ISO standard for SVOC becomes available, it could become part of the validation programme as far as the method would be compatible with existing regulations (e.g. the SVOC regulated in the Finnish regulation).

Substances to be tested

Substances to be tested chemically comprise of the following groups: VVOC, VOC and SVOC. Additionally it is still pending whether to test the products also on sensory aspects such as odour at a later stage. Besides that the secondary emissions in the form of sensitivity to microorganisms is also postponed to be taken into account, but still recommended for pre-normative research.
Secondary emissions can comprise emissions of spores, mycotoxins, synergizers and VOCs from microbial growth on the surface of the product. It has been proven that the product constituents and moisture retention characteristics of a product determine the risk for microbial growth, and therefore sensitivity to microbiological growth is a product characteristic just as adsorption and desorption ability is (Adan, 1994). For pre-normative recommendations see chapter 6.4.

Emissions occurring during the in-use phase as result of oxidation or water, are for the moment not considered, but it is advised in the future to consider those as well, because:

- Organic compounds that react with ozone on the surface are transformed to more highly oxidized species.

- Many esters used in indoor products/materials, such as plasticizers (phthalate esters, phosphates, sebacates, etc..) and flame retardants (halogenated phosphate esters, aryl phosphates,..), are susceptible to hydrolysis, especially under basic (high pH) conditions, a reaction which is slower than oxidation reactions and therefore insignificant in the gas phase (too little time for the reaction to occur before the molecules are ventilated from the space). But, on the surface these reactions can occur and occur more likely when the surfaces are moist. Moisture also facilitates the disproportionation of $NO_2$ in aqueous surface films, leading to increased levels of nitrous acid (HONO) in indoor air.

For recycled products it needs to be tested whether they can cause unintentional contamination of new products by substances now under a restriction or a ban. The solution could be a) to verify the material to be recycled is “clean” when it comes to banned substances or b) to verify that the performance of the finished product is below any limit values.

Generation of emission

For the ITT the procedures in EN ISO 16000-9 need to be adapted by CEN/TC 351 to become more specific and detailed to provide reliable test results for the CPD. Points of attention are:
- Dimensions, materials and cleanliness level of the test chamber
- Ventilation rate, temperature, relative humidity, mixing rate, velocity/turbulence, background levels of pollutants (ozone, VOCs, $CO_2$, CO, etc.), ad/desorption rate of surfaces; and influence of ranges on precision, reproducibility and on level of release.
- Constant conditions for the product: e.g. loading factors

For FPC testing it is advised to check the possibility to use micro-chambers for the generation of emissions. This test should be applicable in the factory and needs to correlate with the tests used for a full ITT. Validation is considered necessary.

Collection and analysis of the emission

From the instructions given in EN ISO 16000-6 it follows that the ranges of sampling volumes and flow rates are rather wide, resulting in an allowed variation of total time of sampling between 5 minutes and 100 minutes. These sampling times are relatively short (as compared to the 3 and 28 days testing times). A longer time of sampling is likely to lead to more accurate results. A continuous measurement over 28 days would enable cumulative test results that give much lower uncertainties. However, the tenax tubes recommended at the moment would not be able to handle such a long testing time. The regulatory limit values are for points in time: in Germany for 3 and 28 days (in a test chamber) and in Finland for 6 months (planning values for a new building). At the moment no regulatory values for a cumulative test are available.
EN ISO 16000-6 gives further instructions as follows: “Connect the sampling tube to the test chamber outlet or other sampling port of the emission test chamber, note and record the time the tube was connected. Note and record temperature and if necessary barometric pressure. At the end of the sampling period disconnect the sampling tube from the chamber sampling port, note and record the time of disconnection, repeat the sampling flow determination, and turn off the pump. Disconnect the sampling tube from the sampling line and seal both ends using screw cap fittings with PTFE ferrules.” The tubes are then either stored or directly analysed. In practice, this procedure is sometimes executed differently: namely, the air sample is directly transferred to an analysing instrument. The pros and cons of this procedure are not known, but it might be a way to perform a cumulative test over 28 days.
It is recommended to consider cumulative testing in the validation programme, if this is deemed compatible with the current regulatory requirements. Even if a cumulative test is not performed,

uncertainties can be lowered by keeping the test specimen in the test chamber for 28 days and not taking it out in between.

<u>Note on release scenarios</u>
For all parties, it would be convenient to work with one 'basic release scenario' as is advised to start with. However, different specific release scenarios might become necessary, when, e.g.

- Specific products might be excluded from use; unless they are used in specific conditions/situations only, where it is safe to use them.
- Specific products are always or potentially used in known situations with high risks, e.g. in places with high temperatures or high humidity.

Here it is necessary to investigate, whether one basic release scenario would be sufficient (and what should be the conditions within that release scenario), or to specify the need and practical usability of more specific release scenarios in consultation with the product TCs.
It seems most preferable to work with one general 'basic release scenario' only.

There are several options:

1. The procedures for testing, evaluation and declaration of product quality should be kept as simple as possible. This may result in one basic release scenario only: use of a construction product in a reference room, tested as uncovered product and tested without other products in the test room. The conditions of the test room should include a worst case situation (pre-set temperature, humidity, ventilation, etc). The duration of the testing depends on the time the peak release occurs. If the peak is just at the beginning (e.g. first day) the test should show where the emission tends to stabilise on a certain level.
2. Same as 1, but products that will be covered immediately are tested as covered.
3. Same as 1 or 2, but with different climate conditions, taking into account climate conditions in countries where the product is used (as far as regulations exist).
4. Same as 1 or 2, but taking into account specific conditions in the specific construction or the specific type of building. E.g. Hospitals or bath houses/saunas with extreme conditions. Or floor covering materials used in combination with floor heating or heating appliances itself.

If option 2 will be included it is essential to define in detail, what is meant with ‘covered’. It should be specified how complete the covering is and how long the covering needs to stay intact. Behaviour of substances in the product on the short and long term should be taken into account. The available procedures to test and evaluate the durability and effectiveness of the covering should be combined with the emission test, if this option would be developed further.
For options 3 and 4 it is essential first to identify and describe specific situations, types of products, their precise intended uses and conditions of use that would fall under the scenarios. It should be shown what magnitude of change in emission may be expected by the differences in use conditions.

In general for producers, users of products, and for authorities it would be preferable to work with one general scenario only. If different basic release scenarios would be proposed, these should be well argued and the attached criteria should be specified and easy to use. It is proposed to:

1. Choose one Specific release scenario for the model room with general conditions, covering the worst cases in ‘normal’ in use situations.
2. Investigate if specific situations would need different testing methods.
3. Specify which information should still be investigated separately and/or in ruggedness testing, to support final decisions on the test standard(s).

Hierarchy in testing
Once the emission characteristics of a product type or class (suitable for evaluation of impact during intended use conditions) are established, *much simpler* testing will suffice for potentially critical parameters at a frequency consistent with the risk of approaching/exceeding a class limit or limit values by (national) regulation.
For these different levels of testing, the following is recommended:
- ITT: to use the EN ISO 16000 series as the basis.
- FPC: for a quick assessment in a short testing time, a shorter testing time may be applicable based on understanding the emission behaviour of the product, in addition either the EN ISO 16000-10 or a microchamber method could be used. Suitable test conditions need to be developed for the latter to ensure that release of substances can be measured in coherence with the reference test adequately. Therefore during ITT the simplified method used should be applied in parallel with the reference test.

## 6.2 Standards recommended for a horizontal approach

As presented in chapter 5, the standards of the ISO 16000 series are the only horizontal standards available for testing construction products on their emission to indoor air. The methods described in the EN ISO 16000 series are very well applicable when comparing emissions of substances from products, but translation to reality in an actual situation is complex. Simulation in a test chamber is just one chosen situation with one sample, which usually represents the most extreme conditions (emissions) for a new product (primary emission). The emission after 3 days and 28 days or 28 days only is measured. Secondary emissions or interactions are not taken into account. Neither is emission in time (after a year for example). The methods given in the EN ISO 16000 series are originating from the ECA report no.18 which was originally intended for emissions of floor coverings.
EN 717 is a vertical standard for testing mainly the emission of formaldehyde from wood based panels. However, it seems that the procedures applied are not that different from the EN-ISO 16000 series besides the (fixed) environmental conditions.

It is therefore recommended to make use of the procedures described in the above mentioned standards and amend the standards to make them more reliable for use under the CPD where necessary.

So far no simple direct relation can be defined between specific emission rates and the indoor air concentrations. An emission test delivers the emission rate of a product as a function of time, which then can be used for calculating the maximum contribution of product emissions to air concentration at a given point of time. It is a "Maximum" because in reality some emitted compounds will be lost by adsorption on other surfaces. This calculation can be performed both for regulatory reference rooms, and for real indoor air situations. To capture all effects and provide a prediction of emission under different exposure conditions of temperature and humidity is not yet possible.

## 6.3 Parameters to be considered for validation

Considering the previous validation tests and awaiting the validation tests of the BAM project, the following parameters need to be considered for validation:

Parameters for testing robustness of method (i.e. change of test results as consequence of change of parameter such as temperature, humidity, loading, etc.)

From the previous validation exercises it can be concluded that change of parameters such as temperature, relative humidity, air velocity and loading can have a considerable effect on the outcome. Therefore in EN ISO 16000, strict guidelines are presented for that. In chapter 2 and 3 some of the available data have been presented (but unfortunately not for all available data was access given) Awaiting those “missing”data, there are still a few points that need to be considered for amendment in the CEN/TC 351 test standard and / or for validation:

- The use of micro-chambers: the relation between emission rates measured in micro-chambers versus other chambers in order to check the possibility for using micro-chambers as a fast measurement technique
- The number of measurement points to determine the emission pattern(s) for products other than flooring materials (for which the current German regulation is applied)
- Details of procedure description (incl. details of procedure for generation, collection and analysis of chemicals).
- Short time testing at 3 and 28 days (5 to 100 minutes as recommended in EN ISO 16000-6) versus cumulative testing.

Parameters for testing performance in the sense of variability (i.e. what is the repeatability within a laboratory and the reproducibility between laboratories)
The two main parameters to consider for validation are:

- Homogeneity of the product tested and
- The variance or error occurring from “wrongly” analysing the chemicals.

It seems that these parameters cause the biggest differences between laboratories (the outcome of the BAM project will need to verify this conclusion).

## 6.4 Pre-normative research / observation of standardisation work in other ISO and CEN/TCs

For the following aspects it is advised to perform pre-normative research or observe the ongoing standardisation activities in other CEN or ISO TCs:

- Procedure for testing SVOC of construction products (scope of existing regulations under the CPD)
- Procedure for testing the emissions of HVAC-systems (and their components, scope of existing regulations under the CPD, product mandates not yet issued)
- Procedure for testing the sensory emissions of construction products (scope of existing regulations under the CPD): In ISO a Work Item for drafting ISO 16000-28 exists (based on chambers described in ISO 16000-9. No pre-normative work is needed.
- Procedure for testing the sensitivity of materials to growth of micro-organisms (scope of existing regulations under the CPD)
- Procedure for translating the results to intended-use situations (relations between specific emission rates and the environmental parameters described are required, scope of existing regulations under the CPD)

**SVOC**
In the last decades VOC were substituted with longer-chained hydrocarbons (SVOC) to reduce emissions.

In laboratory environments it has been shown that several VOCs in combination will cause chemosensory irritation of eyes and nasal passages, even when each individual compound is substantially below its normal irritant threshold (Cometto-Muniz in Spengler et al., 2001). This indicates the existence of agonism among chemicals. The degree of agonism increases with

number of compounds and with the lipophility of such compounds (as a rule, larger homologs having long carbon chain length, are more lipophilic than smaller homologs, having short carbon chain length). Studies of homologs chemical series have shown that the larger homologs (e.g. 2-heptanone) not usually considered particularly irritating compared to smaller homologs (e.g. acetone), have a stronger sensory potency because of their much lower odour and nasal pungency thresholds.
Thus within families of organic compounds, more carbon atoms usually translate to an increase in odour and irritation potential. Compounds with a high number of carbon atoms also have the characteristic to off-gas longer due to lower vapour pressure.

Thus substituting by longer-chained hydrocarbons (SVOC) to reduce VOC emissions in the short term can have the contrary effect than envisaged.
It is therefore important to measure SVOCs from construction products.

**Microbiological growth as a material characteristic**
Microbial growth in buildings is a threat to occupants' health as well as the sustainability of construction products and the building itself. Several factors influence the risk of microbial growth among which some are related to the indoor environment (handling during construction, water production, accidents, human and design errors) and others to product characteristics (intended use, water retention).
We therefore recommend that the characterisation of construction products with regard to risk for microbial growth should be included into the assessment under the CPD / ER3. It is proposed to develop a draft EN for the determination of microbiological potential of construction products in the indoor environment. After this development validation can take place.

Area of application**:** Sensitivity to growth of micro-organisms of construction products in the context of effects on indoor air quality. This means that the resistance against growth of micro-organism is not approached from the degradation of the material, but it concerns the potential health risk of emissions caused by microbiological growth.

Consequence: The application area comprise therefore mostly finishing materials, such as coatings, transparent lacquers, glues, plaster, wall coverings, floor coverings and divers plate materials. Components from HVAC systems, which probably require another approach, are excluded.

Note A negative consequence of a mandatory test for microbial growth would possibly be that manufacturers would start to use more biocides. This could outweigh the health benefits anticipated, unless regulations prohibits the use of biocides in indoor spaces.

Starting point: In the last decade TNO developed a method for the evaluation of so called microorganism sensitivity of materials in the indoor environment. In deviation from current guidelines, this method is focussed on a broad application area of finishing material under several indoor environmental conditions. Moreover, this new method results in a better reproducibility, has very good distinguishing capabilities and a much faster evaluation. While other methods take a period of three months to make an evaluation, this method can already give a distinctive picture after 2/4 weeks. The definition of micro-organism(s) sensitivity is based on more then 10 years experience with lots of construction products.

Phases
1. (further) simplification of the method for micro-organism sensitivity of materials in the indoor environment for implementation and acceptance in European test environments

2. modification for further micro-organisms, taking into account the dominant micro-organisms in diverse European regions.
3. translation of the method into an EN-format to make broad application possible

## References


- Adan, O.C.G., 1994, On the fungal defacement of interior finishes, doctoral thesis, Technical University of Eindhoven.
- AgBB, Committee for Health-related evaluation of building products, Health-related evaluation procedure for volatile organic compounds emissions (VOC and SVOC) from building products, September 2005. (Also an updated version from 2008 is available: www.umweltbundesamt.de)
- Aoki, T. and Tanabe, S., 2007, Impact of reaction products from building materials and furnishings on indoor air quality—A review of recent advances in indoor chemistry, Atmospheric Environment, Volume 41, Issue 15, May 2007, Pages 3139-3150.
- BAM, 2003, Emission of Flame Retardants from Consumer Products and Building Materials, Project No (UFOPLAN) 299 65 321.
- Barry, A., 2007, Effectiveness of barriers to minimize VOC emissions, including formaldehyde
- Bluyssen, P.M., H.J.M. Cornelissen, A.W. Hoogeveen, P. Wouda, J.F.van der Wal, 1996, The effect of temperature on the chemical and sensory emission of indoor materials, INDOOR AIR'96, 21-26 July 1996, Nagoya, Japan, vol. 3, pp.619-624.
- Bluyssen, P.M., 2007, Sensory (odour) testing of the emission of construction products in the indoor environment, June 2007, working document for TG2.
- Bluyssen, P.M., 2008, Health and comfort of people in the indoor environment - Past, present and future drivers, needs and approaches, in press.
- Carslaw, N., 2007, A new detailed model for indoor air chemistry, London conference.
- DIBT, 2005, Principles for health assessment of construction products used in interiors, Notification n°2005/255/D.
- CEN, 2007, CEN/TC 351/WG2 N36, Review of existing and under development standards on the basis of the inventory made for the preparation of the work programme under Mandate M/366, April 10, 2007.
- CEN, 2007b, Terms-definition draft proposal 4-5-2007, CEN TC 351.
- ECA, 1989, Report No. 2 “Formaldehyde Emission from Wood-based Materials – Guideline for the determination of steady state concentrations in test chamber” in April 1989.
- ECA, 1991, Effects of Indoor Pollution on Human Health, 1991, report no.10, European Concerted Action ‘Indoor Air Quality and its impact on man, Luxembourg.
- ECA, 1999, Berglund, B, P.M. Bluyssen, Clausen, G., Garriga-Trillo, A., Gunnarsen, L., Knöppel, H., Lindvall, T., Macleod, P. Mølhave, L., Winneke, G., Sensory evaluation of indoor air quality, Report no. 20, European Collaborative Action, Indoor Air quality & its impact on man, EUR18676EN, ISBN 92-828-5699-2, Italy.
- ECA, 1999b, European Collaborative Action Indoor Air quality & its impact on man, Environment and Quality of life, ECA report no. 21 European inter-laboratory comparison on VOC emitted from building materials and products, EUR 18698.
- EU, 2007, SCHER opinion on risk assessment on indoor air quality, 29 may, http://ec.europa.eu/health/ph_risk/risk_en.htm
- Hansen, V., Larsen, A. Wolkoff, P., 1999, Round robin –chemical emission testing by use of flex, Nordtest report TR438, approved 1999-10.

- Hodgson, A.T. and Alevantis, L., 2004 Testing of Building Products for Emissions of Volatile Organic Compounds: Practical Time Point for Assessing Potential Chronic Health Impacts, (Berkely Analytical Associates & CDHS)
- Hughes, P., et al., 2006, Recent advantages in material emission testing chamber technology, Proceedings of Healthy Buildings 2006, Lisboa, Portugal, vol.4, pp.13-17.
- Jaernstroem, H., 2007, VTT publications 672: Reference values for material emissions and indoor air quality in residential buildings.
- JRC, 2005, The Index report, Final report, 2005, EUR 21590 EN.
- Kephalopoulos, S., et.al., 2005, Harmonisation of indoor material emission labelling systems in the EU, Inventory of existing systems, Report 24, European Collaborative Action Urban air, Indoor environment and human exposure – Environment and Quality of life, EUR 21891 EN.
- De Lor, M., Vause, K., Goelen, E., Maes, F., Nicolas, J., Romain, A.C., Degrave, C., 2008, Horizontal evaluation method for the implementation of the Construction Product Directive (HEMICPD), Document G, Activity report intended for the intermediary evaluation, contract nr P2/00/05.
- Nicolas, M., Ramalho, O. and Maupetit, F, 2007, Reactions between ozone and building products: Impact on primary and secondary emissions, Atmospheric Environment, Volume 41, Issue 15, May, pp 3129-3138.
- NRC, National Research Council, 2005, Managing VOCs and indoor air quality in office buildings, an engineering approach.
- Saarela and Tirkonen, 2004, M1, Emission Classification of Building Materials: Protocol for Chemical and Sensory Testing of Building Materials, The Building Information Foundation RS, Finland, ISBN 951-682-755-1 version 15.
- Schripp, T., Uhde, E., Wensing, M., Salthammer, T., Comparison of a quick analytical metjod to test chamber experiments: emission of plastic samples, Healthy Buildings, 2006.
- Spengler, J.D., Samet, J.M., McCarthy, J.F., Indoor air quality handbook, McGrawhill, USA, ISBN 0-07-445549-4.
- Uhde, E., Borgschulte, A., Salthammer, T., 1998, Characterisation of the FLEC: flow field and air velocities, Atmospheric Environment, vol.32, nr.4, pp.773-781.
- Uhde, E. and Salthammer, T., 2007, Atmospheric Environment, Volume 41, Issue 15, May, pp 3111-3128.
- WHO, 2000, Guidelines for Air Quality, second edition, World regional publication European series no.91 Health Organisation, Geneva.
- WHO, 2006, Housing and health regulations in Europe, Final report.
- Wilke, O., Jann, O., Broedner, D., 2004, VOC- and SVOC emissions from adhesives, floor coverings and complete floor structures, Indoor Air, 14, suppl.8, pp.98-107.
- Windhövel, U., Oppl, R., 2005, Praktische überprüfung des Konzepts zur gesuntheitlichen bewertung von Bauprodukten, Ergebnisse eines ringversuchs, Gefahrstoffe – Reinhaltung der Luft, 65, 2005, nr.3, März.
- Wolkoff, P. and Nielsen, P.A., 1996, A new approach for indoor climate labelling of building materials – emission testing, modelling, and comfort evaluation, Atmospheric Environment, volume 30, pp.2679-2689.
- Wolkoff, P. and Nielsen G.D., 2001, Organic compounds in indoor air – their relevance for perceived air quality, Atmospheric Environment 35, pp.4407-4417.
- Wolkoff, P., Salthammer, T., Woolfenden, E.A., 2005, Emission cells and comparison to small chambers for materials emissions testing, Innenraumluft, 65, nr.3, pp.93-98.
- Zhu, Q., et al., 2007, 3D-CFD analysis of diffusion and emission of VOCs in a FLEC cavity, Indoor Air, 17, pp.178-188.

**Content**

# Annex A. Scopes of product TCs

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| 33 | Doors, windows, shutters and building hardware | Definition of functions of doors, windows, shutters, building hardware, and curtain walls and performance levels and classification associated with these functions which characterize the usage including the ability to meet the essential requirements (of the Construction Products Directive),tests requirements and, if necessary, the essential dimensions, terminology, symbols, packaging, marking and labelling. |
| 46 | Oil stoves | Fuel oil stoves with vaporizing burners. |
| 50 | Lighting columns and spigots | Harmonization of existing standards in the field of lighting poles, especially of connecting dimensions. |
| 51 | Cement and building limes | Standardization in the field of definitions and terminology, specifications and methods of test for cements and limes used in building and civil engineering. |
| 67 | Ceramic tiles | To establish European Standards concerning terminology, technical characteristics, dimensional characteristics and tolerances, test and control methods, design and installation of ceramic tiles. |
| 69 | Industrial valves | The standardization of valves for all industrial applications and for all types of fluids, including: - steam traps; - valve actuator interface; - safety devices against excessive pressure (safety valves and bursting disks); - control valves (excluding the actuator element and their interface); but excluding: - sanitary valves (as defined by CEN/TC 164/WG 8). |
| 72 | Automatic fire detection systems | To prepare standards, harmonised where necessary to meet the essential requirement 'Safety in case of fire' of the Construction Products Directive, in the field of fire detection and fire alarm systems in and around buildings, covering test methods, requirements and recommendations for: - components; - the combination of components into systems; - the planning, design and installation of systems for use in and around buildings; - usage, maintenance and servicing; - the connections to and control of other fire protection systems; - the combination with other systems to form integrated systems; - the combination with fixed fire fighting systems; - the contribution of fire detection and fire alarm systems to fire safety engineering. |
| 88 | Thermal insulating materials and products | Standardisation in the field of thermal insulating materials and products for application in buildings, including insulation for installed equipment and for industrial insulation, covering: terminology and definitions, list of required properties with regard to different applications, methods for the determination of these properties, sampling procedures, conformity criteria, specifications for insulating materials and products, marking and labelling of insulating materials and products. |
| 92 | Water meters | Standardization for meters to measure volume flow of cold potable water and heated water enclosed in full conduits, irrespective of technology applied. |
| 99 | Wall coverings | To elaborate ENs for wall coverings in the sense that the term "wall coverings" is used to cover all forms of flexible webs supplied in roll form for hanging onto walls or ceilings by means of an adhesive; it includes "finished wall coverings", "wall coverings for subsequent |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | decoration", "heavy duty wall coverings" and "textile wall coverings" and cork wall coverings in roll and panel form. |
| 104 | Concrete | CEN/TC 104 deals with the standardisation of provisions for concrete and related products, in particular with respect to properties and requirements for: - fresh and hardened concrete; - production and delivery of fresh concrete; - constituent materials of concrete, e.g. mixing water, additions and admixtures; - sheaths for pre-stressing tendons; grout for pre-stressing tendons; - fibres for use in concrete; - execution of concrete structures; - production and execution of sprayed concrete; - products for the protection and repair of concrete structures. Additionally relevant test methods and provisions for the assessment of conformity for the products and procedures mentioned above are standardized. Not covered by the scope of TC 104 are: - the constituent materials; aggregate (see CEN/TC 154), Pigments (see CEN/TC 298) and Cement (see CEN/TC 51); - the design of concrete structures and components (see CEN/TC 250/SC 2); - precast concrete products (see CEN/TC 229); - prefabricated autoclave aerated and no-fines light weight concrete components (see CEN/TC 177). |
| 112 | Wood-based panels | Preparation of standards for wood-based panels and panels of other lignocellulosic materials covering: - terminology; - classification; - requirements; - product specifications; - methods of tests. |
| 121 | Welding | Standardization of welding by all processes, as well as allied processes; these standards include terminology, definitions and the symbolic representation of welds on drawings, apparatus and equipment for welding, raw materials (gas, parent and filler metals) welding processes and rules, methods of test and control, design of welded joints, qualification and/or education of welding personnel, as well as safety and health. Excluded: Electrical safety matters related to welding which are the responsibility of CENELEC/TC 26. |
| 124 | Timber structures | Preparation of standards for the structural use of timber, covering : - test methods for the determination of strength and stiffness for solid timber, glued laminated timber, mechanical joints, wood based panel products, timber structures and their components; - solid timber: preferred sizes, strength grading and strength classes system (included glued laminated timber), evaluation of mechanical properties; - glued laminated timber: essential requirements, production requirements and control, structural full size finger joints; - mechanical fasteners. |
| 125 | Masonry | Standardization in the field of masonry units of clay, calcium silicate, dense aggregate concrete, lightweight aggregate concrete, autoclaved aerated concrete, natural stone, manufactured stone, mortar for masonry, ancillary components for masonry and associated test methods. |
| 128 | Roof covering products for discontinuous laying and products for wall cladding | Standardization in the area of general and specific requirements and test methods for roof covering products for discontinuous laying and products for wall cladding. |
| 129 | Glass in buildings | Standardization in the field of glass used in building including: - definitions of all types of glass products, basic and processed; - |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | definition of characteristics; - test methods for measurement of characteristics; - calculation methods for characteristics; - requirements e.g. durability; - classifications e.g. anti-bandit glazing; - glazing methods. |
| 130 | Space heating appliances without integral heat sources | To prepare standards for determining the thermal output of space heating appliances (e.g. radiators, heating panels convectors with or without a fan) without integral heat source in order to provide a common basis for their evaluation; - to define standardized criteria for selecting the samples to be tested in order to determine the output of a family of appliances; - to define dimensional characteristics and admissible tolerances in order to compare the normal production with the tested sample. |
| 132 | Aluminium and aluminium alloys | Standardization in the field of unwrought, wrought and cast products made from aluminium and aluminium alloys, particularly: - designations; - terms and definitions; - material specifications; - technical conditions of delivery; - dimensions and tolerances; - methods of testing specific to aluminium. |
| 133 | Copper and copper alloys | Standardization in the field of unwrought, wrought and cast products made from copper and copper alloys, including: - designations, terminology; - material specifications; - conditions of delivery; - dimensions and tolerances; - methods of testing peculiar to copper alloys. |
| 134 | Resilient, textile and laminate floor coverings | Standardization of definitions, requirements, classification and test methods and provision of guidance documents and reports for resilient and textile floor coverings and for laminated floor coverings. |
| 135 | Execution of steel structures and aluminium structures | Standardization of rules for execution of steel and aluminium structures for building and civil engineering works including rules for inspection and control. |
| 154 | Aggregates | Standardization of rules for execution of steel and aluminium structures for building and civil engineering works including rules for inspection and control. |
| 155 | Plastic piping systems and ducting systems | Standardization of requirements and test methods for geometrical, chemical, physical and other characteristics of components, joints and systems; - where "Function TCs" exist, standardization of the plastics related requirements and test methods for fitness for purpose of complete systems related to the application shall be done in liaison with these "Function TCs"; in such cases are excluded from the work of CEN/TC 155 those general requirements for fitness for purpose that are independent of the plastics materials; - where "Function TCs" exist, standardization of the plastics related aspects of Codes of Practice and commissioning rules for specified applications shall be done in liaison with these "Function TCs". The European standards shall be prepared with in view to their use in certification... (see resolution BT 155/1989). |
| 163 | Sanitary appliances | To establish standards for the performance requirements and the corresponding test methods for all sanitary appliances to ensure that the appliance, irrespective of the material of which they are made, will give satisfactory performances. To establish physical and hygiene characteristics, to establish standards on connecting dimensions and to establish tests on the material used in manufacturing sanitary appliances. |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | This Committee is responsible for traps where they are an integral part of the appliances. |
| 164 | Water supply | To establish standards for the performance requirements and the corresponding test methods for all sanitary appliances to ensure that the appliance, irrespective of the material of which they are made, will give satisfactory performances. To establish physical and hygiene characteristics, to establish standards on connecting dimensions and to establish tests on the material used in manufacturing sanitary appliances. This Committee is responsible for traps where they are an integral part of the appliances. |
| 165 | Waste water engineering | Functional standards, standards for performance and installation in the field of waste water engineering for systems and components. Where there is no existing material related TC, product standards for all components of discharge pipes, drain and sewer pipes, pipelines, separators etc. according to the resolutions of BT (for the organization of word in the field of metallic tubes see resolution BT 160/1989). Standards for design, calculation, construction, commissioning, operation and maintenance in the field of waste water engineering from the point of view of origin (with the exception of the product standards for sanitary appliances*) up to the point of disposal, including treatment plants. *) Cisterns, urinals, kitchen sinks, basins bidets, baths, (including whirlpool baths) and shower trays, see TC 163 Resolution 2 (London), WG 3 and 4. |
| 166 | Chimneys, flues and specific products | Standardization in the field of chimneys and vents used for conveying the products of combustion from appliances to outside atmosphere and the connecting pieces and ancillaries needed for their construction and operation. Structurally independent chimneys are excluded. |
| 167 | Structural bearings | Standardization of structural bearing device used for bridges, stadiums, industrial buildings etc. describing the various types and giving the recommendations for design, specifications for materials, manufacture and installation, criteria for acceptance and testing. Excluded, for example, are: connections between piers and columns obtained by reinforced concrete, welded or bolted connections. |
| 175 | Round and sawn timber | Standardization of round and sawn timber in all uses, including timber prefabricated products and excluding structural aspects. |
| 177 | Prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure | Standards for prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure (expanded clay, pumice, etc.). |
| 178 | Paving units and curbs | Standardization of the performance requirements and their associated methods of test of paving units, kerbs and accessories manufactured from clay, concrete, natural stone or other materials used for the surfacing of footways, roads and other paved areas (dock, industrial, parking) |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | considering their application. |
| 185 | Threaded and non-threaded mechanical fasteners and accessories | Standardization in the field of mechanical fasteners, taking cognizance of the ISO standards prepared by ISO/TC 2. Note: The term "Mechanical fastener" covers all types of products designed to connect mechanically two or more structural parts to form a solid or movable joint or to contribute essentially to establish this function, such as screws, nuts, washers, pins and rivets. |
| 189 | Geotextiles and geotextile-related products | Standardization related to geosynthetics; terminology, sampling before testing, identification and marking rules, test methods, requirements related to the intended used. |
| 191 | Fixed fire fighting systems | Standardization in the field of: - components for fixed fire fighting systems;- the design, construction and maintenance of fixed fire fighting systems primarily for installation in buildings and other construction works with recommendations for other possible applications and; - components for fixed smoke and heat ventilation systems; - the design, construction and maintenance of fixed smoke and heat ventilation systems for installation in buildings; - fire extinguishing media for use in fixed systems and other fire fighting equipment. |
| 192 | Fire service equipment | Standardization of equipment and vehicles for rescue and fire fighting, excluding personal protective equipment and that covered by CEN/TC 191. |
| 193 | Adhesives | Standardization in the field of all adhesives to produce: - standards for vocabulary and classification; - general standards for characterization (physico-chemical and mechanical test methods); - standards for methods of test for adhesives and performance standards for specific applications including standards with requirements useful for certification purposes. With the exception, for the time being of those dealt with by CEN/TC 67. |
| 203 | Cast iron pipes, fittings and their joints | Standardization of cast iron pipes, fittings, accessories, and their joints for water supply, drainage and sewerage, gas supply and other application. Valves, pumps and malleable iron parts are excluded. |
| 208 | Elastomeric seals for joints in pipework and pipelines | Standardization of material requirements and test methods for elastomeric seals for joints in pipes for the conveyance of fluids, for example, cold and hot water, waste paper, gas, hydrocarbons and other fluids. |
| 217 | Surfaces for sports areas | This European Standard specifies a method for the determination of the slip resistance of a sports surface in relation to a studded or smooth soled sports shoe. |
| 221 | Shop fabricated metallic tanks and equipment for storage and for service stations | Standardization of shop fabricated metallic tanks for the storage of liquids as well as equipment (including the dispensers) for all kind of storage tanks and for service stations. The standardization may include performance requirements and product descriptions together with necessary test methods and requirements concerning the evaluation of conformity. |
| 226 | Road equipment | To prepare specifications for safety, traffic control and other road equipment in the following fields :a) Safety fences and barriers, including guard rails, safety fences, crash barriers, crash absorbers and bridge parapets; b) Horizontal signs including road studs and road |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | markings; c) Vertical signs including signs, cones and marker posts; d) Traffic lights including signals, traffic control and danger lamps; e) Street lighting, performance requirements only; f) Other equipment including bollards, anti-glare screens and noise protection devices. |
| 227 | Road materials | To prepare specifications, test methods, compliance criteria for materials for construction and maintenance of roads, airfields and other trafficked areas. |
| 229 | Precast concrete products | Standardization of precast concrete products (plain, pre-stressed, or reinforced or composite steel/concrete) covering terminology, performance criteria, preferred shapes and dimensions, tolerances, relevant physical properties special test methods, special features due to transport, erection and connections, not duplicating the work of other TCs, referring however, to concrete material properties covered by TC 104, properties for reinforcing steel covered by ECISS/TC 19, all general design and structural aspects covered by the Eurocodes, particularly Eurocode 2, and excluding products covered by other technical committees (including TC 125, 128, 164, 165, 177and 178). |
| 235 | Gas pressure regulators and associated safety shut-off devices for use in gas transmission and distribution | Standardization of the requirements for the construction, performance, testing and marking of gas pressure regulators and associated safety shut-off/relief devices for use in gas transmission and distribution for pressures up to 100 bar. Proposed Action(s): with resolution CEN/TC 235 N. 4/1999 the CEN/TC has approved its new title and scope as follows (both have already been considered from this point in this revision of the draft Business Plan, BP): title: Gas pressure regulators and associated safety devices for use in gas transmission and distribution; scope: Standardisation of the requirements for the construction, performance ,testing and marking of gas pressure regulators and associated safety devices for use in gas transmission and distribution for pressures up to 100 bar. |
| 236 | Non-industrial manually operated shut-off valves for gas and particular combinations valves-other products | Standardization of the requirements for fitness for purpose (for design, performance, testing, marking, packing, instructions for installation and use) of manually operated shut-off valves for domestic and commercial not directly buried installations inside or outside of buildings, and other particular types of valves strictly combined to particular products or component considered as a whole (e.g. safety flexible metallic hose assemblies and connection valves for domestic gas appliances) |
| 241 | Gypsum and gypsum based products | To prepare European standards for gypsum plasters, gypsum units, gypsum based and ancillary products as well as for design and application of the products: Definitions; – performance requirements; - specifications; - test methods. |
| 246 | Natural stones | Definitions, requirements and test methods for natural stones relating to rough blocks, slabs, semi-finished and finished products intended for use in building and for monuments with the exception of items in the field of work covered by other Technical Committees.<br>The WG 4 (JWG 229/246) covers the agglomerated stones for floor coverings, wall coverings and ancillary uses, for interior and exterior use, with resin or cement binders or a combination of the two and does not |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | cover pressed tiles such as terrazzo tiles which are the territory of CEN/TC 229, or natural stone which is the territory of CEN/TC 246. Note: Reference should be made as far as possible to existing test methods. Submission of WG 4 documents for the formal vote must be decided by resolutions of the two CEN/TCs. |
| 249 | Plastics | Standardization of terminology, test methods and specifications in the field of plastics and plastics-based materials, semi-finished products and products (thermoplastics, thermosets, cellular plastics, degradable plastics, thermoplastics elastomers, composites and reinforcement products for plastics) as well as plastics recycling. Rubber is excluded. Specific end-product related items are also excluded if they are covered by the scope of an existing product TC |
| 254 | Flexible sheets for waterproofing | Preparation of European Standards on factory made flexible sheets for waterproofing for use in building construction and civil engineering. |
| 266 | Thermoplastic static tanks | Standardization on thermoplastic static tanks for the storage of liquids other than drinking water. |
| 277 | Suspended ceilings | To establish ENs on suspended ceilings for building and civil engineering works covering items such as terminology, fire, acoustics, thermal performances and also specifications for installations and application. To coordinate the outgoing work in relation to suspended ceilings in other functional and material related TCs. |
| 295 | Residential solid fuel burning appliances | Standardization in the field of residential heating and cooking appliances burning solid fuels: to include solid mineral fuel burning appliances, wood- burning appliances and multifuel appliances. The standardization to cover appliance construction, performance, (e.g. efficiency and emissions), safety and commissioning requirements, together with their associated test methods and installation and operating instructions. The standardization of test fuels and test methods for the assessment of the suitability of fuels for the various appliance types. |
| 297 | Free-standing industrial chimneys | Standardization in the field of free-standing chimneys for industrial and utility applications including terminology, performance requirements, safety aspects, design as far as not covered by the Eurocodes, construction and maintenance of the shell, lining and accessories. A chimney may also be considered as free-standing, if it is guyed or supported or if it stands on another structure. All flue gas ducts to the chimney are outside the scope. Note: "Utility applications" can include schools, hospitals, assembly rooms, theatres, swimming pools, prisons etc. |
| 298 | Pigments and extenders | Standardization in the field of pigments, dyestuffs and extenders. Implementation of existing standards and drawing up of additional standards relating to terminology, general test methods, test methods related to the intended application and specifications for pigments, dyestuffs and extenders. Work related to the application of the above groups of products in textiles is excluded. |
| 323 | Raised access floors | Preparation of European Standards in the field of raised access floors. These include: Terminology, product requirements as well as methods and measurement. |
| 336 | Bituminous binders | Standardization of test methods, methods of sampling, terminology, |

| CEN/TC | TITLE | SCOPE |
|---|---|---|
| | | classification and specifications for bituminous binders. Main field of competence: standardization of petroleum refined bitumens, modified bitumens, bitumen emulsions, petroleum fluxed bitumens and petroleum cut-back bitumens, used for paving and other industrial applications. |
| 340 | Anti-seismic devices | Standardization of the design, manufacture, testing, installation and maintenance of anti-seismic devices for use in structures erected in seismic areas and designed in accordance with Eurocode 8. |
| BT/TF/119 | Stretched ceilings | Specifications and test methods for stretched ceilings made up of single or multi-layer sheets, coated fabrics or fabrics made up of coated or monofilament yarn with a fastening system. Method of conformity assessment for stretched ceilings. |
| ECISS/TC 10 | Structural steels - Qualities | Standardization of steel qualities for hot-rolled steel for structural applications, and associated subjects such as surface conditions and through thickness properties. |
| ECISS/TC 13 | Flat products for cold working - Qualities, dimensions, tolerances and specific tests | Standardization of steel flat cold formed products for cold working in coils, sheets, narrow strips and steels for enamelling. |
| ECISS/TC 19 | Concrete reinforcing steel -Qualities, dimensions and tolerances | Standardization of qualities, dimensions and tolerances and other properties appropriate to: 1) steel products (bars, coils, welded fabric, lattice girders) for the reinforcement of concrete; 2) pre-stressing steels. Standardization of any test methods specific to the steel products not already covered by other ECISS Committees. |
| ECISS/TC 23 | Steels for heat treatment, alloy steels and free-cutting steels-qualities | Standardization of technical delivery requirements for heat treatable and alloy steel including free-cutting, stainless, heat-resisting, valve and tool steels used mainly in the machine and automotive industry in either the non-heat treated or the heat treated condition. |
| ECISS/TC 29 | Steel tubes and fittings for steel tubes | Standardization of: - steel tubes for all applications; - threaded fittings (steel and iron); - steel fittings for butt welding; - threading (including gauging). Included are definitions and symbols, qualities, dimensions and tolerances, mechanical and non-destructive testing relating specifically to tubular products, and coatings (metallic and organic). Excluded are flanges, hollow sections and the design, calculation and testing of metallic piping systems. |
| ECISS/TC 31 | Steel castings | Standardization of technical delivery conditions and of quality prescriptions for steel castings. Definition of welding qualification mode for these products. Standardization of test methods and tolerances specific to these products. |

# Annex B. CEN/TC 351 abbreviations

(In due time to be replaced by reference to the CEN/TC 351 document on Terminology)

**Abbreviations**

| Abbreviation | Full name | Source |
|---|---|---|
| **AB** | Approval Bodies (Bodies authorised by the Members States according to Article 10 of the CPD to issue European Technical Approvals) | GP-K |
| **AoC** | Attestation of conformity according to Chapter V in conjunction with Annex III of the CPD | GP-K |
| ***CEN*** | Comité Européen de Normalisation (European Standardisation Organisation) | GP-L |
| ***CEN/MC*** | CEN Management Centre | GP-L |
| **CEN/TC** | Technical Committee of CEN | GP-K |
| **CENELEC** | European Committee for Electrotechnical Standardization (Comité Européen de Normalisation de l'Electricité) | GP-K |
| ***CPD*** | Construction Products Directive (see references) | GP-L |
| **CUAP** | Common Understanding of Assessment Procedure for European Technical Approval without guideline (art. 9.2 of the CPD) | GP-K |
| ***DAV*** | Date of availability of the EN standard | GP-L |
| ***DoW*** | Date of withdrawal of a conflicting national standards | GP-L |
| ***EAS*** | European Acceptance Scheme for construction products in contact with drinking water | ACL-Conc |
| ***EC*** | European Commission services | GP-L |
| **EC:** | European Commission Services | GP-K |
| ***EEA*** | European Economic Area | GP-L |
| ***EG-CPDW*** | Expert group formed by the Commission to advise on construction products in contact with drinking water | ACL-Conc |
| ***EN*** | European standard | GP-L |
| ***ENV*** | European pre-standard | GP-L |
| ***EN Eurocode*** | Version of Eurocode approved by CEN as a European standard | GP-L |
| ***ENV*** | European pre-standard | GP-L |
| ***ENV Eurocode*** | Version of Eurocode published by CEN as a pre-standard ENV (for subsequent conversion into EN) | GP-L |
| ***EOTA*** | European Organisation for Technical Approval (article 9.2 of the CPD) | GP-L |
| ***ETA*** | European Technical Approval (CPD Chapter III type of "technical specification") | GP-K |
| ***ETAG*** | European Technical Approval Guideline | GP-L |
| **FPC** | Factory Production Control | GP-K |
| **GNB** | Group of Notified Bodies | GP-K |
| **hEN** | harmonised European Standard (CPD Chapter II type of "technical specification") | GP-K |
| ***hEN*** | Harmonised European standard for a construction product (to enable CE Marking) | GP-L |
| ***ID*** | Interpretative Documents (article 11 of the CPD) | GP-L |
| **ITC** | Initial Type Calculation | GP-K |
| **ITT** | Initial Type Testing | GP-K |
| ***NAD*** | National Application Document for the use of ENV Eurocodes at the National level | GP-L |
| **NB** | Notified Body (also called "Conformity Assessment Body" under other New Approach Directives), which have been designated by Members States for tasks to be carried out for the purpose of conformity assessment). According to the CPD, Notified Bodies include *certification bodies*, *inspection bodies* and *testing laboratories*, | GP-K |
| ***NDP*** | Nationally Determined Parameter | GP-L |
| **NPD** | No Performance Determined | GP-K |
| ***NSB*** | National Standards Body (CEN Member) | GP-L |

| Abbreviation | Full name | Source |
|---|---|---|
| ***PPD*** | Public Procurement Directives (see references) | GP-L |
| ***SCC*** | Standing Committee on Construction (articles 19 and 20 of the CPD) | GP-L |
| | | |

**Sources (sources for terms, definitions and abbreviations)**
CPD-Guidance Paper L, 2003, Application and use of Eurocodes

| | |
|---|---|
| **CPD** | CPD; Construction Products Directive (89/106EC) |
| **ER3** | ER3; Essential Requirements 3; hygiene, health and environment |
| **GP-A** | CPD-Guidance Paper A |
| **GP-B** | CPD-Guidance Paper B |
| **GP-C** | CPD-Guidance Paper C, 2002, The treatment of kits and systems under the Construction Products Directive |
| **GP-D** | CPD-Guidance Paper D, 2002, CE Marking under the CPD |
| **GP-E** | CPD-Guidance Paper E, 2002, Levels and classes under the CPD |
| **GP-F** | CPD-Guidance Paper F, 2002, Durability aspects under the CPD |
| **GP-G** | CPD-Guidance Paper G |
| **GP-H** | CPD-Guidance Paper H |
| **GP-I** | CPD-Guidance Paper I |
| **GP-J** | CPD-Guidance Paper J, 2002, Transitional Arrangements under the CPD |
| **GP-K** | CPD-Guidance Paper K, 2004, The attestation of conformity systems and the role and tasks of the notified bodies in the field of the Construction Product Directive |
| **GP-L** | CPD-Guidance Paper L, 2003, Application and use of Eurocodes |
| | CPD-Guidance Paper M |
| | CPD-Guidance Paper N |
| **DS-036** | Without testing/without further testing (WT/WFT) (draft) Procedural aspects; DS 036 rev.8; 18-8-2006 |
| **ACL-Conc** | CEN/TC104/WG14 N 93; Sub-Group 3: Non-metallic inorganic products and materials. Draft post SG3 meeting 5 September 2006; Approved constituents list (acl) for concrete and mortar |

# Annex C. Instruction to CEN technical committees for the development of horizontal test protocols

## C.1 Introduction

This annex builds on the introductory remarks on testing steps, horizontal modules and test protocols in Part 2. Below, the steps 1-7 of the measurement chain (see Figure below) are worked out in detail. Together these paragraphs form an instruction on how to set up a "horizontal" test protocol.

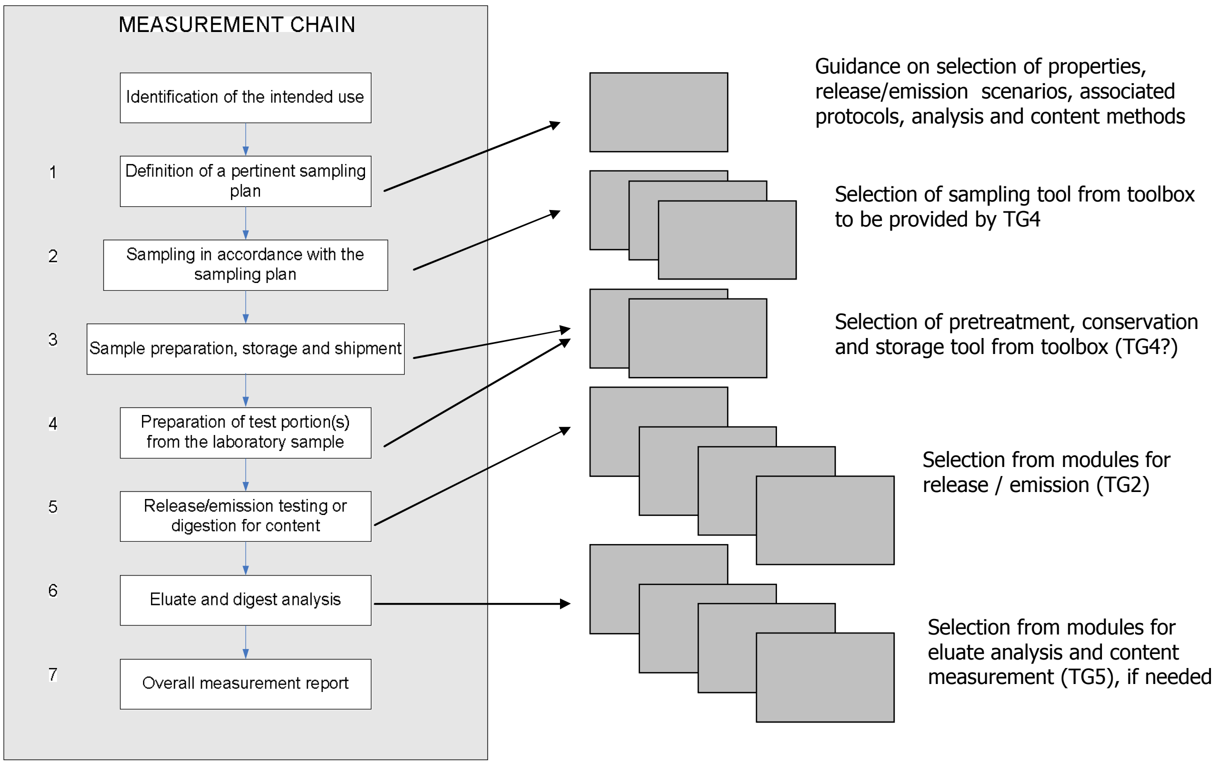



*Figure. The measurement chain or test program for assessment of almost any property illustrating the modular horizontal approach in providing selection of relevant tools (modules) at different steps in the measurement chain. To the right is referred to different Technical Reports (TR) covering the specific issues in detail.*

## C.2 Steps in the measurement chain

### *C.2.1 The sampling plan*

The first steps relate to "sampling" and we stress here that this subject is dealt with in TR4. Below, a number of considerations that came up during the work for TR2 regarding sampling issues are outlined.

In designing a sampling protocol, an important consideration is the maximum uncertainty that may be associated with the end result to allow a proper decision. Aspects that play a role in the choices to be made for sampling modules are:

- nature of the construction product (granular, coarse granular or monolithic, covered or not covered, mineral or organic)
- specimen size (monoliths) or particle size (granular products)
- the scale of sampling (truck, a pile, …)
- the properties of the construction product to be determined (physical, chemical, environmental…)
- for a given property the measurement range, the detection limit and the precision
- the heterogeneity or homogeneity of the construction product with respect to the property(ies) to be assessed
- possible sampling locations (static or dynamic)
- sensitive properties in relation to sample handling, which may lead to deterioration of a sample for a particular property, if not addressed properly (volatiles – loss of substances, alkaline materials -carbonation, reducing products – oxidation, … )

The goal of the sampling protocol is to ensure that a sufficient quantity of material is collected to enable all required measurements to be carried out and that sufficiently representative material is obtained to allow a conclusion on the construction product meeting predetermined specifications in a conformity assessment. Beforehand, it is not possible to declare the precision of the answer, as all steps of the measurement chain contribute to the overall uncertainty. Preferably the uncertainties in all steps of the entire measurement chain are known. From experience some guidance can be provided, and in several cases observed limitations (e.g. heterogeneity) can be overcome by taking proper measures. In reality, deviations occur and both higher and lower precision than anticipated or aimed for can be obtained.

De facto, the basics for adequate sampling is always the same. However, it often *seems* different by taking implicit decisions and by editing sampling chapters in different ways.

For sampling, the horizontal approach follows a systematic approach. All basic parameters and points of attention in sampling are considered explicitly and included in the testing protocol.

A ‘module: Sampling Plan’ gives a checklist with all relevant points of attention. These points include:

- administrative information on type of testing, e.g. kind material/product, position of the material, location, etc,
- goals of testing, expressed in statistical terms, stated by the authority or by the principal.
  These goals and the choices are explicitly mentioned in the testing protocol, such as the statistical term (e.g. mean level, maximum level, etc,) the population, the scale of testing, the representativity, the reliability of the testing, the (expected) homogeneity of the product, etc.
- sampling technique.

Instructions on the statistical approach and calculation of number of increments per laboratory sample, etc, can be found in a module on the statistical approach of sampling.

Instructions on the sampling technique can be found in another module, providing a list of sampling techniques and instructions on each of these techniques, from which the most relevant method for the specific situation can be selected. This paragraph on sampling refers to some of these.
So the chapter on the sampling plan provides information on the expected heterogeneity of the material/product to be investigated and gives information on the contribution of the sampling to the total 'standard deviation' of the complete test that can be expected[1]. However the sampling plan also shows what measures could and should be taken to narrow down this contribution to the standard deviation, by means of putting less or more effort in the sampling.

*C.2.2 Taking (a) product sample(s)*
The sampling plan refers to the module with options and further instructions on sampling techniques. The most adequate technique should be chosen. The technique may depend on the appearance of a product, e.g. as aggregate, block or monolith and the position, such as static or on a belt or in another kind of stream.
The modules on the sampling also provide information on handling of specific points of attention, such as volatile substances, and options of polluting the sample during sampling. If relevant specific instructions on these points should be referred at.
If the product performance may change over time, special instruction should be included. E.g. due to volatility or redox reactions of substances.

*C.2.3 Condition of the sample and transport to the laboratory*
This chapter refers to modules that provide further instructions on conditioning of samples.
It should prevent that samples are polluted, damaged or changed. It should take into account risks of evaporation, chemical reactions in the product, etc, that may influence the final test result.
The sampling plan should reflect which material/product status is considered representative for such 'still changing' product and how to care that the laboratory will investigate the relevant, reproducible form of the product.
The sampling plan may limit the time between sampling and analysis in the lab. It also should give instructions on the conservation of the sample(s).

*C.2.4 Preparation of the test sample*
This part of the testing protocol specifies the amount and performance of the laboratory sample, which is needed for the main test or directly for the analyses. It takes into account if the tests should be executed singular, in duplo or more times. It also takes into account specific behaviour of relevant substances, such as volatile substances.
Finally it specifies if the sample should be treated, e.g. by taking sub samples according to specific techniques or by grinding the material in the sample.
For these instructions, the protocol might refer to specific modules and to the modules on the 'main test' and the 'analyses', that specify the amount and performance of the

[1] It is often said that sampling contributes dominantly to the testing standard deviation. However it should be considered that it is the heterogeneity of the materials itself that contribute the most. By adequate and sufficient attention to sampling this contribution can decreased dramatically. In sampling for testing low amounts of dangerous substances in, or released from, products, heterogeneity may be relatively high, and so adequate sampling needs sufficient attention.

sample needed. To counter the problem of sample heterogeneity,more than one test portion may be subjected to testing to obtain a better averaged result for the material.

*C.2.5 Execution of the main test, e.g. extraction for release, emission or content*
This step may include diversity of operations. For environmental tests on dangerous substances if mostly focuses on extraction of substances from a solid material, release from a solid material, filtration of liquids containing suspended matter, determination of content, etc.

The protocol refers to the relevant module on leaching, emission, extraction, etc.

*C.2.6 Analysis of the extract*
Once a substance is dissolved in a fluid, for a specific substance or group of substances the analysis step usually is the same.
So one can refer to the same module on analysis for such (group of) substance(s). There may be different modules available, e.g. if not all tests need the same low level of detection, or the same high precision.
For a number of cases extraction and analysis are integrated in one routine. In such cases there might be a need to include both steps in one module.

*C.2.7 Preparation of the test report*
This part of the test program specifies the presentation of the test results. It may include formulae for calculating measuring results and transferring these to data and unities that are required.

## C.3 Test protocol for specific products or materials

The testing program should be laid down in a product testing protocol. Such protocol can be delivered as EN standard, as national standard, but also as protocol edited and stated by an individual producer, a notified body or another organisation. The basic structure is given in Table 1 below.

The horizontal approach includes a uniform way of editing product testing standards. The field of work should be defined in the scope (chapter 1 of the protocol). This may be a general definition, making the procedure usable for all products with the same characteristic (e.g. leaching of inorganic substances from metal plating.). However the procedure may also be limited to one specific product. Or it may be limited to only FPC-testing of a specific product.
By using the ‘horizontal approach structure’ for test protocols, it is easy to understand and compare test procedures. And it will be easy to use or copy such procedures for other products.
It also will be easy to specify a protocol for a certain type of product into a protocol for FPC of an individual producer, taking into account the specified way of production and available data and knowledge of the specific production.

For terms and definitions (chapter 3) a general standard may be developed, which can be referred at.

**Content of a horizontal product testing protocol**

--------------------------------------------------------------------------------

Foreword

1. Scope
2. Normative references
3. Terms and definitions

4.1. Principle

4.2. Specification of main statistical starting points and goals of the testing protocol

5. Testing programme

*(Each subchapter is based on references to modules.)*

5.1. Definition of the sampling plan

5.2.Taking (a) product sample(s)

5.3.Condition the sample and transport to the laboratory and

5.4.Preparation of a test sample

5.5.Execution of the main test, e.g. release or emission extraction

5.6.Analysis of the extract

5.7.Production of the test report, including calculations

In chapter 4, a special sub chapter is included on the statistical and practical basics for the testing. These include e.g., the representativity, the population, the scale of testing, the expected inhomogeneity, the statistical way of expressing results such as mean value, etc.
In chapter 5 is referred at the relevant test modules, or specified parts of the modular test standards. As far as strict necessary additional instructions are given.

Information on the total precision of the test is given in an informative annex. References are given to the relevant modular standards and relevant reports. This information on validation is not normative. This information does not lead to any direct standardised obliged action, direct connected to the data of the validation.
The information is relevant for the standard writers and for the users when defining the sampling plan and the statistical instructions on sampling and testing. It is up to them to interpret the data from the validation and other data on precision if available.

For product test protocols (PTP), general requirements include:

- The title and scope of a PTP may be specified for a specific product but may also be formulated in general terms (e.g. type of procedure, type of materials, type of substances covered) covering a group of products; in this way the module can cover all products that fulfil these criteria.
- The formulation of a PTP may not exclude TC's, producers and others to develop a specific protocol on the same subject, but that e.g. takes into account available

information on the specific product, or that focuses on another type of testing, as FT in stead of ITT.
- The protocol should for all steps primarily refer to modules. It should specify which modules should be used. As far as necessary special instructions can be added to make an adequate link in the testing procedure from one module to the next.
- Each PTP should use the same terminology with reference to a general terminology standard.
- In the module strict separation to be made between (1) normative instructions and exemptions, etc , and (2) informative notes and informative annexes with explanations on the normative instructions.
- The PTP should summarize the results of validation in an informative annex. In general this will be the results of validation of the relevant modules. If possible conclusions may extracted on the expected precision for the whole procedure. If available results from validation or testing on the complete procedure may be added.
  That annex also should give references to reports of the validation work. (Validation data are no normative information; it doesn't result in normative instructions and it isn't used in normative procedures.)
- In the PTP, information should be provided on the quantitative detection limits for the whole procedure. It might be necessary to address different modules (e.g. for analysis) if different levels of release or content should be reported in different situations.

These specifications should be elaborated more into detail in parallel with elaborating examples for modules and Product Test Protocols.

## C.4 Specific test modules for specific products or materials.

Test methods and test modules should be developed horizontally, in a way that they can cover all products. If this might not be possible, adjusted or even 'vertical' test modules should be developed to cover all required testing. But how to define adjusted and vertical modules? And when to use? As stated before, for each step in testing, more than one module may be developed.

E.g. 1: for testing organics other extraction procedures may be needed than for extraction of inorganic substances.
E.g. 2: for testing PAH in mineral materials, such as sand, cement concrete or ceramic materials, the basic extraction procedure can be used. But in bituminous materials, such as asphalt concrete or bitumen roofing materials, the relative high concentration of bitumen requires a specific extraction procedure. So, in NL, a special extraction method was developed for testing organics in products containing bitumen. This specific test method is developed as horizontal module, usable for all mineral products and materials containing bitumen.

These different extraction procedures each cover types of materials and substances and so types of products. All can be called horizontal test methods.
If specific problems occur for a specific product, it should be investigated first if this can be solved in a general way by adjusting an available module or by developing a

specific horizontal module, solving the same problems for other products and materials.
Only if this would not be possible at all, a specific test module for one product could be developed.

## C.5 Structuring and editing of horizontal test modules

Test modules should be able to fit in Product test protocols easily. It should be possible to replace one module easily by another, without the need of changing other parts of the structure.
It should be taken into account that many different TCs may contribute to the development of test modules. And even more need to work with the modules.

This needs strict agreements on structuring and editing test modules, apart from the basic CEN requirements on editing standards. If there might turn out conflicting requirements, these should be solved soon, giving room for adequate further development of this horizontal structure.

For test modules, general requirements include:

- The title and scope of a module should be formulated in general terms (e.g. type of procedure, type of materials, type of substances covered); in this way the module can cover all products that fulfil these criteria. Title and scope of horizontal test modules will not be linked to individual products and/or individual environmental sectors anymore. Title and scope should first be specified in objective technical/physical terms, which may cover several or many different products, materials and different environmental and health sectors.It should be specified how to edit and use such titles and scopes. CEN-bureau and CEN/TCs should accept such approach. This approach started now within CEN-Construction, coordinated by CEN/TC351. In project Horizontal covering soil, sludge and biowaste this discussion was initiated already. But it is important to agree on the further development with the Environmental TCs and with other CEN/TCs.
- The text should only focus on the relevant step itself. (It is the product test protocol that appoints the relevant module for each step and that coordinates if necessary)
- A module may set the requirements for the deliveries from a former step. E.g. the amount of sample needed, the required grain size, the amount of total organic substances, etc.
- Each module should use the same terminology with reference to a general terminology standard.
- In the module strict separation to be made between (1) normative instructions and exemptions, etc , and (2) informative notes and informative annexes with explanations on the normative instructions.
- Each module need validation, unless validation is technically not possible or is not useful. (e.g. terminology modules or ‘administrative’ modules with reporting and calculation requirements)
- Results of validation should be summarized in an informative annex. That annex also should give references to reports of the validation work. (Validation data are no normative information; it doesn’t result in normative instructions and it isn’t used in normative procedures.)
- If the test procedure/module was validated in combination with another test procedure, validation results should be summarized in both modules.

- In the relevant standards, especially in step 5 and 6, information should be provided on the quantitative detection limits. This information can be given in an informative way as well, since it might be possible that detection limits improve by further developments of testing techniques.

## C.6 Quality of testing standards (modules)

For CE-marking, test results should be reliable and reproducible. So the standard deviation of test results should be limited.
For the development of a test procedure standard deviation should be known of each module and the total test procedure. An increase level of inhomogeneity of the product/material can (partly) be compensated by intensifying the sampling or alternatively to test more test portions in the same test run.

*C.6.1 Validation*

Each test module should be validated; here we refer to SABE Guide N215$^{rev}$ (CEN Guide on Validation policy); document CEN/TC 351 N 0154.

Validation especially concerns the modules in step 5 and 6 of the 7 testing steps, and parts of other steps.

Validation consist of 3 main phases.
- Definition phase to prepare a draft standard
- Ruggedness testing
- Precision testing

The first step is to develop a first draft protocol based on existing information and expert knowledge. The next phase is to evaluate if the test conditions as defined can fulfil the requirements. As far as test results lack special tests can be done by one or some labs. Based on these results, the draft test standard can be adjusted.
In the third step, the precision of the test is determined, by executing the test in more than 10 laboratories. The precision testing is executed for some specific combinations of product and substances. In general it is not necessary to validate all possible combinations falling under the scope of a standard.

The results of precision validation are expressed as:
$S_r$ = repeatability (within lab testing)
and
$S_R$ = Reproducibility (between lab testing)

*C.6.2 Precision of tests in individual modules*

For each test the precision of the test, or relevant parts of the test should be determined and presented in an informative annex. It should be explained for which kind of products/materials and which substances the validation may be used as reference. References to research reports can be given.
As far as possible the repeatability and reproducibility should be presented for only the step covered by the relevant standards/module.
For some steps direct validation is not possible, but it can be done in an indirect way. E.g. for sampling, duplo testing and other approaches can give a rough estimate of the precision of the procedure.

Especially regarding sampling one should take into account the contribution of the heterogeneity of the product/material and the influence of the sampling procedure. The technical tools and the statistical tools of sampling (resulting in choice of a number of increments per sample and number of samples) can be validated. Determining the heterogeneity of products/materials should be done case by case, as far as specific information on heterogeneity of a type of product or an individual product is needed, additionally to available information.

*C.6.3 Total precision of a test*

When a product test protocol is drawn up from available modules, the precision of the designed test procedure can roughly be estimated by the formulae:

$$(S_{R\text{-tot})})^2 = (S_{R\text{-}2)})^2 + (S_{R\text{-}3)})^2 + (S_{R\text{-}4)})^2 + (S_{R\text{-}5)})^2 + (S_{R\text{-}6)})^2$$

If the Reproducibility of one step is dominant, its value may be a good estimate for the total reproducibility as well. This approach gives an indication as upper bound. In many cases it has been shown that the range in practice is smaller as uncertainty contributions are not unidirectional, but partly compensate oneanother. In addition, some parameters tend to be controlled by factors that are relatively independent on the sampling (e.g solubility controlled substances).

*C.6.4 Detection limits*

In selection and development of test modules and product test protocols, attention should be given to analytical detection limits. Test should be chosen with detection limits (far) below the limit values with which the analytical result is to be compared (e.g., the maximum allowable release of a substance expressed in mg substance/kg product). For adequate evaluation of test results, the 'quantitative detection limit' should preferably be a factor 10 or more below this limit value. In general the 'qualitative detection limit' is a factor 3 below the 'quantitative detection limit'. Between those limits the tests just indicate that a substance is or might be present. Just above the quantitative detection limit the reproducibility is less precise than at a 3-5 higher level, from where the reproducibility usually is much better.
These ranges have to be taken into account when evaluating a test method (module) and when selecting a test method for a certain procedure.

In ruggedness testing and precision testing information on the detection limits should be investigated. It should be reported in the annex on validation. Based on this information a future user of a test module can decide which test is suitable regarding the required detection limit.

# Annex D. The building cycle and the special case of recycled aggregates

## D.1 The Building Cycle

In the future, after the revision of the CPD, ER3 may address life cycle aspects not currently covered by the CPD. Following the assessment of the relevance of the 60 Construction TCs for potential release of substances to soil, surface water and ground water and emission to indoor air, the relevant TCs have been placed in a position in the "building cycle" related to the intended use of the products. This is meant as an illustration/extension of Tables 1.2 and 1.3 in Part 4.

The "building cycle" is shown in Figure 1.1 and covers all stages of the construction process: from raw constituents to half products, final products, intended use, and finally demolition/recycling.

Only shown are the TCs that are in the first and second column of Tables 1.2 and 1.3 (i.e. TCs dealing with final products, and intermediate products, respectively). The figure shows that recycled/intermediate products (stage 5-1) are used by TCs that produce final products in the next stages (stage 1-4). Intermediate products are not relevant for testing in relation to soil, surface water and ground water impact except in the final product. For instance, cement and building limes are intermediate products in the production of mortar and concrete. Mortar and concrete can be judged in different intended use conditions using the same basic release information (see Annex G).
Cement, building lime, filler or aggregates are not representing an intended use, as they are used to prepare a final concrete on site (exceptions are pre-cast concrete products). This implies that any testing of half-products should be based on a "standard" final product containing these constituents such as described in a draft standard in preparation by TC 51 and TC 104 (CEN TR:XXXX:2007 Concrete – Release of regulated dangerous substances into soil, groundwater and surfacewater – Test method for new or unapproved constituents of concrete and for production concretes).

Products can leave the "building cycle" when they can no longer be used as a construction product or a recycled construction product (i.e. in that case they can be regarded as "waste"). There are also streams that are recycled, but not necessarily within the building cycle. This is the case for metals; after intended use many metals will normally be recycled as scrap metal. Many other products will after demolition be recycled as recycled aggregate for utilization in the same primary product where it originated from (concrete construction debris recycled as aggregate for concrete) or as unbound aggregate in for instance road construction. These aggregates may therefore re-circulate in the building cycle. Although still a very substantial proportion of the material flow through aggregate production plants is of natural origin, a growing proportion consists of recycled construction debris and other alternative material streams (see Annex F for the evaluation of MSWI bottom ash). Aggregates are therefore in part be seen as a special TC in comparison with several others, see next paragraph.

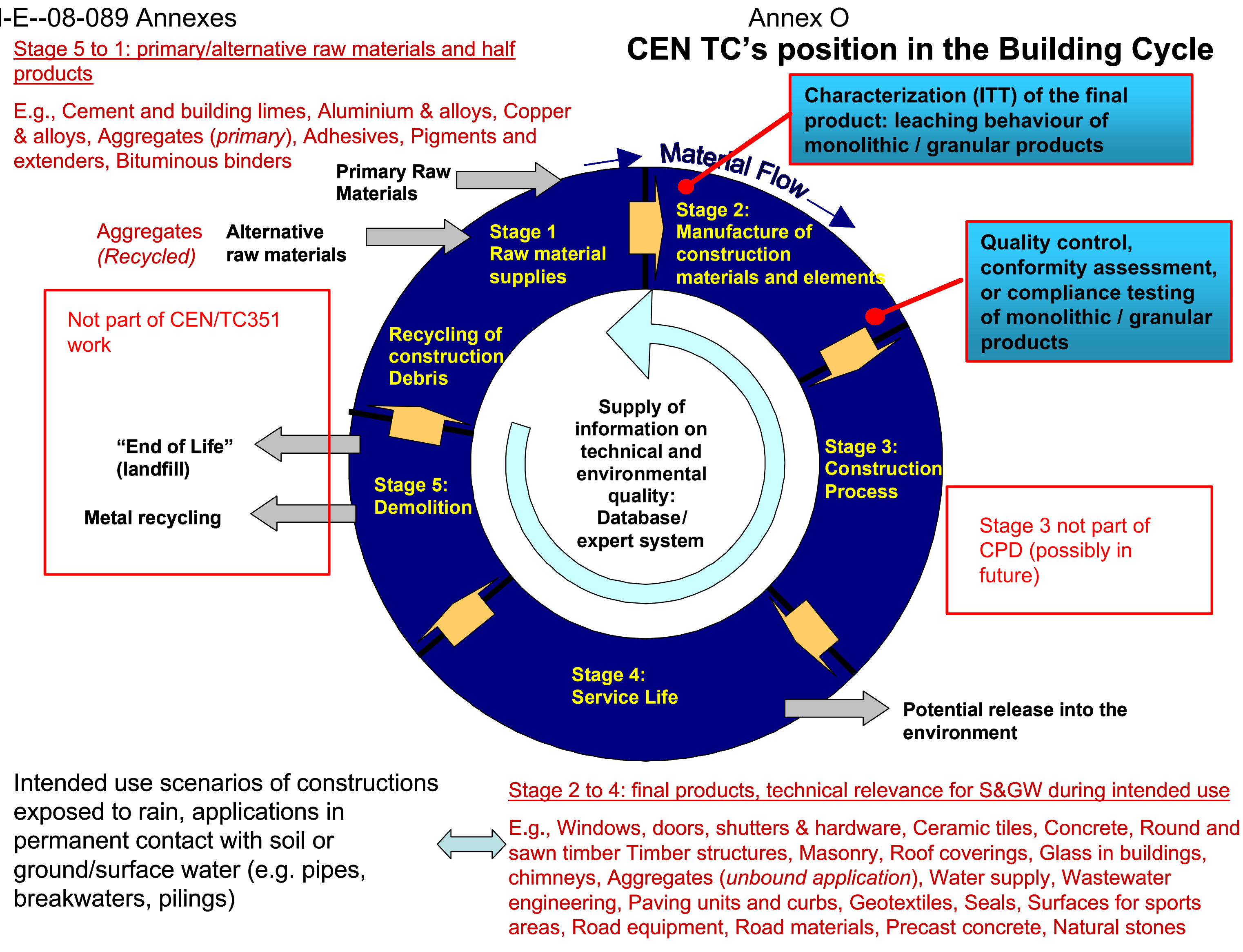



*Figure 1. The building cycle and the position of the different TCs (by name). See text for explanation.*

**D.2. The special situation for aggregates**

CEN/TC 154 Aggregate in part serves as a spindle in the recycling/reuse that is inherently implied in the structure of the CEN/TCs on construction products, as it stands today. Basically all construction debris from the various construction activities circle through one of the SC's under TC 154. There are only two ways products can exit the construction cycle without interference with TC 154 activities:

- One relates to recycling of metals, plastics, wood or flat glass, which are processed in another industry and may or may not come back as new constituent or product used in construction
- The other is "end of life" (landfill) for rejects from processing the material stream offered for recycling. These rejects are no longer fit for purpose and need to be disposed.

In principle, the aggregates that are produced as an intermediate product for use in a final product shall not be tested. Only final products are covered by the testing requirements for ER3, which implies that other TC's are responsible for the final products in which aggregates are used as a constituent (e.g., concrete, masonry, road materials).

However, final products containing aggregates may return to TC 154 in the form of recycled unbound aggregates, generally the final use scenario for aggregates. To prevent unexpected release in this final use scenario of aggregates, an option is to prepare a "standard" concrete, masonry unit or road material with the aggregate already one step earlier. This situation for aggregates is similar to that of cement and building limes. The half-product cement is not tested as such, but as a "standard" mortar (EN 197). Testing an intact concrete, masonry unit or bituminous product will generally not be very relevant as the leaching will most likely not be very different from the product without the aggregate added. In fact there is proof for this statement based on the test results obtained for Pb/Zn slag used as aggregate in concrete tested using a monolith leach test and the pH dependence test [17]. To obtain information on the release of unbound recycled aggregates the crushed standard concrete, masonry unit or bituminous product containing natural or manufactured aggregates can be tested as representing unbound recycled aggregates. The particle size should be such that it resembles practice as much as possible.

The advantage of the option of testing final products containing natural or manufactured aggregates as size reduced material is that when the requirements are met recycled product containing such aggregates will have acceptable environmental properties in all stages of the "construction cycle", whether it is part of a new final product or will be used as unbound recycled aggregate. To prevent the spilling of resources due to environmental problems in a later stage (outside the current CPD), products with environmental properties that are unacceptable in the unbound scenario are either not produced or are modified in the formulation prior to use such that they do not pose a potential environmental problem at some point during service life, and/or in the recycling stage.

In CEN/TC 154, EN 1744-3 [18] has been developed a leaching test for aggregates. The relationship between EN 1744-3 and the ITT leaching tests TS14429/TS14997 and TS14405 is necessary to establish a proper link between the test result and soil, surface water and ground water criteria, which at present is difficult as the compliance test EN 1744-3 does not represent or is not linked to any specific intended use.

# Annex E. Release from construction metals (example for zinc roof materials – M/120, 121 and 122)

This annex describes the release and emission principles of metal construction products, and how results from test methods relate to intended use conditions. We use metal roof materials (zinc gutters) as an example.

An extensive study based on semi- field measurements has been carried out by the Dutch research institute RIZA (RIZA 2003). The purpose of the experiments was to make a more accurate estimate of the runoff of metals from these types of materials (plate and gutter material made of zinc, aluminium, copper and also EDPM rubber). In short, runoff of heavy metals was measured in the field from large- scale experimental set-ups (results expressed in g metal/$m^2$ year; $m^2$ is the area of 'installed' zinc material). Included in the experiments were (among other) measurements of the effects of rainfall (precipitated amounts and contents of $NO_x$ and $SO_4$ etc), angle of roof exposed to the atmosphere, pH in run-off, temperature, and wind direction etc. Different types of metal gutters were tested: new versus old (weathered) metal and surface-treated metal. Also, the effect of organic material in the gutters was tested.

Expressed in g/$m^2$ yr, the results for zinc (the material receiving the highest attention because it is widely used) showed a strong positive correlation with the amount of precipitation (almost linear). Effects of air quality were well measurable, as was the effect of organic material in the gutter and the type of tile (concrete or glazed tiles). Measured concentrations of zinc, lead and copper in the different experiments varied generally within one order of magnitude (including time series variation, types of zinc material and literature data from other countries) and mostly smaller (effects of a factor 3 as function of exposition angle, and industrial/countryside area).

Given the experience gained from several large European projects (HORIZONTAL, GRACOS), the reported variations seem extremely small. Zinc solubility changes orders of magnitude as a function of pH, in particular in the pH area around neutral. For instance, a small change in pH of 0.2 pH units may shift concentrations by a factor of 2.5 in the neutral area (2 log units per unit pH). Zn solubility is often modelled by the dissolution/precipitation of Zn minerals such as zincite (ZnO)(Meima & Comans 1997).

At the ECN laboratory (unpublished results), the processes that control the Zn leaching from new and old Zn sheets was investigated with a tank test (NEN 7345). The results of this test are shown in Figure E.1. It appears that a slope of 0.5 (indicating diffusion control) is not reached over the entire time period, which indicates that possibly other processes control the release, such as solubility control (equilibrium dissolution of Zn minerals such as ZnO(s), Zn(OH)2(s)). To investigate if this is the case, the measured concentrations were plotted as a function of time and pH in Figure E.2. Together with the measured data, blind- predicted equilibrium model curves* are shown for equilibrium with zinc oxide (ZnO). As the measured data can be described adequately by the dissolution of zincite (ZnO; the dashed lines), this is a strong indication that the Zn release from the Zn plates in the diffusion test is likely to be **solubility controlled**.

* Using the geochemical speciation code PHREEQC.

The first time step in the diffusion test is 6 hours, which is apparently long enough to establish equilibrium conditions. However, in practice, contact times will often be (much) shorter. Shorter contact times in the diffusion test may be advisable to investigate the importance of (dissolution) kinetics at equilibration times more closely to the contact times found in practice.

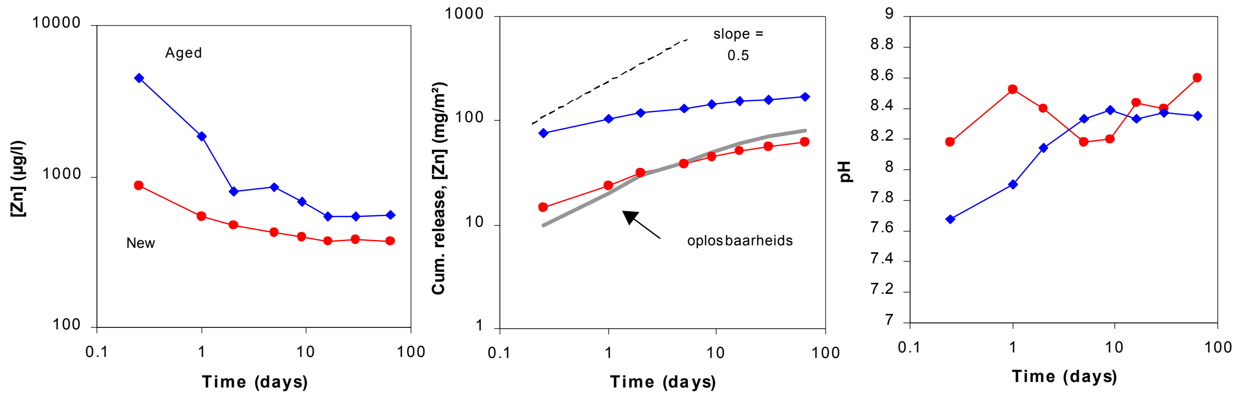



*Figure E.1. Results of the release of Zn from new and old Zn sheets (aged) in the tank test (NEN 7345). (Left in microgram/l, middle in mg/m² and in the right figure the pH per fraction) The slope of 0.5 indicates the standard diffusion control. The data do not follow this slope, so it should be checked if and what other mechanism is the basis for leaching. In the middle figure a hypothetical solubility control line for Zn-new is included (for illustration).*

Comparing lines in the above Figure shows that solubility control may be the main factor controlling Zn release. This conclusion can be better verified by the figures below.

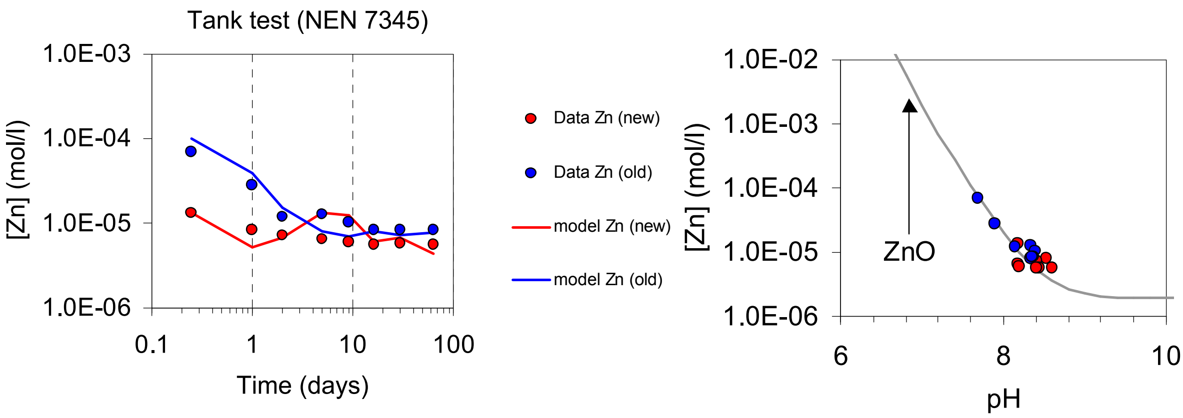



*Figure E.2a and b. The same experimental data from the previous Figure is plotted now in concentration as a function of time (a) and as function of pH (b). Equilibrium model curves are drawn for ZnO.*

The figure illustrates that the measurements for fresh and aged Zn plate material follow closely a model- calculated equilibrium dissolution curve of zinc minerals (in the left and right figure). This means that in the tank test the leaching from Zn plates is not diffusion controlled. This way of data presentation (fig E.2b) shows that pH is an extremely important parameter for the Zn release, in particular in the neutral area (pH 6-9) where Zn concentrations may vary orders of magnitude.

We can attempt to interpret the measured data of RIZA in terms of solubility control. The almost linear cumulative release graphs of Zn, Pb and Cu measured in the field (cumulative release versus precipitation, Fig 17-24 in the RIZA report (RIZA 2003)) indicate a relatively constant release over time, which is a strong indicator for solubility control. Assuming chemical equilibrium with ZnO (as seen in Figure C2.b), the solution concentration of Zn at pH 7.7 is about 6500 ug/L (equivalent to $1x10^{-4}$ mol/l, Figure C.2a, first data point is at pH 7.7). Assuming a gross precipitation of 800 L/$m^2$ year (average in the Netherlands), and a Zn plate of 1 $m^2$ (flat; 0 degrees with the surface), the Zn release would be 800 L/$m^2$ yr * 6500 ug/L = 5.2 g Zn/ $m^2$ year. This is in the order of magnitude of the release estimated by RIZA (their best estimate is 2.3 g Zn/$m^2$ installed Zn per year). Because both estimates are so close, this suggests that even in practice (near) equilibrium conditions are met. Of course, many factors influence the Zn release (contact angle versus precipitation, the pH, gutters versus plates etc). A direct comparison with measured concentrations of RIZA has not yet been done at the time of writing (January 2007), but is needed to confirm solubility control as the release controlling mechanism under field conditions. It may be that in some cases other Zn minerals may control the solubility in practice (which together make up the "patina", the weathering layer on metal surfaces).

Some consequences of solubility control (possibly the controlling mechanism) for the release are:

- The total amount of Zn released to the environment (g Zn/year) can be approximated by the product of precipitation (L/$m^2$/year), equilibrium concentration (g Zn/L), and exposed surface area ($m^2$). Given constant environmental conditions (such as annual rainfall, pH), the amount of zinc emitted can be expressed in a rather constant number; e.g. 2.3 g Zn/m2 year, as seen from the RIZA measurements..
- As follows from the above, the amount of Zn released (expressed in kg Zn/year) is approximately linear with the exposed surface area (a factor 2 increase in area would double the released amount);
- As follows from the above, the amount of Zn released (expressed in kg Zn/year) is approximately linear with the amount of precipitation (a factor of 2 increase in precipitation would double the released amount).

The above consequences of solubility control largely comply with the findings of RIZA. The cumulative release of Zn versus precipitation only slightly deviates from linear (RIZA, 2003).

The strong binding of Zn to organic matter is possibly the primary reason for the observed increased release of Zn in "dirty" roof gutters as observed by RIZA. The strong complexation of heavy metals to natural organic matter has received much scientific attention during the past decade and has resulted in a number of mechanistic adsorption models (Tipping 1998; Kinniburgh *et al.* 1999; Gustafson 2001). These have been shown to predict metal leachability successfully in strongly organic systems such as soils (Weng *et al.* 2002), (Dijkstra *et al.* 2004). The DOC complexation effect can well be calculated using current modelling capabilities using a number of standard geochemical models. Unfortunately, DOC measurements were not available in the work of RIZA.

Although the leaching of Zn was tested here with a tank test (NEN 7345), a **pH dependence test** would be suitable to further specify the behaviour and to make the further evaluation described above. It may help to specify the potential effects that the above named parameters have on the run-off of metals from building metals. As stated before, the possible effect of dissolution kinetics should be investigated into more detail.

Note that the work from RIZA also showed a near linear cumulative release curve for Pb from Pb sheets, Cu from Cu sheets and Al from Al sheets.

We assume that mechanisms that underlie observed release (e.g., solubility of metal (hydr)oxide phases on the exposed surface) are similar for other metal construction products (e.g., aluminium, copper), as is also confirmed by data. We did not consider *coated* metal products as the amount of information is too limited at present.

From these results it can be concluded that limited testing of metal plate products will suffice as the solubility is unlikley to change significantly as a result of production. When the solubility needs to be quantified the most appropriate procedure is a modified pH dependence test, as a tank test only shows one pH condition and a wider range of pH conditions needs to be evaluated, as products will be exposed to externally imposed pH conditions in intended use.

**References:**


- Dijkstra, J.J., Meeussen, J.C.L. & Comans, R.N.J. 2004. Leaching of heavy metals from contaminated soils: an experimental and modelling study. Environmental Science and Technology 38, 4390-4395.
- Gustafson, J.P. 2001. Modelling the acid-base properties and metal complexation of humid substances with the Stockholm humid model. Journal of Colloid and Interface Science, 244, 102-112
- Meima, J.A.& Comans, R.N.J. 1997. Geochemical modelling of weathering reactions in MSWI bottom ash. Environmental Science and Technology, 31, 1269-1276.
- RIZA, Emissies van Bouwmetalen. Vaststelling afspoelsnelheden op basis van metingen aan proefopstellingen (Emissions from metal roof construction materials, Dutch language). Report nr. RIZA 2003.027, Nov 2003.
- Tipping, E. 1998. Humic ion binding model VI: an improved description of the interactions of protons and metal ions with humic substances. Aquatic Geochemistry, 4, 3-48.
- Weng, L., Temminghoff, E.J.M., Lofts, S., Tipping, E. & van Riemsdijk, W.H. 2002. Complexation with dissolved organic matter and solubility control of heavy metals in a sandy soil. Environmental Science and Technology, 36, 4804-4810.

# Annex F: Release from aggregate (example for MSWI bottom ash – M/124 and M/125)

**Introduction**

There are several judgement aspects of MSWI bottom ash, which require a different level of information. Examples of such needs are: the development of criteria to assess impact from MSWI bottom ash use in different constructions, the evaluation of treatment options to improve the quality of MSWI bottom ash for beneficial use purposes, the regular quality control to verify compliance with the specified limit values.

In many scenarios a form of infiltration will occur, which implies that the L/S (liquid to solid ratio (l/kg)) will change with time. This calls for insight in changes of leaching behaviour as a function of L/S. In addition, the material will undergo chemical changes with time, which translates into a.o. a decreasing pH of the material due to weathering and remineralisation processes.

The difficult part is that a pH change resulting from carbonation in a laboratory test does not necessarily keep pace with the infiltration in a lab test (increased speed relative to field). Therefore a percolation test in the lab will never reflect precisely what will happen in practice. Therefore, the primary goal of test methods should not be to simulate an emission scenario, but to recognize which processes play a dominant role for the release, and to use the test results as verification data for models that incorporate these processes. Only through modelling a prediction can be made for the long-term based on understanding the relevant processes.

A hierarchy in testing can provide the necessary detail required to answer some specific questions as well as the simple straightforward testing needed for production control to verify compliance with previous characterisation/ITT data and subsequently with derived criteria based on characterisation test results. A well-defined link between characterisation/ITT test and compliance/conformity assessment procedures is essential to be able to make the inferred relation.

Initial Type Testing ITT

ITT of this granular material will consist of:

- *pH static test (TS14997/TS14429).* These test results provide insight in the dependence of release from the pH, and forms the basis for the assessment of the chemical speciation of substances and for full mechanistic chemical reaction/transport modelling. The information is of importance to assess the changes in release behaviour after carbonation in intended use, which implies that the leaching behaviour of relatively fresh material is not representative for the release in intended use..
- *Percolation test* and compliance options (preferred first fraction of elaborate method) The percolation test reflects many aspects that are relevant for the translation from lab to field (dependence of release from L/S).

- *physical characteristics* (not covered here) e.g. strength, porosity, permeability, density. Several physical parameters are relevant for modelling transport in field scenarios.
- *ecotoxicity* – At present there are no regulations addressing ecotoxicity. However, extracts from the above mentioned test could be used. In the waste field EN 14735 has been standardised. For assessing ecotoxicity under intended use conditions, the laboratory leaching methods seem unsuitable, as the release in the lab test does not relate to intended use conditions and unlike leaching is more difficult to translate from extreme exposure conditions

In figure D.1 various judgement aspects of MSWI bottom ash are indicated in the combination of pH dependence test and percolation test, which form the basic characterisation for granular materials.

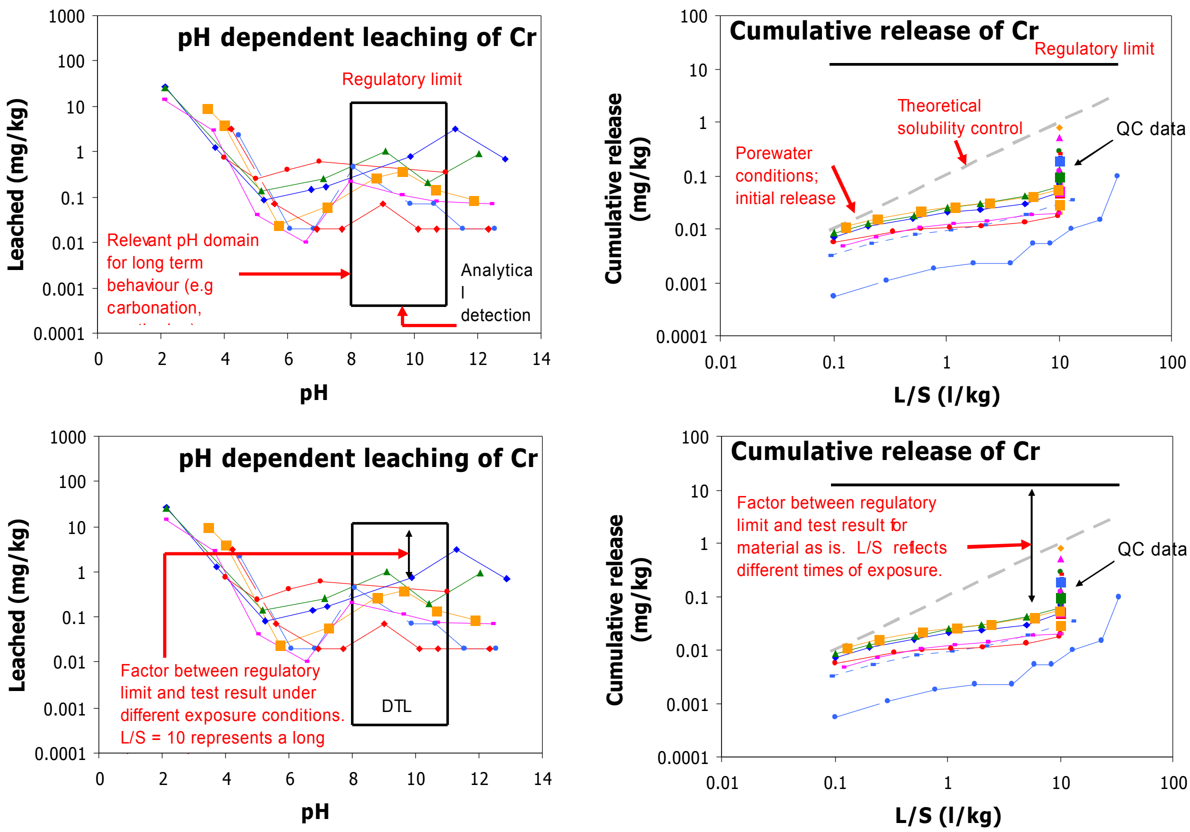



*Figure F.1. Illustration of the different judgement aspects covered by the combination of pH dependence test (chemical speciation aspects) and percolation test (time dependent release).*

Questions arise with respect to:
- variability in production (between facilities and in time within one facility) and variability between different countries
- factors controlling the release of specific substances and if undesirable what can be done to reduce such critical levels by improvement of quality to acceptable release

Approach to address multiple questions related to a material (in line with EN 12920 Methodology)

- Evaluation of the question to be answered
- Perform the proper testing to assess the relevant properties
- Evaluate possible critical substances
- Model the release in the scenario under consideration
- Verify the outcome against field observations
- Adjust model when needed
- Develop criteria by comparison of impact against target objectives or identify compliance with regulatory targets
- Identify key controlling factors and based on the understanding select a suitable test condition for compliance purposes (preferably a condition selected from the ITT methods to avoid the need for separate validation)
- Draw conclusion on acceptance or rejection.

Verification against regulatory criteria will allow

- determination of crucial substances (reduction of number of parameters to be tested in FT as part of FPC) and
- frequency of testing (less frequent testing when values sufficiently far from the critical limit).

Method of evaluation of an emission scenario

Define exposure window in terms of pH and L/S (identify relevance of redox and DOC)
Define time scale relevant for the assessment
Define conditions (wet / dry cycles, temperature, etc)

Check substances based on this against limit values
if more than 10 times lower (subjective to be made objective) - non critical
Check for variability in production

General remark: Bottom ash from different locations and installations shows very consistent leaching behaviour when judged based on characterisation leaching tests (Comparison of MSWI ashes from the Netherlands, Austria, Germany, France, Taiwan – see figure F.2) and presentation by Jung at al. at WASCON 2006 (comparison of bottom ashes from Japan, NL, Korea)

Very good repeatability possible for percolation test (Presentation J.J. Dijkstra at Wascon 2006) and quality control of same ash over several years (ECN, NL, 2008)

**Approach for judgement of possible critical parameters**
Judgement of possible critical parameters based on characterisation (reference Building Materials Decree (BMD) 1995 as reference) is given in table D.1. When a range in the factor is specified, it implies that the factor is not constant over the pH range considered. The factor applies to the upper bound of the range of data considered.

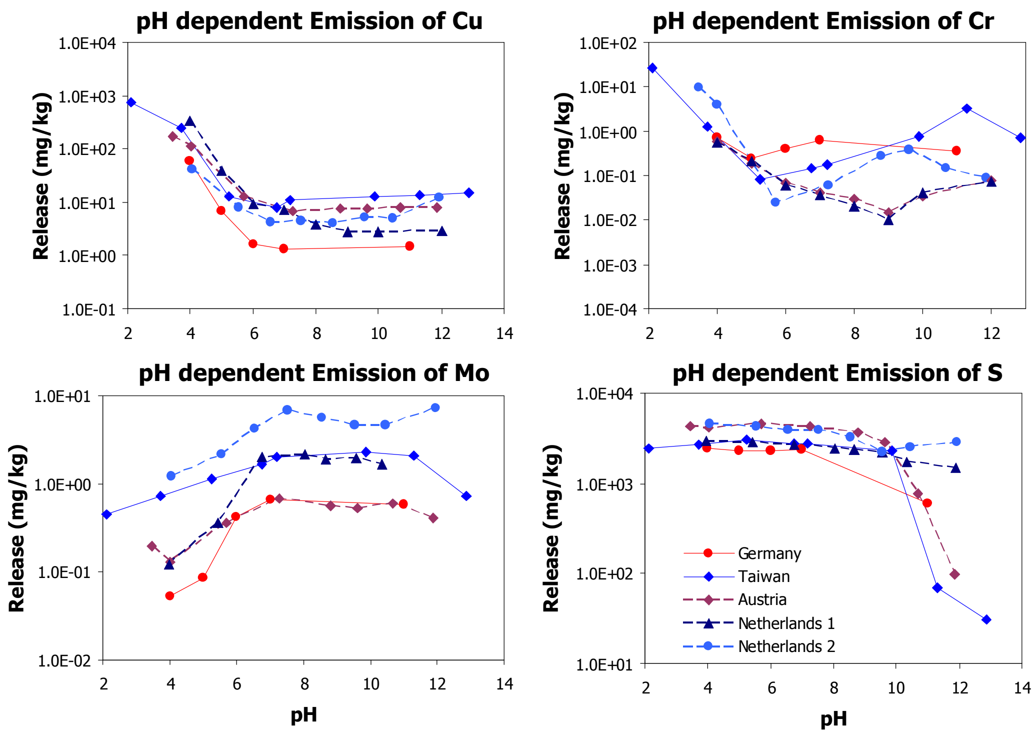



*Figure F.2 Comparison of release behaviour of Cu, Cr, Mo and SO4 as S from MSWI bottom ashes from Netherlands, Austria, Germany, Taiwan as a function of pH.*

Table F.1. Judgement of MSWI bottom ash against regulatory criteria (factors derived from judgement of actual leaching test data)

| Substance | Service life: Cat 2 BMD column test data | Factor | Recycling: Cat 2 BMD after carbonation pH stat | Factor | Remarks |
|---|---|---|---|---|---|
| Al | | | | | Consistent data |
| As | Pass | 80 | Pass | 100 | After carbonation increase in leachability at high pH |
| B | | | | | After carbonation increase in leachability at high pH |
| Ba | Pass | 8 | Pass | 5 | After carbonation slight increase in leachability at high pH |
| Ca | | | | | Consistent data |
| Cd | Pass | 4 | Pass | 1 - 15* | At pH 7.8 full carbonation close to limit |
| Cl | Pass | 2 | Fail | 1.3 | |
| Cr | Pass | 150 | Pass | 10 - 100* | Maximum in selected pH range |
| Cu | Fail | 2 | Fail | 2-3 | Cu DOC controlling |

| Substance | Service life: Cat 2 BMD column test data | Factor | Recycling: Cat 2 BMD after carbonation pH stat | Factor | Remarks |
|---|---|---|---|---|---|
| Fe | | | | | Consistent |
| K | | | | | Consistent |
| Li | | | | | Consistent |
| Mg | | | | | Consistent |
| Mn | | | | | Consistent |
| Mo | Pass | 2 | Fail | 1.7 | |
| Na | | | | | Consistent |
| Ni | Pass | 5 | Pass | 13 | |
| P | | | | | Consistent |
| Pb | Pass | 8 | Pass | 2-100* | High leachability at high pH |
| SO4 as S | Pass | 2 | Pass | 2 | After carbonation increase in leachability at high pH |
| Sb | Pass | 2 | Fail | 0.3 - 5* | Maximum at pH 7.8 (full carbonation) |
| Si | | | | | Consistent |
| Sn | Pass | 100 | Pass | 100 | |
| Sr | | | | | Consistent |
| V | Pass | 100 | Pass | 100 | |
| W | | | | | Similar to Mo |
| Zn | Pass | 5 | Pass | 2 - 100* | Minimum in pH range selected |

* Range indicates that in the relevant pH domain significant change can occur.

**FT method for FPC:**

The use of the EN 1744-3 procedure for compliance is not suitable for MSWI bottom ash, as it can not be linked to the ITT methods, which are needed for the link with regulation. A very suitable compliance with a close link to reality would be a percolation test where the first fraction(s) is (are) collected and combined for a single analysis. Placing this information in context with previous characterisation data will provide a sound basis for judgement A batch test at LS=10 is also possible. However, in a batch test the release of organic contaminants, in particular, will be substantially overestimated (easily a factor 10) due to mobilisation of fine particles and DOC. In case of a batch test it will also be crucial to place the information obtained in context with previously obtained characterisation information to allow proper judgement.

Potentially critical substances for MSWI bottom ash (based on BMD evaluation):
Cl, Cu, Mo, SO4, Sb

Frequency of testing (outline of a possible approach):
All substances: upon major change in input stream with a minimum of once every year

Cu, Mo, Sb: every week composite sample of daily charges

Cl, SO4: depending on the time series of the facility weekly composite or monthly

**Strength of this combination of characterisation/ITT and compliance (Conformity Assessment):**

- Potential to recognise deviations in leaching behaviour on a single data point
- Potential to assess changes in process conditions

**References**


- van Zomeren, A., Comans, R.N.J., 2004. Contribution of natural organic matter to copper leaching from municipal solid waste incinerator bottom ash. *Environ. Sci. Technol.,* **38**, 3927-3932.
- Meeussen, J.C.L., 2003. ORCHESTRA: An object-oriented framework for implementing chemical equilibrium models. *Environ. Sci. Technol.*,**37**, 1175-1182.
- Milne, C.J., Kinniburgh, D.G., van Riemsdijk, W.H., Tipping, E., 2003. Generic NICA-Donnan model parameters for metal-ion binding by humic substances. *Environ. Sci. Technol*., **37**, 958-971.
- Dijkstra, J.J., Meeussen, J.C.L., Comans, R.N.J., 2004. Leaching of heavy metals from contaminated soils: an experimental and modelling study. *Environ. Sci. Technol*., **38**, 4390-4395.
- Dijkstra, J.J., Meeussen, J.C.L., van der Sloot, H.A. and Comans, 2003. Modelling speciation and transport in MSWI bottom ash. In: Ortiz de Urbina, G. and Goumans, J.J.J.M., WASCON 2003, conference proceedings, San Sebastian, Spain.
- LeachXS - Database/expert system www.leachxs.com
- Jung, Chang-Hwan. Environmetal safety assessment system for recycled materials in WASCON 2006, Belgrade.

# Annex G. Cement based products: guidance in testing for environmental impact assessment, treatment evaluation and regulatory compliance aspects example: cement mortars and concrete (M/100, M/114, M128)

The judgement of environmental aspects of cement mortars and concrete requires different information on the environmental characteristics for different purposes. Examples of such needs are: the development of criteria to assess impact from cement mortar and concrete use in different construction scenarios and the quality control to verify compliance with the specified limit values.
For an assessment of impact in different scenarios of application the range of exposure conditions, which may occur, is relevant. In addition, the material will undergo changes with time (e.g. carbonation). To take these changes into account an assessment of other conditions is required than when evaluating a fresh sample. This may involve pH and, possibly, redox changes resulting from carbonation, weathering and remineralisation.
In all impact scenarios the degree of contact with water will be the key aspect determining the release. This calls for insight in changes of leaching behaviour as a function of time. The difficult part is that a pH change resulting from carbonation in the field does not necessarily keep pace with the exposure in a lab test (too short relative to field). Therefore a tank test in the lab will never reflect precisely what will happen in practice. Only through modelling a prediction can be made based on understanding the relevant processes.
A hierarchy in testing can provide the necessary detail required to answer some specific questions as well as the simple straightforward testing needed to verify compliance with previous characterisation data and subsequently with derived criteria based on characterisation test results. A well-defined link between characterisation test and compliance procedures is essential to be able to make the inferred relation.

Initial Type Testing ITT of monolithic materials will generally consist of:

- *Composition*. In case of construction materials this is not a preferred means of judgement, but may be required for other regulations and other purposes
- *pH static test data* (TS14429/TS14997) These test results provide insight in the chemical speciation of substances and form the basis for full mechanistic chemical reaction/transport modelling
- *tank test* (e.g., NEN 7375) and compliance options (preferred first fraction of the elaborate method) The tank test reflects many aspects that are relevant for the translation from lab to field. This relates in particular to the tortuosity of the product (measure for the pore structure).
- *physical characteristics* (not covered here) e.g. strength, porosity, permeability, density. Several physical parameters are relevant for modelling transport in field scenarios.
- *ecotoxicity* – At present there are no regulations addressing ecotoxicity. However, extracts from the above mentioned test could be used. In the waste field EN 14735 has been standardised. For assessing ecotoxicity under intended use conditions, the laboratory leaching methods seem unsuitable, as the release in the lab test does not relate to intended use conditions and unlike leaching is more difficult to translate from extreme exposure conditions.

Questions arise with respect to:

- Variability in production (between facilities and in time within one facility) and variability between different countries
- Behaviour of material in reuse/recycling options in a size reduced form

Approach to address multiple questions related to a material (in line with EN 12920 Methodology)

- Evaluation of the question to be answered
- Perform the proper testing to assess the relevant properties
- Evaluate possible critical substances
- Model the release in the scenario under consideration
- Verify the outcome against field observations
- Adjust model when needed
- Develop criteria by comparison of impact against target objectives or identify compliance with regulatory targets
- Identify key controlling factors and based on the understanding select a suitable test condition for compliance purposes
- Draw conclusion on acceptance or rejection.

Verification against regulatory criteria will allow

- determination of crucial substances (reduction of number of parameters to be tested in compliance testing, if needed) and
- frequency of testing ( less frequent testing when values sufficiently far from the critical limit).

Method of evaluation of a scenario

Define exposure window in terms of pH and time (identify relevance of redox, atmospheric exposure and dissolved organic carbon - DOC)
Define conditions (wet / dry cycles, temperature, etc)

Check substances based on this against limit values
if more than 5 times lower (to be decided elsewhere) - non critical
Check for variability in production

General remark: very consistent leaching behaviour when judged based on characterisation leaching tests between cements produced at different locations worldwide.
Very good repeatability possible for tank test (BCR reference sample tested over a period of several years and in a repeatability study of 10 tests on the same specimen, ECN, 2007)

Judgement of critical parameters based on characterisation (Building Materials Decree, 1995 as example) for both the intact specimen (product in use phase) and as recycling material for unbound application is given in table G.1. In figure G.1 it is indicated how the factor between the regulatory limit and the observed behaviour is derived.

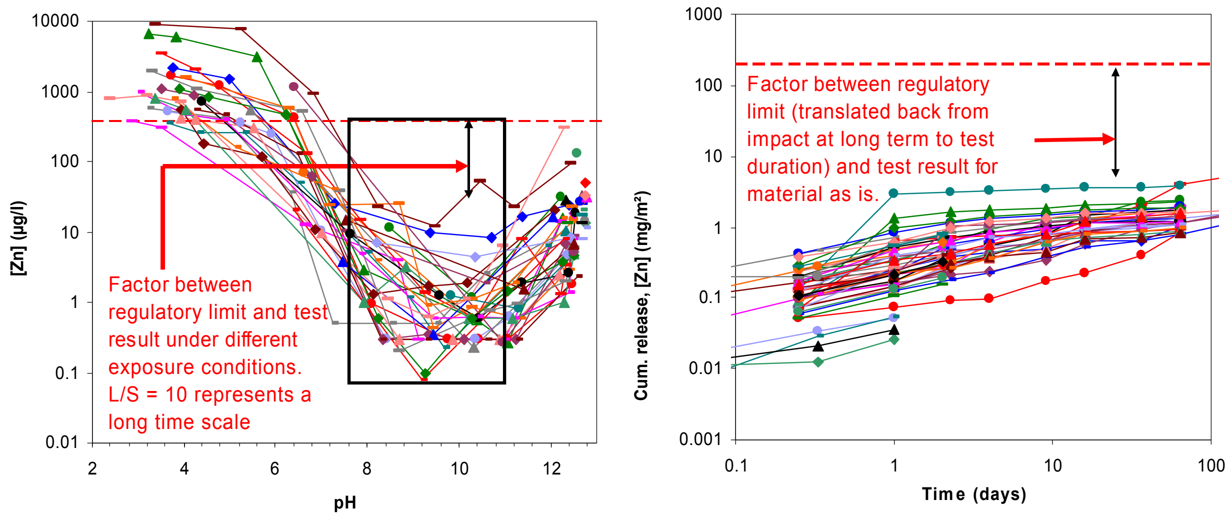



*Figure G.1. Judgement of cement based products and recycled concrete aggregate based on characterisation test data.*

Table G.1. Judgement of cement mortar in use and unbound recycled concrete aggregate.

| Substance | Service life: Cat 1 BMD tank test data at 64 days | Factor# | Recycling: Cat 1 BMD fresh and after carbonation pH stat (L/S=10; neutral pH; < 2mm) | Factor# | Remarks |
|---|---|---|---|---|---|
| Al | | | | | Consistent data. After carbonation decrease in release. |
| As | Pass | 10 | Pass | 30 | |
| B | | | | | After carbonation increase in leachability from pH 12 to 10.5 |
| Ba | Pass | 5 | Fail | 5 | Ba release strongly related to sulphate leachability. |
| Ca | | | | | Very consistent data |
| Cd | Pass | 3 | Pass | 3 | At pH 7.8 full carbonation close to limit |
| Cl | Pass | | Pass | | Very limited data |
| Cr | Pass | OPC 23 Bl C 60 | OPC Fail BFS and slag blended Pass | 30 | Maximum in selected pH range |
| Cu | Pass | 100 | Pass | 30 | |
| Fe | | | | | Consistent |
| Hg | Pass | 10 | Pass | | |
| K | | | | | Consistent |

| Substance | Service life: Cat 1 BMD tank test data at 64 days | Factor# | Recycling: Cat 1 BMD fresh and after carbonation pH stat (L/S=10; neutral pH; < 2mm) | Factor# | Remarks |
|---|---|---|---|---|---|
| Li | | | | | Consistent |
| Mg | | | | | Consistent, very pH sensitive |
| Mn | | | | | Consistent |
| Mo | Pass | 10 | Fail | 5 | |
| Na | | | | | Consistent, all ww cements within a factor 10 |
| Ni | Pass | 50 | Fail (pH 8-9)<br>Pass (pH 9-12) | 10<br>10 | |
| P | | | | | Consistent |
| Pb | Pass | 30 - 100* | Pass | 4 | |
| SO4 as S | Pass | 10 | Fail | 2 | After carbonation increase in leachability |
| Sb | Pass | 2-100* | Fail | 10 | Maximum at pH 7.8 (full carbonation) |
| Si | | | | | Consistent |
| Sn | Pass | 100 | | | Poor analysis |
| Sr | | | | | Consistent |
| V | Pass | 20 - 1000 | Fail | 0 - 7* | |
| Zn | Pass | 100 | Pass | 5-50* | |

# A factor in connection with pass or fail indicates the factor below the limit for pass and the factor above for fail
* A range in the factors presented for the granular material implies that there is a significant difference in the pH domain. A range in the factors for service life indicates the bandwidth

Conclusion (applies to materials falling in the "normal" range of cement mortars, not special blends or additives):

Factory Production Control FPC:
First steps of the tank test possibly combined to one fraction for analysis
For recycling an optimal controlled pH condition for size reduced material (< 4 mm) at L/S=10 is recommended (for mortar and concrete this will be a pH condition between pH 9 and 10)

Potentially critical substances based on leaching:
Service life (64 day tank test): None
Recycling unbound (L/S=10): Ba, Cr, Mo, Ni, SO4, Sb, V

Frequency of testing (service life):

WT for all substances after demonstration once that the production on the site matches with the existing worldwide database.

Frequency of testing (recycling):
WFT for several substances from cement mortar derived aggregate based on non critical leaching (source materials non critical).
FT for Cr, SO4 for all OPC derived aggregates and Mo, Sb and V depending on the nature of the (alternative) materials used.

Note: judgement of recycling based on size reduced material (< 2 mm). Judgement on other size fractions will show less critical conditions for several parameters. This aspect requires a further evaluation. As testing different particle sizes for compliance purposes is cumbersome (how to define the contribution of fine particles?) a modelling approach is in preparation.

Strength of this combination of characterisation and compliance:
Potential to recognise deviations in leaching behaviour on a single data point
Potential to assess changes in process conditions

In figure G.2 and G.3 below the judgment underlying the conclusions in table E.1 is illustrated for Cr and Zn from cement mortars.

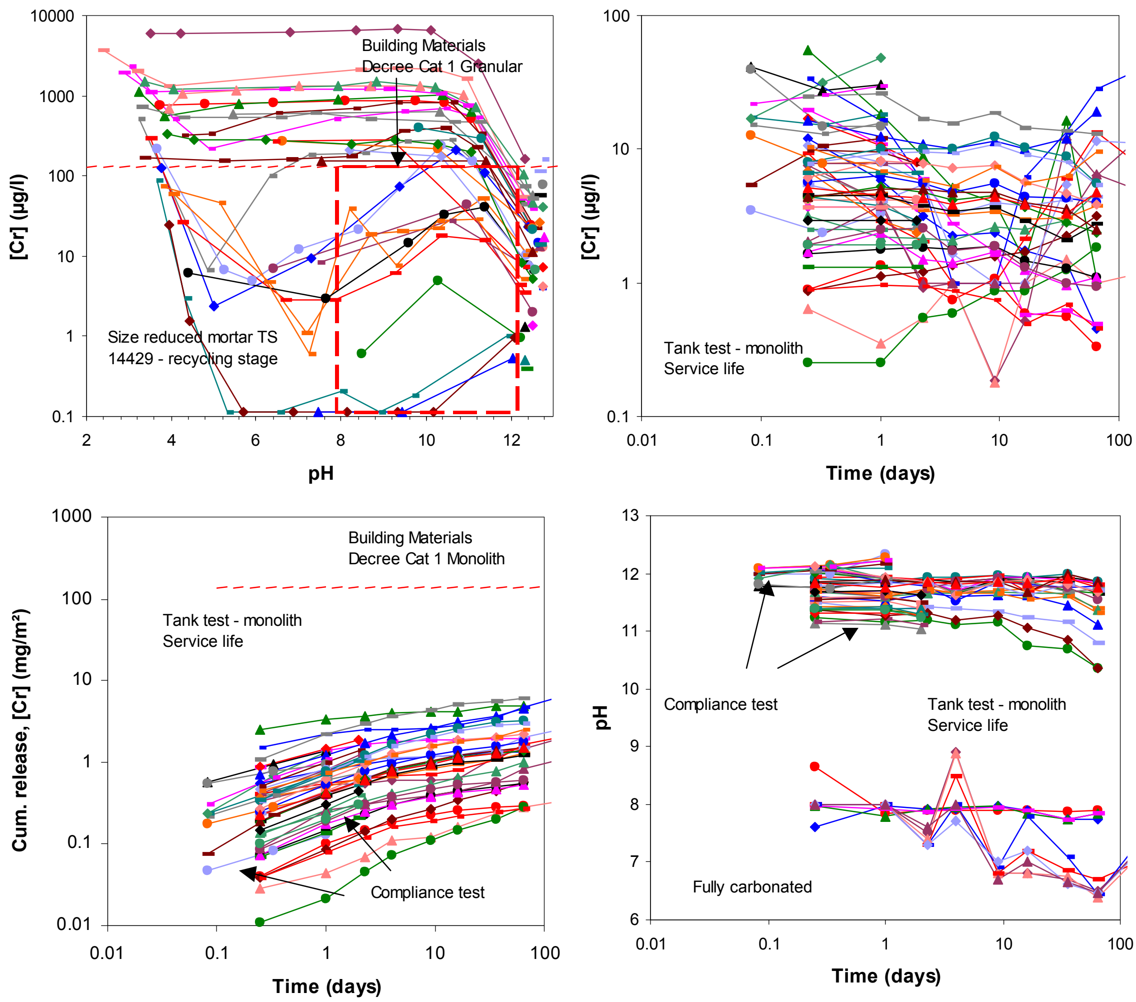



*Figure G.2. Initial type testing for Cr in cement mortars according to EN-197. Top left: pH dependence leaching (TS14429) data of OPC and blended cements with a box denoting the relevant pH domain for judging release (initial pH – full carbonation). The upper limit is the regulatory criterion (here BMD cat I for granular materials); the lower limit represents the analytical detection limit. All three other graphs show data as obtained in the tank leach test (NEN 7345 or the like). Top right: concentration as a function of time; bottom left: cumulative release with regulatory limit (here BMD Cat I for monolithic materials); bottom right pH as measured in the test illustrating the difference between uncontrolled (own pH) and testing under imposed carbonating conditions. FPC test results are given for comparison.*

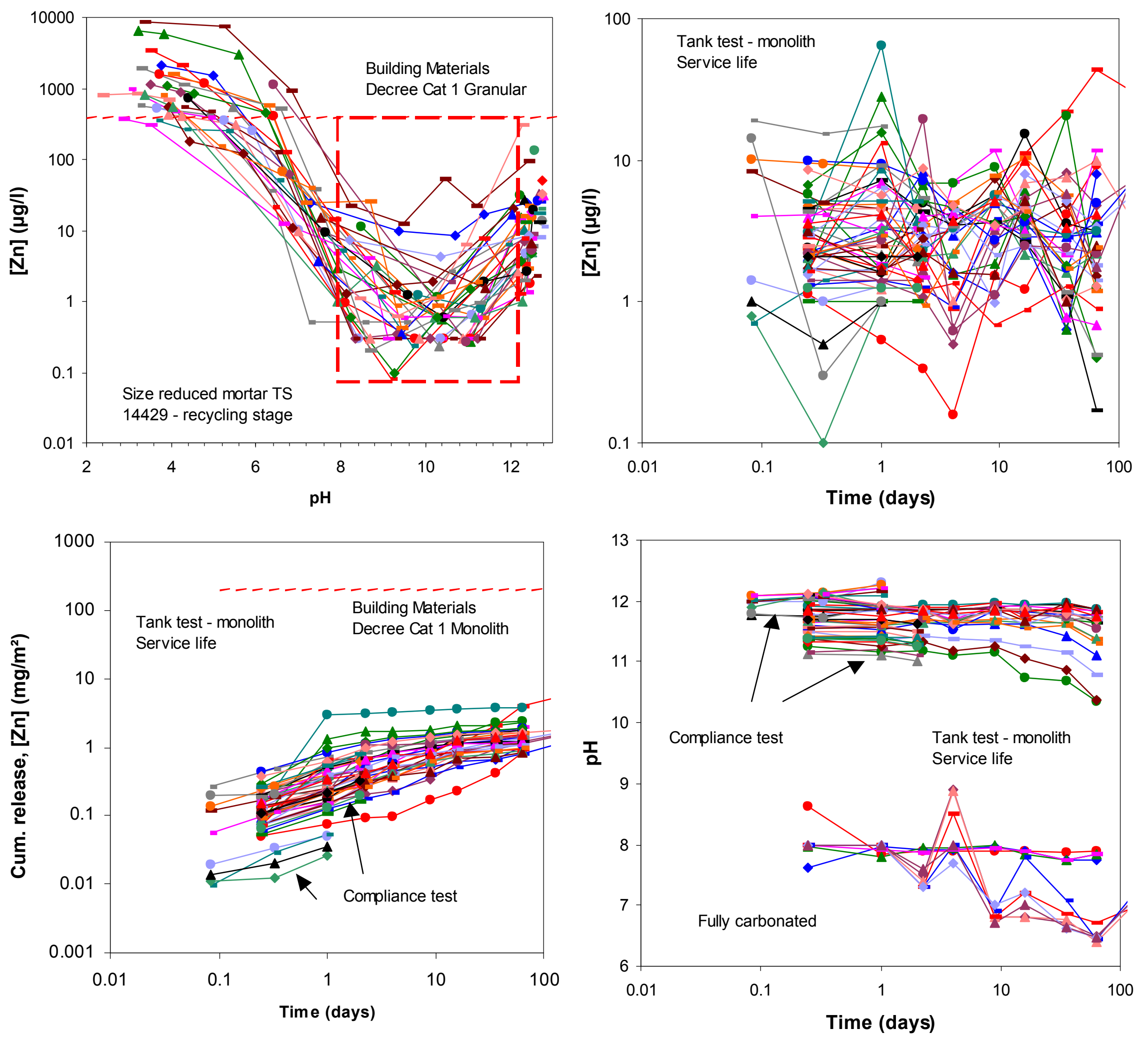



*Figure G.3. Initial type testing for Zn in cement mortars according to EN-197. Top left: pH dependence leaching (TS14429) data of OPC and blended cements with a box denoting the relevant pH domain for judging release (initial pH – full carbonation). The upper limit is the regulatory criterion (here BMD cat I for granular materials); the lower limit represents the analytical detection limit. All three other graphs show data as obtained in the tank leach test (NEN 7345 or the like). Top right: concentration as a function of time; bottom left: cumulative release with regulatory limit (here BMD Cat I for monolithic materials); bottom right pH as measured in the test illustrating the difference between uncontrolled (own pH) and testing under imposed carbonating conditions. FPC test results are given for comparison.*

Assessment for utilisation or disposal based on different scenario conditions

relevant pH domain in use phase
degree of water contact
exposure to atmosphere
site/application layout
........

Development of criteria, if needed can be based on forward modelling using a scenario approach targeted to a unsaturated (above soil) or saturated exposure scenario. For this full mechanistic modelling is envisaged. This implies understanding the release controlling factors

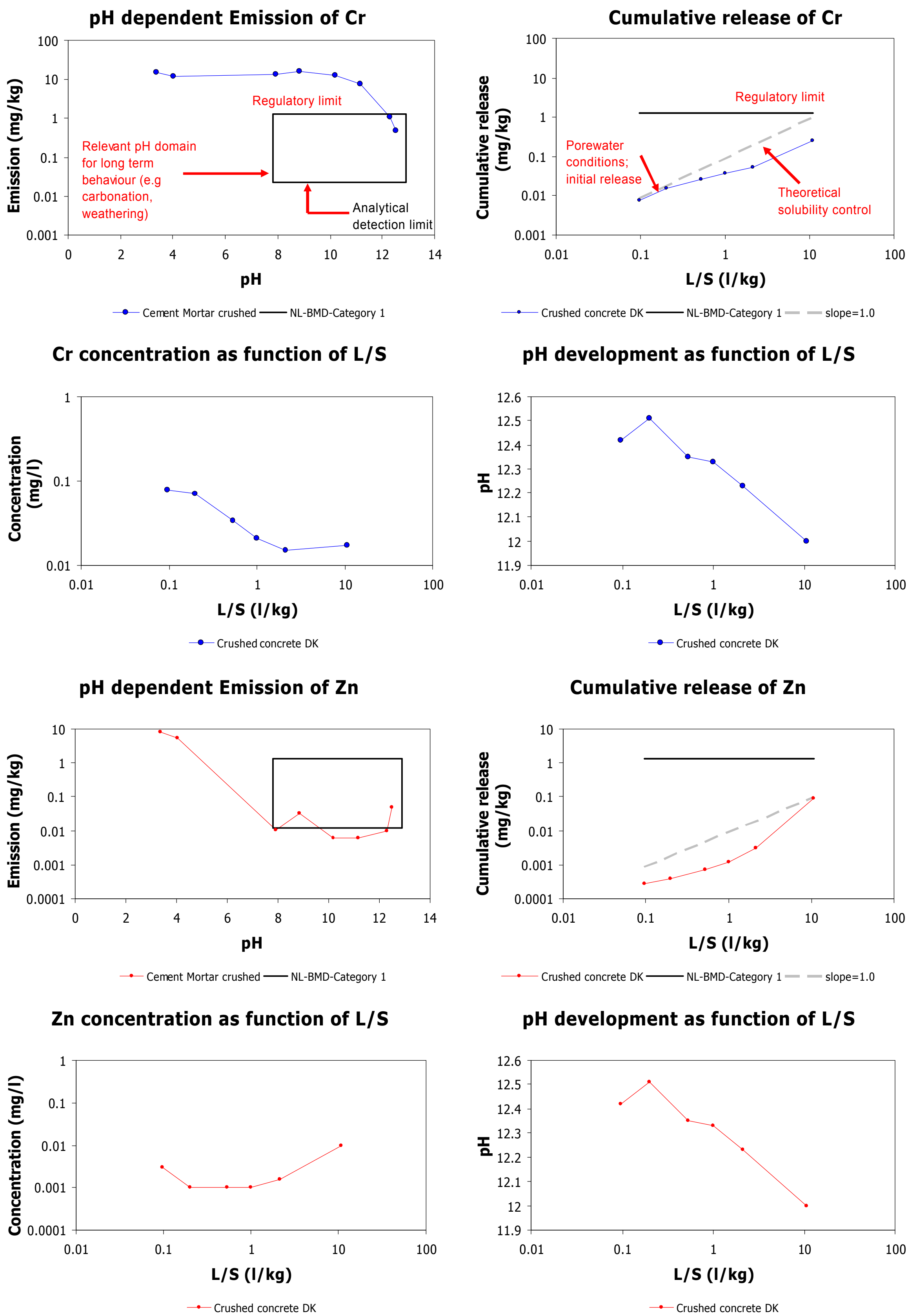



*Figure G.4. Judgement of Cr and Zn in recycled concrete aggregate against criteria illustrating acceptance at own pH of the material and exceeding of limits upon carbonation. Particle size in the test is 4 mm. Correction for particle size needed to relate lab data to practice.*

in sufficient detail to allow prediction of the laboratory test data. For field impact evaluation the source term obtained this way will only have to be extended with site specific exposure conditions, like degree of water contact, tortuosity of the material to be judged, temperature, dimensions, etc.

**Statistics**
With sufficient data in the database now a proper evaluation of product performance can be made. In figure G.5 the statistics are given for the cumulative release of Zn from cement mortars.

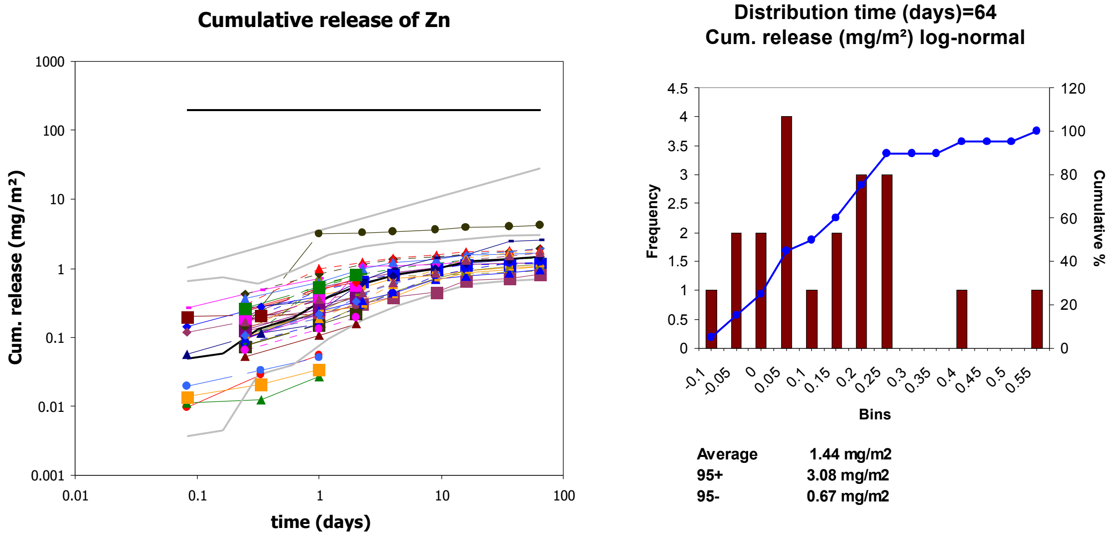



*Figure G.5. Statistics on cumulative release curves for Zn at 64 days as obtained in ITT (tank leach test, n=20).*

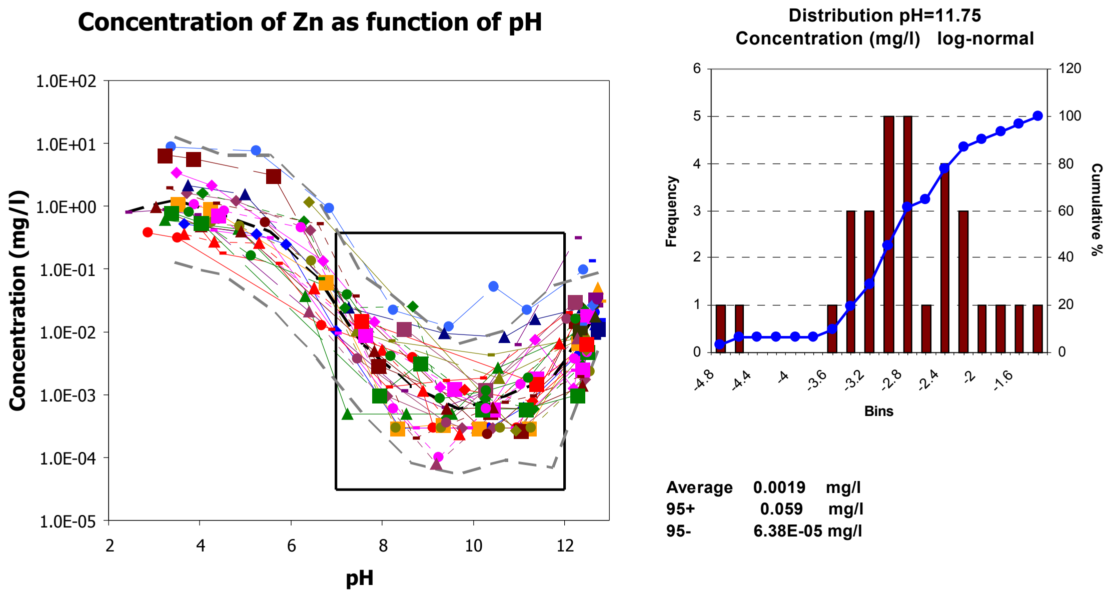



*Figure G.6. Statistics on pH dependent release curves for Zn at pH 11.75 as obtained in ITT (TS14429, n=31).*

The leaching data need to be judged in a log-normal distribution as a linear scale would overrate the higher concentrations.

**Judgement of FPC test data**

FPC test data can be compared in tables, but much more effectively in terms of decision power is a judgement in the context of the more detailed testing information in the already existing database. By identifying the data set against which data are compared, the new data can be placed in proper perspective with respect to pH and time dependent release. In figure G.7 the conformity evaluation is given for a assessment based on leaching.

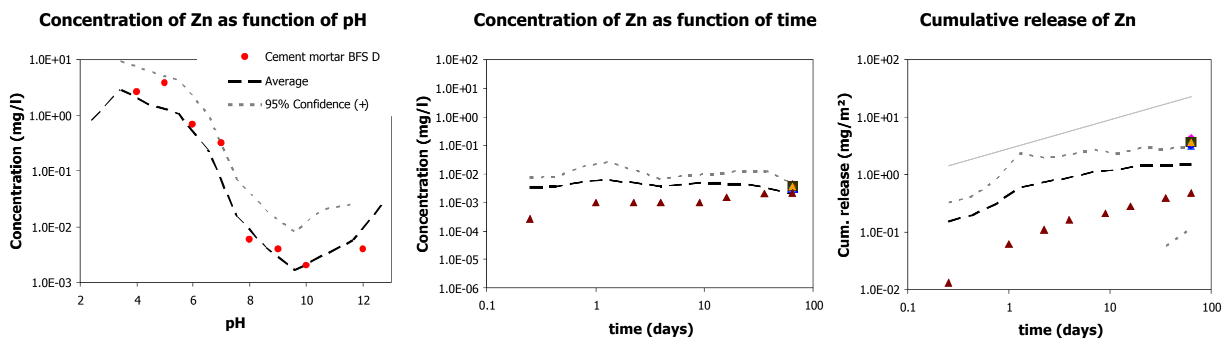



*Figure G.7. FPC test data in relation to performance data based on a worldwide dataset.*

To evaluate the changes in release for a production process with time, a presentation mode has been developed that allow data to be judged on this aspect. In figure G.8 the variation with time is given for concrete mortars tested over a period of 7 years.

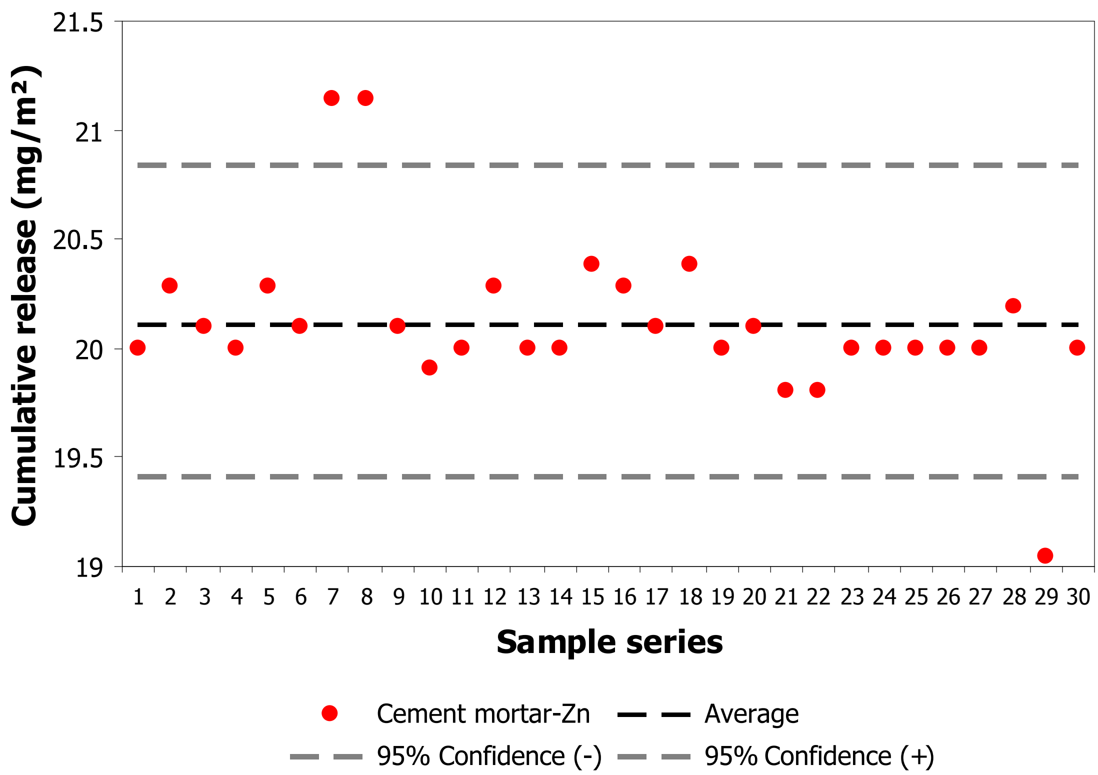



*Figure G.8. Time series variation in cement production assessed on leaching of mortar specimen*

**Impact evaluation**

Based on intrinsic parameters obtained from the pH dependence test (pH change due to carbonation) and tank leach test (time evolution) a scenario description can be developed for different applications of concrete. The same basic information can be used for these different applications. Main parameters that need to be varied in an intended use scenario are: mode and intensity of contact with water, mode and intensity of contact with the atmosphere, type of leachant, temperature in intended use (rate of diffusion), surface area exposed.
Examples of scenarios are:

- drinking water pipe with continuous flow and stagnant conditions at times
- concrete in groundwater

**Referenties**


- ECN, personal communication, 2007, data available upon request)
- ECRICEM I en II
- Engelsen, C. J., Fidjestøl, P., van der Sloot, H. A., Justnes, H., Mulugeta, M. Recent advances in modelling of the constituent release from recycled concrete aggregates with different degree of carbonation. In Sustainable Concrete Construction; India Chapter of the American Concrete Institute: Mumbai, India, 2008, pp 109-116
- Van der Sloot H.A. (2000): Comparison of the characteristic leaching behaviour of cements using standard (en 196-1) cement-mortar and an assessment of their long-term environmental behaviour in construction products during service life and recycling. Cement & Concrete Research 30, 1 – 18
- Building Materials Decree. Staatsblad van het Koninkrijk der Nederlanden, 1995, 567.

# Annex H. Glass: guidance in testing for environmental impact assessment, treatment evaluation and regulatory compliance aspects example: glass and glass products – M/135)

Tentatively, glass is considered a non critical construction product in view of impact to soil and groundwater and indoor air. The main question is to what extent glasses other than white glass may be critical for specific substances used in glass production. Without data one might assume that glass in non critical. However, questions remain for stained glass, hardened glass, etc.
The possible critical nature might be judged based on content, but especially for glass this is a poor measure for impact to soil, surface water, ground water or indoor air. The impact to indoor air can be ruled out on the basis that only intact glass panes are applied indoors and release by gaseous emission is nil.
The impact to soil, surface water and ground water can possibly not be neglected for the huge glass surfaces applied in specific high rise buildings and green houses, where the entire surface consists of glass. A means to assess potential impact is to assess the leaching behaviour of size reduced material. When such test information is placed in perspective to other materials or existing regulations covering other materials a judgement can be made.

In terms of substances, the role of organic contaminants can generally be ruled out for any glass type as the product is produced in a high temperature by melting, which destroys any organic substance in its basic chemical components ($CO_2$, $H_2O$, $N_2$, and any other substance that may have been present in the raw materials. Inorganic substance may be relevant as discussed below. However, in some double pane windows special gases are applied for better isolation. For example SF6 has been forbidden due to negative climate impacts.

A suitable basis of reference is the pH dependence leaching test as it covers a wide range of material exposure conditions. It reflects a worse case scenario as the test is applied on size reduced material. The liquid to solid ratio (L/S) of 10 l/kg that is commonly applied reflects the release over a longer time frame depending on the infiltration rate. In figure H.1 an illustration of the leaching behaviour of Pb and Sb from glass and vitrified materials is given with a regulatory reference (BMD).

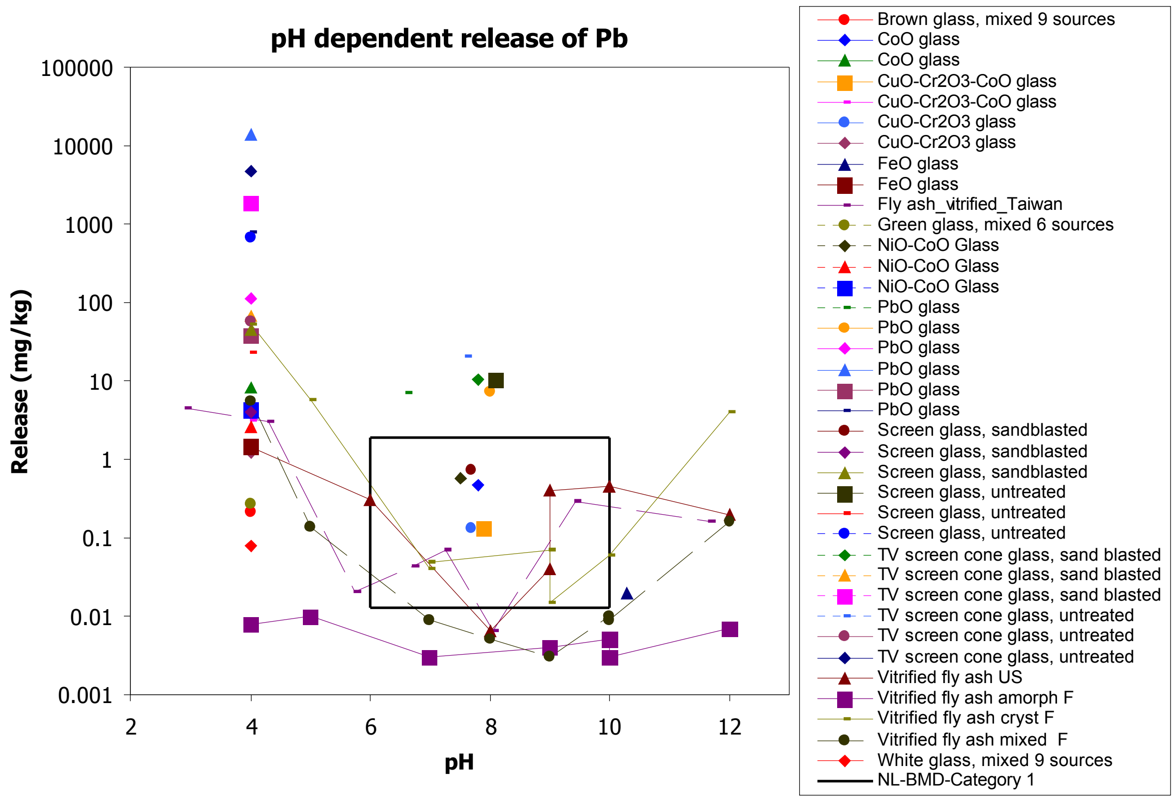



*Figure H.1. Pb leachability from different vitrified materials and types of glasses. (Clean up)*

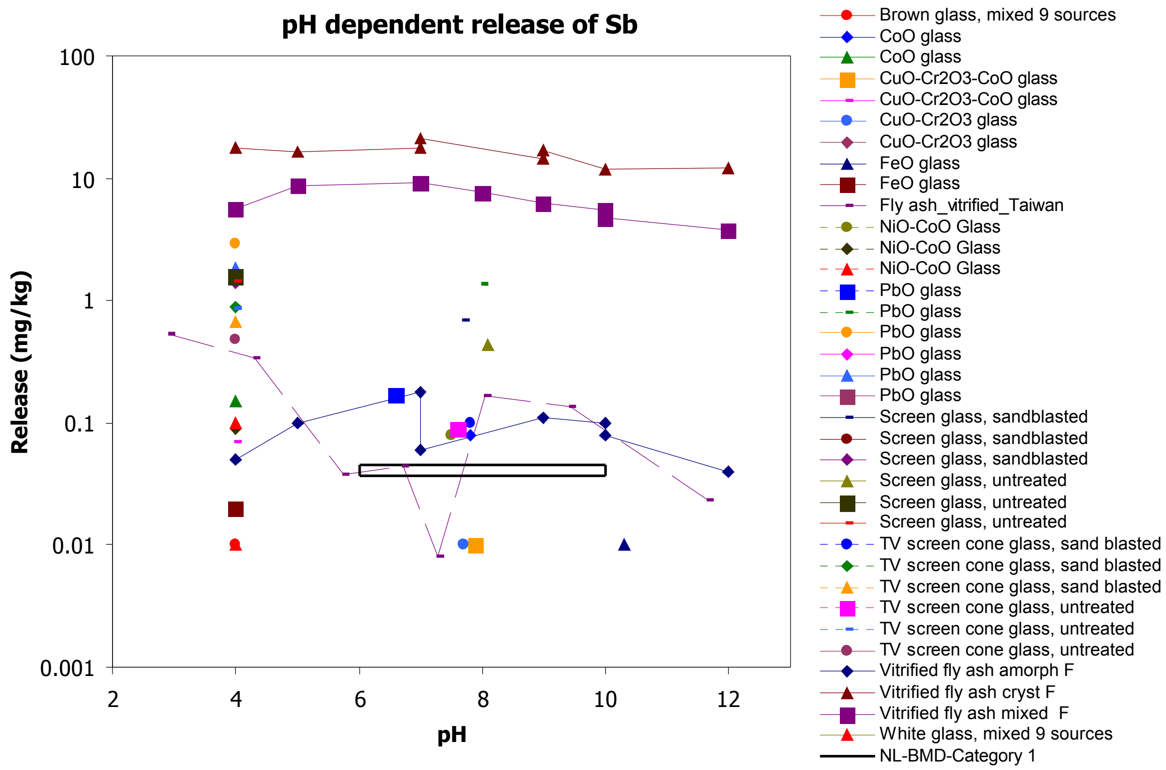



*Figure H.2. Sb leachability from different vitrified materials and types of glasses.*

In case of glass information is available on vitrified waste (full test) and limited test data (pH 4 and own pH) on a variety of glass types [Larm, 2006]. By comparing the test results of the various glass types including waste glasses with regulatory criteria for other construction products [BMD,2005], the majority of the glass types can be classified as non critical for any of the inorganic substances of concern. In table H.I a summary of glass type and potential critical substances is given.

Table H.1. Evaluation of size reduced glass.

| Substance | Glass type exceeding Cat 1 BMD pH stat (L/S=10; neutral pH; < 10mm) | Factor# | Remarks |
|---|---|---|---|
| Ba | Screen glass | 2 | |
| | Pb O Glass | 2 | |
| | Vitrified fly ash | 2 | |
| Co | Pb glass | 1.5 | |
| | Vitrified fly ash | 2 | |
| Cu | Vitrified fly ash | 2 | |
| Mo | Vitrified fly ash | 1.5 | |
| Ni | vitrified | 1.3 | |
| Pb | PbO | 5 | Pb leachability is substantially higher at pH < 4 |
| | Screen glass | 5 | |
| | TV screen glass | 3 | |
| Sb | Vitrified fly ash | 100 | Sb release typical component released from glasses |
| | PbO | 10 | |
| | Screen glass | 5 | |
| | TV screen glass | 5 | |
| Zn | Vitrified fly ash | 2 | |

# A factor in connection with pass of fail indicates the factor below the limit for passing a criterion

**Conclusion:**

Screen glass, which contains significant leachable quantities of metals (Pb) and oxyanions (Sb, As), must be kept separate from the more common glass types to avoid contamination and potential exceeding of criteria. Based on these data common glass types can be considered non-critical from a release to soil & groundwater point of view and can thus be considered suitable for WT or as not relevant for ER3.

Vitrified ash feature leaching characteristics that require testing for at least a few substances (Pb, Sb, As), when used in fine ground form. If used in coarse granular form the surface area release may prove low and pass stringent release criteria.

Optimal characterisation testing for glasses requiring testing:
pH dependence test TS14429
Depending on the use of the glass in unbound form a percolation test will be a suitable test for assessing release.

Optimal compliance/conformity testing for glasses of vitrificates:
Own pH extraction at L/S=10

Potentially critical substance based on leaching:
Service life (as pane): None
Recycling unbound (L/S=10): Ba, Co, Mo, Ni, Pb, Sb

Screen glass, which is contains significant leachable quantities of metals (Pb) and oxyanions (Sb, As), must be kept separate from the more common glass types to avoid contamination and potential exceeding of criteria. Based on these data common glass types can be considered non-critical from a release to soil, surface water and ground water point of view.

# Annex I. Statistical aspects of testing release

The quality of measurements is of importance in judging release from construction products to soil, surface & groundwater and emissions to indoor air. Different aspects are addressed below.

## 1. Representative sampling

Sampling shall be done in such a manner that the measurement result is representative for a specified quantity of the construction product produced by a producer. As indicated before the measurement result is the final answer obtained after a sequence of steps consisting of sampling on site, sample pre-treatment, release testing, analysis and reporting. Beforehand it is generally not known which step of this sequence is contributing most to the overall uncertainty of a measurement result.
In this context the question about product quality may be limited to one charge within a production plant, several production dates of the product in the same plant, different production locations in a country of even across boundaries between production locations in different countries. In table I.1 the different uncertainty ranges associated with each of these situations is illustrated for element release from cement mortars.

Table I.1. Repeatability of the quantification of release of Zn from cement mortars (product from same production date tested 10 times), variability in release within the same plant at different production dates (3 times) and variability in release for cement mortars from production locations worldwide.

| Element | One production (n=10)# | | Different production dates (n=3) | | Different locations worldwide (n=29) | |
|---|---|---|---|---|---|---|
| | Average mg/m$^2$ | Std (%) | Average mg/m$^2$ | Std (%) | Average mg/m$^2$ | Std (%) |
| Al | | | 271 | 35 | 209 | 65 |
| Ba | 40 | 6.4 | 26 | 23 | 29 | 106 |
| Cd | 0.59 | 3.8 | | | 0.08 | 157 |
| Cr | | | 1.56 | 40 | 1.94 | 85 |
| K | 34100 | 2.1 | 11898 | 31 | 13450 | 58 |
| Mo | 0.48 | 7.4 | 0.08 | 33 | 0.47 | 155 |
| Na | 22130 | 2.4 | 3909 | 29 | 3300 | 60 |
| Pb | 4.8 | 55 | 0.14 | 123 | 1.84 | 172 |
| SO4 as S | 425 | 5.1 | 431 | 30 | | |
| V | 1.63 | 5.2 | 0.21 | 146 | | |
| Zn | 6.9 | 26 | 1.12 | 41 | 1.63 | 57 |

\# As there are no repeatability data on concrete, data from a validation study with mortar containing 15 % MSWI fly ash was used. This implies the absolute values do not match, but the repeatability data are indicative for concrete and mortar.

The repeatability within one lab can be quite good (around 5 % or 95?), which implies that the analytical capabilities are not limiting. The variability from different production dates with variations in meal composition show a larger variability. For common elements this variability is in the order of 30 %. For the worldwide set of standard cement mortars (EN-

197) the variability is mostly within a factor of 2-3, which is surprisingly consistent. This is not necessarily the case for all substances of interest.

## 2. Data interpretation and use

In judging release data the distance between the measured value and a regulatory limit value or other control value is a criterion to decide on the relevance of substances to be taken along in the factory production control (if not WT or WFT) and a criterion to decide upon frequency of testing for a given substance.

Decisions are needed on the size of the production, for which a conclusion is needed. A decision on WT covers a specific construction product and may cover the product generically as produced at various locations. This is different from WFT and particularly FT, which may be location specific as it depends on source materials used in the production.

## 3. Measurement range and sensitivity

The methods to be applied for assessing release should be adequate in terms of measurement range and sensitivity (detection limits of analytical methods employed) to meet the requirements set by regulatory criteria or other control values.

### 3.1 Accuracy of measurements

The accuracy is the degree to which the measured release is correct in terms of amount of substance released under the experimental conditions applied. The accuracy may be affected by adsorption losses of substances to the container wall in which the test is carried out. Another factor is the degree to which substances are lost due to volatilization (only relevant for substances that are volatile under ambient conditions of the test). Also the analytical method may not reflect precisely the absolute quantity, in case the recovery of a substance in for instance an extraction step is guaranteed at for instance > 90 %.

### 3.2 Ruggedness testing

The ruggedness of a method is the sensitivity of the test result to limited variations in the execution of a protocol. Such variations are assessed prior to the intercomparison validation that involves different EU laboratories. This step in the validation process may well lead to a tightening of the formulation of a protocol.

### 3.3 Repeatability and reproducibility

The repeatability and reproducibility of a test are determined in an intercomparison validation study.
The repeatability is determined as an interval around a measurement result (i.e. "repeatability limit"). This interval corresponds to the maximum difference that can be expected (with a 95% statistical confidence) between one test result and another, both test results being obtained in accordance with all the requirements of the standard by the same laboratory using its own facilities and testing laboratory samples obtained from the same primary field sample and prepared under identical procedures. The repeatability limit is calculated using the relationship: $r_{test} = f \cdot \sqrt{2} \cdot s_{r,test}$ with the critical range factor f = 2 with $s_{r,test}$ as the repeatability standard deviation.
The reproducibility is also determined as an interval around a measurement result (i.e. "reproducibility limit"). This interval corresponds to the maximum difference that can be expected (with a 95% statistical confidence) between one test result and another test result obtained by another laboratory, both test results being obtained in accordance with all the

requirements of the standard by two different laboratories using their own facilities and testing laboratory samples obtained from the same primary field sample and prepared under identical procedures. The reproducibility limit was calculated using the relationship: $R = f \cdot \sqrt{2} \cdot s_R$ with the critical range factor f = 2 with $s_R$ as the reproducibility standard deviation.
The repeatability standard deviation and the reproducibility standard deviation can also be used to determine the effective regulatory limit to comply with or meet the criteria set as limit values. In figure G.1 such an evaluation is given for PAH measurements soil, sludge, bio waste and waste (no such data available at present for construction products).

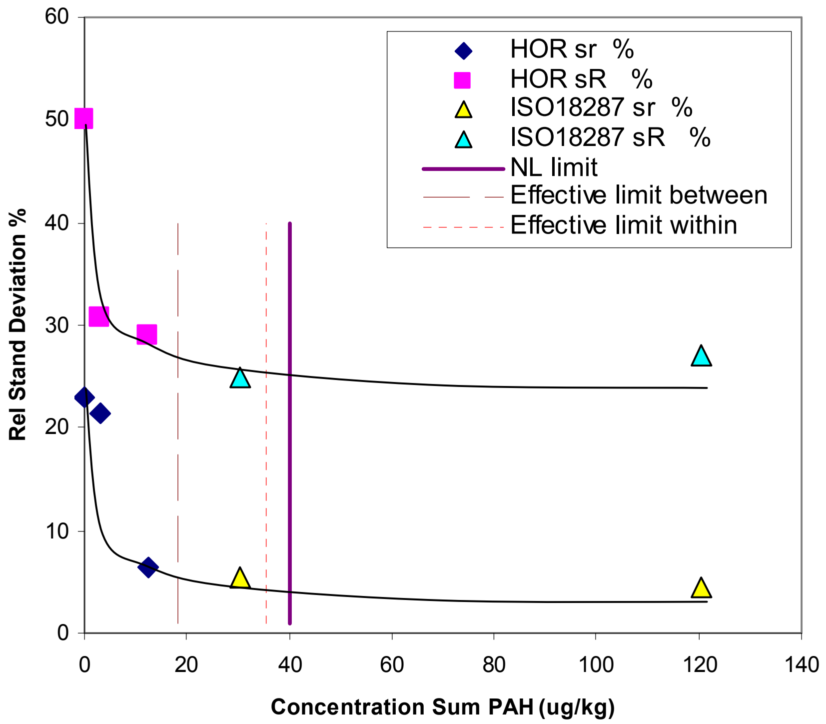



*Figure I.1. Repeatability and reproducibility standard deviations for the measurement of Sum PAH in soil, sludge, treated biowaste and waste as a function of concentration. The effective limit is calculated for both the repeatability (within a lab) and the reproducibility (between labs) limit as 35.6 mg/kg and 18.4 mg/kg respectively starting from a limit value of 40 mg/kg as an example.*

**3.4 Limitations of linear statistics for test data ranging over orders of magnitude**
For many parameters the normal statistics to define production targets to meet specified criteria in FPC apply without a problem. However, as soon as larger uncertainties occur, either due to inherent variability of the substances in a given matrix, still limited experience with certain substances or relatively low concentration levels of substances in the product considered, then normal statistics may not work anymore. In that case using an evaluation based on a log-normal distribution can work better.
The situation may occur that a measurement can be done over a fairly wide concentration range with acceptable repeatability, but the reproducibility may be poor. In that case, it will be difficult using normal statistics to define at what concentration level the target should be placed to comply with the regulatory limit value. E.g. when the reproducibility standard

deviation exceeds 50 %, the concentration to target for to comply with regulation at a 95% confidence interval can not be determined (concentration becomes negative). For this same situation one may find that one can determine a concentration under repeatability conditions and determine that with 95 % confidence, the product passes or fails the limit value. To be able to define a target concentration a log normal distribution may prove helpful. After quantifying the performance data for the log-normal data back calculation to the original concentrations allows realistic limits to be derived for this situation. An illustration of this situation is worked out in table I.2 below.

Table I.2. Total PCB data with and without log transformation to assess a target for FPC.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total PCB** | | **Linear** | | | | | |
| Mean = | 183.5 | µg/kg | % | | | Range<br>Mean + 2*sr | Mean - 2*sr |
| Repeatability variance | $S^2_r$ = | 227 | | | | | |
| Repeatability std. | $S_r$ = | 15.1 | 8.2 | | | 257 | 197 |
| Between lab variance | $S^2_L$ = | 8606 | | | | | |
| Reproducibility var. | $S^2_R$ = | 8833 | | | | | |
| Reproducibility std. | $S_R$ = | 94 | 51 | | | 372 | -4.5 |
| Remarks: | 1 Lab rejected! (60L) based on ISO 5725 statistics (n=21) | | | | | | |
| **Total PCB** | | **Log values** | | | | | |
| Mean = | 2.21 | | | | | | |
| Repeatability variance | $S^2_r$ = | 0.0010 | | | | | |
| Repeatability std. | $S_r$ = | 0.032 | | | | | |
| Between lab variance | $S^2_L$ = | 0.067 | | | | | |
| Reproducibility var. | $S^2_R$ = | 0.068 | | | | | |
| Reproducibility std. | $S_R$ = | 0.260 | | | | | |
| Remarks: | 2 Labs rejected! (60L ,17L) based on ISO 5725 statistics (n=21) | | | | | | |
| | Transformation to linear data | | | | | Range | |
| Mean = | 161.3 | µg/kg | Mean + sr# | Mean - sr# | % | Mean + 2*sr | Mean - 2*sr |
| Repeatability std. | $S_{r+}$ = | 12.4 | 173 | 149 | 7.7 | 187 | 139 |
| Repeatability std. | $S_{r}$ - = | 11.5 | | | 7.1 | | |
| Reproducibility std. | $S_R$ + = | 132.5 | 293 | 88 | 82 | 535 | 49 |
| Reproducibility std. | $S_R$ - = | 72.7 | | | 45 | | |

# Calculated as Exp (2.303*(mean [log value]+ sr or sR [log value])

As can be seen from this example on PCB analysis in soil, sludge and bio waste (Horizontal, 2007) the limit to comply with in case of a between lab reproducibility of > 50 percent becomes meaningless (negative values). In case the test data can be assumed to be log normal distributed, a meaningful effective limit can be derived after log transformation (48 µg PCB/kg).

**3.5 Heterogeneity**

Heterogeneity can be recognized in repeated measurements of the same test sample, when the observed variability is outside the range of normal values observed for that concentration level. This is illustrated in figure G.2 for TOC in compost versus TOC measurement in sludge and soil.

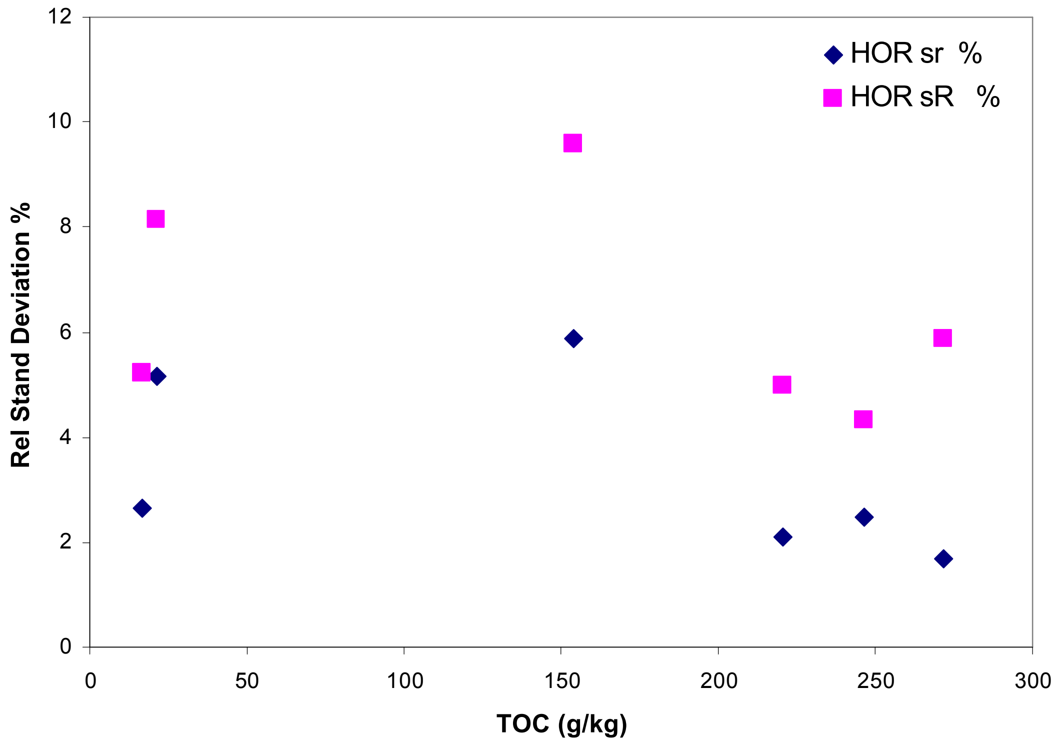



*Figure I.2 Illustration of heterogeneity of one matrix or one product relative to other products. The increased within and between lab variability of TOC for the product at 150 g/kg is indicative of sample heterogeneity as at that concentration level a factor of 2 better should have been achieved.*

In table I.3 heterogeneity can be identified for Cu, Pb and Zn in the composition of municipal solid waste incinerator bottom ash. At the concentration levels observed analytical uncertainty should be around a few percent. The explanation is the presence of metal pieces (like staples and pieces of wire, solder and zinc treated metal parts, which may or may not be present to the same degree in sub-samples taken from a bulk. In this case the uncertainty in the release measurement is considerably less for both Cu and Zn, while for Pb the higher uncertainty is now related to the low concentration level measured in the eluate.

Table I.3 Comparison of total composition and leaching data for municipal solid waste incinerator bottom ash illustrating heterogeneity in composition for Cu (e.g. staples, wire,), Mo, Pb and Zn. Release data are much more consistent and in a few cases are more determined by concentrations near the detection limit (As, Cr, and Pb) than heterogeneity problems.

| | Total content (mg/kg) | | | Leaching (mg/kg at L/S=10 ) | | | Ratio |
|---|---|---|---|---|---|---|---|
| Element | Average | Stdev | Stdev % | Average | Stdev | Stdev % | Leaching/Total |
| As | 13.9 | 1.7 | 12.4 | 0.0086 | 0.0057 | 67 | 6.15E-04 |
| Cr | 193 | 31 | 15.9 | 0.018 | 0.0077 | 43.2 | 9.15E-05 |
| Cu | 3652 | 2815 | 77.1 | 0.55 | 0.057 | 10.3 | 1.50E-04 |
| Mo | 4.4 | 1.9 | 42.9 | 0.051 | 0.0053 | 10.3 | 1.15E-02 |
| Pb | 1218 | 524 | 43 | 0.01 | 0.0078 | 75.9 | 8.40E-06 |
| SO4 as S | 2885 | 240 | 8.3 | 104 | 9.16 | 8.8 | 3.57E-02 |
| Zn | 2275 | 1045 | 45.9 | 0.017 | 0.0025 | 14.9 | 7.39E-06 |

### 3.6 Quality control

For FPC the variation of a production with time is of relevance. In figure G.3 this type of QC data are given for Zn from cement mortar. When these results are placed in context with regulatory criteria of 400 mg/m$^2$, it is immediately obvious that all results meet the criteria easily and this parameter would qualify for WT.

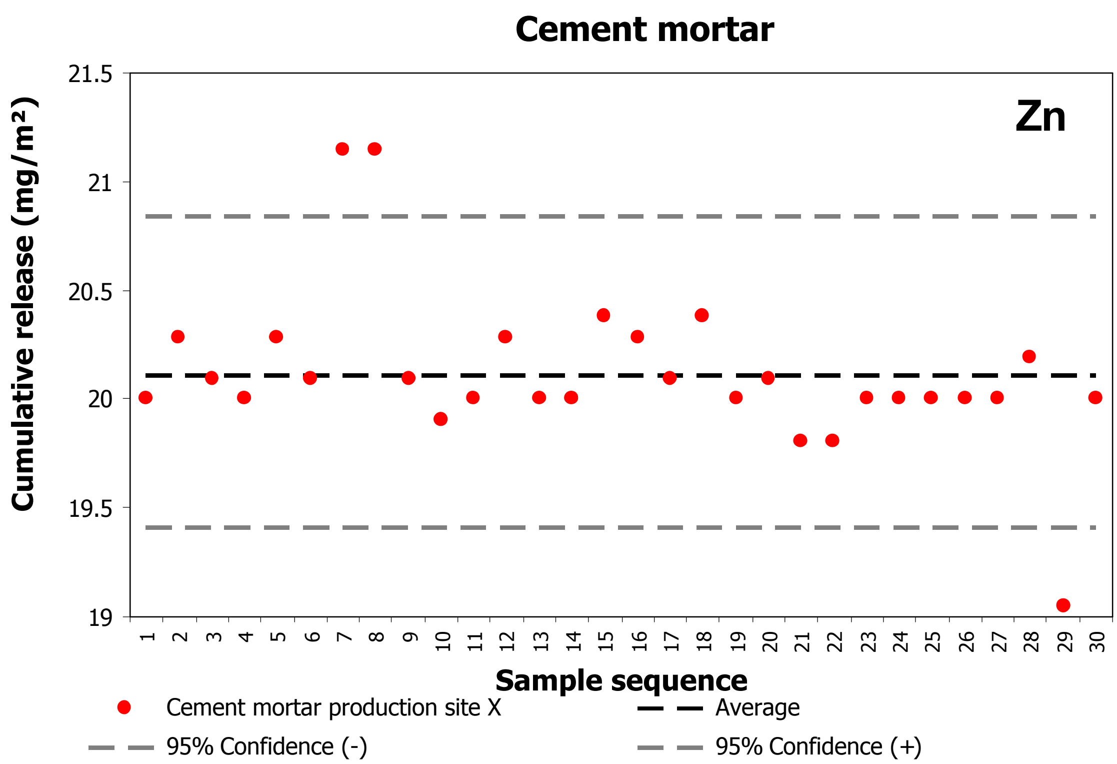



*Figure I.3 Factory production control data sheet as illustration for stability of production.*

# Annex J. Mandated work under the CPD

Summary from Construct 7/791

| MANDATE N° | PRODUCTS COVERED | TCs INVOLVED |
|---|---|---|
| M/100 | PRECAST CONCRETE PRODUCTS | CEN/TC 229 ‘Precast concrete products<br>CEN/TC 177’Prefabricated reinforced components of autoclaved aerated concrete or lightweight aggregate concrete with open structure’ |
| M/101 | DOORS, WINDOWS | CEN/TC 33 “Doors, windows, shutters and building hardware’ |
| M/102 | MEMBRANES | CEN/TC 254 ‘Flexible sheets for waterproofing” |
| M/103 | THERMAL INSULATION PRODUCTS | CEN/TC 88 ‘Thermal insulating materials and products’ |
| M/104 | STRUCTURAL BEARINGS | CEN/TC 167 ‘Structural bearings’ |
| M/105 | CHIMNEYS | CEN/TC 62 ‘Independent gas-fired space heaters’<br>CEN/TC 180 ‘Domestic and non-domestic gas-fired air heaters and non-domestic gas-fired overhead radiant heaters’<br>CEN/TC 166 ‘Chimneys, flues and specific products’<br>CEN/TC 297 ‘Free-standing industrial chimneys’ |
| M/106 | GYPSUM PRODUCTS | CEN/TC 241 ‘Gypsum and gypsum based products’ |
| M/107 | GEOTEXTILES | CEN/TC 189 ‘Geotextiles and geotextile-related products |
| M/108 | CURTAIN WALLING | CEN/TC 33 ‘“Doors, windows, shutters and building hardware’ |
| M/109 | FIXEX FIRE-FIGHTING EQUIPMENT | CEN/TC 72 ’Automatic fire detection systems’<br>CEN/TC 191’ Fixed fire fighting systems’<br>CEN/TC 192 ‘Fire service equipment’ |
| M/110 | SANITARY APPLIANCES | CEN/TC 163 ‘Sanitary appliances’ |
| M/111 | CIRCULATION FIXTURES | CEN/TC 50 ‘Lighting columns and spigots’<br>CEN/TC 226 ‘Road equipment’ |
| M/112 | STRUCTURAL TIMBER PRODUCTS AND ANCILLARIES | CEN/TC 124 ‘Timber structures’ |
| M/113 | WOOD-BASED PANELS | CEN/TC 112 ‘Wood-based panels’ |

| MANDATE N° | PRODUCTS COVERED | TCs INVOLVED |
|---|---|---|
| M/114 | CEMENT | CEN/TC 51 ‘Cement and building limes’ |
| M/115 | REINFORCING STEEL | ECISS/TC 19 ‘Concrete reinforcing steel-Qualities, ‚dimensions and tolerances’ |
| M/116 | MASONRY | CEN/TC 125 ‘Masonry’ |
| M/118 | WASTE WATER ENGINEERING | CEN/TC 155 ‘Plastic piping systems and ducting systems’<br>CEN/TC 165 ‘Waste water engineering’ |
| M/119 | FLOORINGS | CEN/TC 67 ‘Ceramic tiles’<br>CEN/TC 129 ‘Glass in buildings’<br>CEN/TC 134 ‘Resilient and textiles floor coverings’<br>CEN/TC 175 ‘Round and sawn timber’<br>CEN/TC 178 ‘Paving units and curbs’<br>CEN/TC 217 ‘Surfaces for sports areas’<br>CEN/TC 229 ‘Precast concrete products’<br>CEN/TC 246 ‘Natural stones’ |
| M/120 | STRUCTURAL METALLIC PRODUCTS | CEN/TC 121 ‘Welding’<br>CEN/TC 132 ‘Aluminium and aluminium alloys’<br>CEN/TC 133 ‘Copper and copper alloys’<br>CEN/TC 135 ‘Execution of steel structures and aluminium structures’<br>CEN/TC 185 ‘Threaded and non-threaded mechanical fasteners and accessories’<br>ECISS/TC 10 ‘Structural steels – Qualities’<br>ECISS/TC 13 ‘Flat products for cold working-qualities, dimensions, tolerances and specific tests’<br>ECISS/TC 19 ‘Concrete reinforcing steel – Qualities, dimensions and tolerances’<br>ECISS/TC 23 ‘Steels for heat treatment, alloy steels and free-cutting steels-qualities’<br>ECISS/TC 29 ‘Steel tubes and fittings for steel tubes’<br>ECISS/TC 31 ‘Steel castings’ |

| MANDATE N° | PRODUCTS COVERED | TCs INVOLVED |
|---|---|---|
| M/121 | WALL AND CEILING FINISHES | CEN/TC 67 ‘Ceramic tiles’<br>CEN/TC 99 ‘Wall coverings’<br>CEN/TC 128 ‘Roof covering products for discontinuous laying and products for wall cladding’<br>CEN/TC 175 ‘Round and sawn timber’<br>CEN/TC 246 ‘Natural stones’<br>CEN/TC 249 ‘Plastics’<br>CEN/TC 277 ‘Suspended ceilings’<br>BT/TF/119 ‘Stretched ceilings’ |
| M/122 | ROOF COVERINGS | CEN/TC 128 ‘Roof covering products for discontinuous laying and products for wall cladding’ |
| M/124 | ROAD CONSTRUCTION PRODUCTS | CEN/TC 127 ’Road materials’<br>CEN/TC 336 ‘Bituminous binders’ |
| M/125 | AGGREGATES | CEN/TC 154 ‘Aggregates’ |
| M/126 | AMENDMENTS TO M/100, M/101, M/102, M/103 | see M/100, M/101, M/102, M/103 |
| M/127 | ADHESIVES | CEN/TC 67 ‘Ceramic tiles’<br>CEN/TC 193 “Adhesives’ |
| M/128 | PRODUCTS RELATED TO CONCRETE, MORTAR AND GROUT | CEN/TC 104 ‘Concrete’<br>CEN/TC 298 ‘Pigments and extenders’ |
| M/129 | SPACE HEATING APPLIANCES | CEN/TC 46 ‘Oil stoves’<br>CEN/C 130 ‘Space heating appliances without integral heat sources’<br>CEN/TC 295 ‘Residential solid fuel burning appliances’ |
| M/130 | AMENDMENTS TO M/100, M/101, M/102, M/105, M/106, M/109 | See M/100, M/101, M/102, M/105, M/106, M/109 |

| MANDATE N° | PRODUCTS COVERED | TCs INVOLVED |
|---|---|---|
| M/131 | PIPES, TANKS NOT IN CONTACT WITH DRINKING WATER | CEN/TC 69 'Industrial valves'<br>CEN/TC 92 'Water meters'<br>CEN/TC 155 'Plastic piping systems and ducting systems'<br>CEN/TC 164 'Water supply'<br>CEN/TC 193 "Adhesives'<br>CEN/TC 203 'Cast iron pipes, fittings and their joints'<br>CEN/TC 208 'Elastomeric seals for joints in pipework and pipelines'<br>CEN/TC 221 'Shop fabricated metallic tanks and equipment for storage and for service stations'<br>CEN/TC 235 'Gas pressure regulators and associated safety shut-off devices for use in gas transmission and distribution'<br>CEN/TC 236 'Non-industrial manually operated shut-off valves for gas and particular combinations valves and other products'<br>CEN/TC 266 'Thermoplastic static tanks' |
| M/132 | AMENDMENT TO M/104, M/111, M/109 | CEN/TC 241 "Gypsum products"<br>CEN/TC 340 'Anti-seismic devices' |
| M/135 | GLASS | CEN/TC 129 'Glass in buildings' |
| M/136 | CONSTRUCTION PRODUCTS IN CONTACT WITH DRINKING WATER | CEN/TC 69 'Industrial valves'<br>CEN/TC 92 'Water meters'<br>CEN/TC 155 'Plastic piping systems and ducting systems'<br>CEN/TC 164 'Water supply'<br>CEN/TC 193 "Adhesives'<br>CEN/TC 203 'Cast iron pipes, fittings and their joints'<br>CEN/TC 235 'Gas pressure regulators and associated safety shut-off devices for use in gas transmission and distribution'<br>CEN/TC 236 'Non-industrial manually operated shut-off valves for gas and particular combinations valves and other products'<br>CEN/TC 266 'Thermoplastic static tanks' |
| M/138 | AMENDMENT TO M/103 | CEN/TC 88 "Thermal insulating materials and products' |

| MANDATE N° | PRODUCTS COVERED | TCs INVOLVED |
|---|---|---|
| M/139 | AMENDMENTS TO M/100, M/106, M/109, M/110, M/125 | See M/100, M/106, M/109, M/110, M/125 |
| M/367 | ADDENDUM TO M/103 | CEN/TC 88 “Thermal insulating materials and products’ |
| M/368 | AMENDMENT TO M/110 | CEN/TC 163 ‘Sanitary appliances’ |
| M/369 | AMENDMENT TO M/129 | CEN/TC 312 “Thermal solar systems and components” |
| M/386 | AMENDMENT TO M/107 | CEN/TC 189 ‘Geotextiles and geotextile-related products” |
| M/387 | AMENDMENT TO M/124 | CEN/TC 227 ’Road materials’ |

**OTHER MANDATES (For test methods)**

| MANDATE | TEST METHODS | TCs INVOLVED |
|---|---|---|
| M/88 | Reaction to fire test methods | 127 ‘Fire safety in buildings’ |
| M/117 | Resistance to fire | 127 ‘Fire safety in buildings’ |
| M/123 | Amendment to M/88 | 127 ‘Fire safety in buildings’ |
| M/133 | Amendment to M/88 | 127 ‘Fire safety in buildings’ |
| M/134 | Amendment to M/117 | 127 ‘Fire safety in buildings’ |
| M/137 | Amendment to AoC fire | 127 ‘Fire safety in buildings’ |
| M/385 | Amendment to M/88 | 127 ‘Fire safety in buildings’ |
| M/366 | Development of horizontal standardized assessment methods for harmonized approaches relating to dangerous substances under the CPD | 351 ‘Construction products -Assessment of release of dangerous substances |

# Annex K. Effects and exposure limit values

| Pollutant | Possible sensitivity/effect | Recommended exposure limit |
|---|---|---|
| **Organic gases** | | |
| Formaldehyde ($CH_2O$)* | Short-term: irritation of the eyes, nose and throat, together with concentration-dependent discomfort, lachrymation, sneezing, coughing, nausea, dyspnoea and finally death<br>Long-term: upper and lower airway irritation and eye irritation in humans; degenerative, inflammatory and hyperplastic changes of the nasal mucosa<br>nasopharyngeal cancer | The non-carcinogenic no-effect level is 30 µg/m$^3$. Pending on IARC revision of formaldehyde carcinogenecity, a guideline should be as low as reasonably achievable |
| Benzene ($C_6H_6$)* | aplastic anemia and acute myelogenous leukemia | Benzene is a carcinogen, its indoor air concentration should be kept as low as reasonably achievable, and not exceed outdoor concentrations. |
| Naphtalene ($C_{10}H_8$)* | sensitivity of certain subpopulations to naphthalene toxicity, including infants and neonates<br>hemolytic anemia caused by deficiency in glucose-6-phosphate dehydrogenase (G6PD), | long term guideline value is 10 µg/m$^3$. |
| Acetaldehyde ($C_2H_4O$)* | Short-term: irritation of the eyes and respiratory tract and altered respiratory function<br>Long-term: eye and upper respiratory tract irritation with the possibility of chronic tissue damage and inflammation in the respiratory tract<br>considered a probable human carcinogen: upper respiratory tract cancer (smoking) | 200 µg/m$^3$ |
| Toluene ($C_7H_8$)* | Short-term: Dysfunction of the central nervous system and narcosis; irritation of the skin, eye, and respiratory tract; Inhalational abuse of toluene with high Long-term: progressive and irreversible changes | 300 µg/m$^3$<br>Acute 15,000 µg/m3 |

| | | |
|---|---|---|
| | in brain structure and function | |
| Xylenes ($C_8H_{10}$) meta (m-), para (p-) and ortho (o-)* | short-term inhalation: irritation of the eyes, nose, and throat, gastrointestinal effects, eye irritation, and neurological effects. Chronic (long-term) inhalation: central nervous system (CNS) effects, such as headache, dizziness, fatigue, tremors, and incoordination; respiratory, cardiovascular, and kidney effects have also been reported. | 200 µg/$m^3$<br>Short-term 20 µg/$m^3$ |
| Styrene ($C_8H_8$)* | Short-term: irritate the eyes and mucous membranes and may be toxic to the central nervous system<br>Long-term: central nervous system (CNS) and peripheral nervous system effects,<br>Possible carcinogenic | long-term 250 µg/$m^3$ |
| Limonene ($C_{10}H_{16}$)* | low acute toxicity | 450 µg/$m^3$ |
| α-pinene ($C_{10}H_{16}$)* | irritative effects to the eyes, nose and throat | 450 µg/$m^3$ |
| TVOC | Irritation, intoxication, cancer, allergy | TVOC $<$ 0.2 mg/$m^3$<br>Allergic people: with much lower concentrations effects possible |
| | **Inorganic gases** | |
| $O_3$** | decrements in lung function, airway inflammatory changes, exacerbations of respiratory symptoms and symptomatic and functional exacerbations of asthma in exercising susceptible people. | 120 µg/$m^3$ (8 hour) |
| Ammonia ($NH_3$)* | Short-term: site-of-contact lesions primarily of the eyes and the respiratory tract; eye, nose, and throat irritation, coughing, and narrowing of the bronchi.<br>Long-term: respiratory distress | Short 70 µg/$m^3$<br>Long term 100 µg/$m^3$ |
| Radon | Radon is a known human carcinogen (classified by IARC as Group 1 with | A lifetime lung cancer risk below about 1 × 10–4 cannot |

| | | |
|---|---|---|
| | genotoxic action.) | be expected to be achievable because natural concentration of radon in ambient outdoor air is about 10 Bq/m$^3$. No guideline value for radon concentration is available. |
| **Particulate matter** | | |
| PM 10**<br>PM2.5** | Short term: Eye irritation, conjunctivitis, reduced lung function Long-term exposure to particulate matter is associated with reduced survival, and a reduction of life expectancy in the order of 1–2 years. Prevalence of bronchitis symptoms in children, and of reduced lung function in children and adults. | These effects have been observed at annual average concentration levels below 20 µg/m$^3$ (as PM2.5) or 30 µg/m$^3$ (as PM10). No guidelines can be given. |
| Man-made vitreous fibres (MMVF)** | MMVF of diameters greater than 3 µm can cause transient irritation and inflammation of the skin, eyes and upper airways;<br>IARC classified rock wool, slag wool, glass wool and ceramic fibres in Group 2B (possibly carcinogenic to humans) while glass filaments were not considered classifiable as to their carcinogenicity to humans (group 3) | The corresponding concentrations of refractory ceramic fibres producing excess lifetime risks of 1/10 000, 1/100 000 and 1/1 000 000 are 100, 10 and 1 fibre/l, respectively.<br>For most other MMVF, available data are considered inadequate to establish air quality guidelines. |
| **Bioaerosols** | | |
| Moulds (10 – 30 µm), mycotoxines | Intoxication, allergy | - |

* INDEX report (JRC, 2005);** WHO guidelines (WHO, 2000) *** ECA, 1991

# Annex L. Questionnaires

## *L1. Products TCs for first round of evaluation*

### EVALUATION OF RELEVANCE FOR INDOOR AIR IMPACT

For TCs covering several products or product groups, it may be most convenient to list all products or product groups covered by the TC in this table and then in case different intended use scenarios apply link products/product groups to the answers for each issue in separate tables. To the extent relevant additional information may be provided in annexes. Where appropriate, references to existing information can be provided.

| **CEN/TC 88 Thermal insulating materials and products** | |
|---|---|
| **Scope:** Standardisation in the field of thermal insulating materials and products for application in buildings, including insulation for installed equipment and for industrial insulation, covering: terminology and definitions, list of required properties with regard to different applications, methods for the determination of these properties, sampling procedures, conformity criteria, specifications for insulating materials and products, marking and labelling of insulating materials and products. | |
| **Issues** | **Description** |
| Products covered [a] | Thermal insulation for walls, floors and ceilings (between interior and exterior wall or as part of a pre-fabricated panel), for pipes and ducts (on outside) |
| Relevant scenario(s) for intended use[b] | In general: not in direct contact with indoor air |
| Typical composition of product(s) [c] | Products are generally made of organic fibres, inorganic fibres and particles, plastics (foamed), or glass (foamed).M1 |
| Typical emissions of (groups of) substances[d] | Potential release of dangerous substances: benzo(a)pyrene back bitumen), biopersistent fibres, biocides (used timber, wood fibres), CMR substances Cat. I/II, flame retardants, formaldehyde (synthetic resin), phenol (synthetic resin), pyrethroids (sheep wool), VOC. |
| Related legislation[e] | |
| Relevant substances normally tested [f] | VOC, formaldehyde |
| Available (standardized) test methods [g] | ISO 16000 series |
| Available test data [h] | |
| Recycling [i] | recycled glass might be contaminated with metal fibres; recycled wood or organic matter might contain biocides |
| Additional information [j] | |
| Volume of product(s) produced/used annually [k] | |
| Used schemes and labelling systems[l] | M1? |
| Europe organization [m] | EURIMA, EUMEPS, BING, EPFA, etc. |

| **CEN/TC 104 Concrete** | |
|---|---|
| **Scope:** Deals with the standardisation of provisions for concrete and related products, in particular with respect to properties and requirements for: - fresh and hardened concrete; - production and delivery of fresh concrete; - constituent materials of concrete, e.g. mixing water, additions and admixtures; - sheaths for pre-stressing tendons; grout for pre-stressing tendons; - fibres for use in concrete; - execution of concrete structures; - production and execution of sprayed concrete; - products for the protection and repair of concrete structures. Additionally relevant test methods and provisions for the assessment of conformity for the products and procedures mentioned above are standardized. Not covered by the scope of TC 104 are: - the constituent materials; aggregate (see CEN/TC 154), Pigments (see CEN/TC 298) and Cement (see CEN/TC 51); - the design of concrete structures and components (see CEN/TC 250/SC 2); - pre-cast concrete products (see CEN/TC 229); - prefabricated autoclave aerated and no-fines light weight concrete components (see CEN/TC 177). | |
| **Issues** | **Description** |
| Products covered [a] | Concrete and related products |
| Relevant scenario(s) for intended use[b] | 1.Applied in direct contact with indoor air<br>2.<br>3. chapter 2.1 |
| Typical composition of product(s) [c] | Sand, water and filler? |
| Typical emissions of (groups of) substances[d] | Of interest to indoor air: the amount of water still present in the concrete after indoor finishing materials are applied |
| Related legislation[e] | |
| Relevant substances normally tested [f] | ? |
| Available (standardized) test methods [g] | ISO 16000 series? |
| Available test data [h] | |
| Recycling [i] | Aggregates can consist of chemically undefined recycled materials |
| Additional information[j] | |
| Volume of product(s) produced/used annually [k] | |
| Used schemes and labelling systems[l] | M1? |
| European organization [m] | ERMCO |

| **CEN/TC 112**: **wood based panels** | |
|---|---|
| **Scope:** Preparation of standards for wood-based panels and panels of other lignocellulosic materials covering: - terminology; - classification; - requirements; - product specifications; - methods of tests. | |
| **Issues** | **Description** |
| Products covered [a] | The main wood-based panel types present on the market are fibreboards, particleboards and OSB (oriented strand board), and plywood. Wood-based panels are mainly used in the building sector and in the furniture industry. Besides unfaced raw boards wood-based panels are overlaid e.g. covered with melamine impregnated papers or veneers on their panel surfaces. |
| Relevant scenario(s) for intended use[b] | Finishing and construction product directly in contact with indoor air, sometimes covered with a thin layer |
| Typical composition of product(s) [c] | solid wood, chipped wood, wood veneers, wood fibres, impregnated paper, (melamine formaldehyde), metal, organic adhesives (resins), inorganic adhesives (cement), paints, coatings |
| Typical emissions of (groups of) substances[d] | arsenic, benzene (adhesives, dyes, coatings), benzo(a)pyrene, biocides, cadmium and its compounds (dyes), chromium, CMR substances Cat. I/II. Flame retardants, mercury, PCB (used wood), phenols, heavy metals (used wood), tar oils, formaldehyde and VOC |
| Related legislation[e] | Formaldehyde regulations fall into classes E1/E2. several member states require E1 (NL, DK, FI, SE,..) |
| Relevant substances normally tested [f] | Formaldehyde |
| Available (standardized) test methods [g] | CEN EN 717 2004 Wood-based panels – Determination of formaldehyde release<br>Part 1 : Formaldehyde emission by the chamber method<br>Part 2: Formaldehyde release by the gas analysis method<br>Part 3 : Formaldehyde release by the flask method<br>CEN EN 120 Wood-based panels – Determination of formaldehyde content – Extraction method called the perforator method<br>CEN 1250-1 Wood preservatives – Methods for measuring losses of active ingredients and other preservative ingredients from treated timber – Part 1 : Laboratory method for obtaining samples for analysis to measure losses by evaporation to air<br>ISO 16000 Indoor air in particular: Part 2 : Sampling strategy for formaldehyde and Part 3 : Determination of formaldehyde and other carbonyl compounds – Active sampling method |
| Available test data [h] | |
| Recycling [i] | Recycled metal may be used in these wood based panels |
| Additional information [j] | Differences between ISO 16000 and EN717? |
| Volume of product(s) produced/used annually [k] | |
| Used schemes and labelling systems[l] | M1? |
| European organization [m] | European wood, CEI-BOIS (these are connected) |

| **CEN/TC 134 Resilient, textile and laminate floor coverings**[2] | |
|---|---|
| **Scope:** Standardization of definitions, requirements, classification and test methods and provision of guidance documents and reports for resilient and textile floor coverings and for laminated floor coverings | |
| **Issues** | **Description** |
| Products covered [a] | Resilient, textile and laminate floor coverings<br>(Inorganic floorings such as ceramic tiles, natural stone floorings and artificial stone floorings are not part of this TC, which only includes organic materials.) |
| Relevant scenario(s) for intended use[b] | Products are used indoors in large surface to volume ratio and are potential indoor air polluters. |
| Typical composition of product(s) [c] | **Resilient floorings**: ready-made products in the form of strips or tiles that are capable of recovering to a certain extent after pressure has been exerted on them. The include PVC, polyolefins, linoleum, rubber and cork.<br>**Textile floor coverings**: made of natural and artificial fibres, e.g. Pile carpets and Needled floor coverings. Comprises of a wear layer and a backing. Pile carpets can be bonded physically or chemically. Needled pile floorings can be partly or completely impregnated with a bonding agent (synthetic latex or acrylates or bitumen). They generally receive a chemical finish e.g. flame retardants, pesticides or antistatic sprays.<br>**Laminate floorings**: rigid flooring (next to wood floorings), consisting of a surface layer by one or more this sheets of a fibrous material (usually paper) impregnated with amino plastic thermosetting resins. A backer is applied to the lower side of the substrate to balance and stabilize the product, it consists of pressed laminate, impregnated veneer or veneer. |
| Typical emissions of (groups of) substances[d] | Finishing materials of floors in indoor spaces. The emission of VOC in indoor air and SVOC (mostly attached to house dust) are relevant.<br>At room temperature, floorings can release volatile organic compounds that are constituents of diverse materials used in them. The adhesives used may cause extra emissions, especially if proper physical and chemical conditions in substrate layer is neglected when inserting flooring in the building. Use of proper cleaning methods is also critical. . |
| Related legislation[e] | AgBB? |
| Relevant substances normally tested [f] | VOC |
| Available (standardized) test methods [g] | DIN ISO 2424 gives a classification of textile floorings.<br>ISO-16000 series and AgBB |
| Available test data [h] | |
| Recycling [i] | ? |
| Additional information [j] | |
| Volume of product(s) produced/used annually [k] | |
| Used schemes and labelling systems[l] | M1 and AgBB? |
| European organisation | |

[2] Chapter 6 of UBA report 14/06 Implementation of Health and Environmental Criteria in Technical Specifications for Construction Products

| **CEN/TC 349 Sealants for joints in building construction** | |
|---|---|
| **Scope:** not available? | |
| **Issues** | **Description** |
| Products covered [a] | Sealants for joints in building construction (Glass products such as glazing) |
| Relevant scenario(s) for intended use[b] | Direct contact to indoor air |
| Typical composition of product(s) [c] | |
| Typical emissions of (groups of) substances[d] | The sealants applied to glazing and the connections of the glazing with the windows can give arise to emissions of dangerous substances. Primary emissions of sealants and secondary emissions caused by micro-organisms in the in-use phase; sensitivity to growth should be specified |
| Related legislation[e] | |
| Relevant substances normally tested [f] | VOC, Microbiological growth |
| Available (standardized) test methods [g] | ISO 16000 series |
| Available test data [h] | |
| Recycling [i] | |
| Additional information [j] | |
| Volume of product(s) produced/used annually [k] | |
| Used schemes and labelling systems[l] | M1? |
| European organization [m] | |

Notes:

a Here the different construction products or product groups covered by the TC can be listed.

b Relevant scenarios for intended use in indoor environment are specified here

1.In direct contact with indoor air: Products/components that are applied in such a manner that they are in direct contact with the indoor air, e.g. the finishing materials of floor, wall and ceiling (flooring, wallpaper, paint). These materials can directly emit or release substances into the indoor air: volatile organic compounds, radiation, biological compounds etcetera.

2. Not in direct contact with indoor air, possible impact on indoor air.

3. Not in direct contact with indoor air, impossible impact on indoor air

c Provide information on the typical composition of the product(s) related to emission to indoor air.

d What are the typical (groups of) emissions of substances from the products?

e Are there relevant European and/or national legislation related to the composition or emission of the products?

f Which substances emitted from the product(s) are normally tested?

g Which existing test methods (European or international standards) are available/used providing relevant information? Provide reference number and title of the method(s).

h Are test results available? If yes, please provide typical test results as example. Provide reference to documentation or literature providing background information on test development/ test validation/test use.

jiThe CPD covers the in-use phase. However, recycling of products at the end of their service life is becoming standard practice nowadays. Recycling in other sectors can be foreseen, which may be limited to referencing another TC (e.g. TC 154).

j At this place additional information may be given. An example is effects of cleaning agents , when that is normally not addressed, but which may play a significant role.

k An estimate of the volume of the construction product (s) falling under the scope of the TC produced annually in Europe and used for the building construction is requested to get an impression of the relative importance of potential impacts.

lList the schemes and labelling schemes for which the product(s) are tested and registered

m Are European organizations involved in the coordination of market and legal aspects, including the impact of CPD, for the construction product(s) falling under the scope of the TC?

## *L2. Questionnaire for second round of evaluation*

**Questionnaire**
Dear Convenor of CEN/TC XXX,

CEN/TC351/TG2 would like to get some help from you.

The European Commission has decided to add environmental aspects to the CE-marking of construction products with respect to essential requirement 3 of the Construction Products Directive: Hygiene, Health and the Environment. A mandate to specify harmonized horizontal standards of chemicals emissions from (and sometimes chemicals content of) construction products was issued by the Commission in 2006, CEN/TC 351 was created to perform the tasks laid down in that mandate.

One of the main goals of this standardization project is to minimize and organize the number of standards in use today. This will in the future make the burden of testing for chemicals easier on the producers and open up the European market for trade.

One of the first tasks is to write a technical report describing which construction products are relevant for emissions to indoor air or release to soil and ground water, what chemical substances they may emit and by which scenario, and how this is measured today. And also to identify whether the construction products in question are subject to specific legislation (national or harmonized) concerning content or emission of chemical substances.

Our task is to write this report regarding emissions to indoor air. To describe the state of the art we need to describe what product groups are relevant and in which way. Since we do not have the knowledge to judge the products, we need your help. Which product TCs have been chosen to answer the questionnaire has been based on a list of mandated product TCs and the scopes of those. By the scope of your TC, you are very important to us. Please help to fill in the questionnaire enclosed with this letter. Any information would be very helpful.

To help you to fill in the questionnaire, enclosed you will the first draft of the report. This draft report is far from finished and is a first attempt and we invite you to comment it wherever you find appropriate. The final report is expected to be finished by the end of the year. Your reply, questionnaire and comments on report, is needed as soon as possible but no later than the end of September 2007.

Yours sincerely,

Any questions may be sent to philo.bluyssen@tno.nl or sara.giselsson@boverket.se.

## Questionnaire for products TCs and EOTA working groups

| **CEN/TC "XX" Title** | |
|---|---|
| **Scope:** | |
| **Issues** | **Description** |
| Products covered [a] | |
| Relevant scenario(s) for intended use[b] | |
| Typical composition of product(s) [c] | |
| Typical emissions of (groups of) substances[d] | |
| Related legislation[e] | |
| Relevant substances normally tested [f] | |
| Available (standardized) test methods [g] | |
| Available test data [h] | |
| Additional information [i] | |
| Volume of product(s) produced/used annually [j] | |
| Used schemes and labelling systems[k] | |
| Europe organization [l] | |

Notes:

a Here the different construction products or product groups covered by the TC can be listed.
b Relevant scenarios for intended use in indoor environment (see Chapter 2.1 page 7 of draft report )
c Provide information on the typical composition of the product(s) related to emission to indoor air.
d What are the typical (groups of) emissions of substances from the products? (you can use the list on page 13 of the draft report for this)
e Are there relevant European and/or national legislation related to the composition or emission of the products?
f Which substances emitted from the product(s) are normally tested?
g Which existing test methods (European or international standards) are available/used providing relevant information? Provide reference number and title of the method(s). (please use Annex E of the draft report and if standardisation is missing please indicate)
h Are test results available? If yes, please provide typical test results as example. Provide reference to documentation or literature providing background information on test development/ test validation/test use.
i At this place additional information may be given.
j An estimate of the volume of the construction product (s) falling under the scope of the TC produced annually in Europe and used for the building construction is requested to get an impression of the relative importance of potential impacts.
kList the schemes and labelling schemes for which the product(s) are tested and registered
l Are European organizations involved in the coordination of market and legal aspects, including the impact of CPD, for the construction product(s) falling under the scope of the TC?

## *L3. Answers*

| **CEN/TC 88 – WG10** – FEF (prEN 14304) | |
|---|---|
| Scope: Product Standard for Flexible Elastomeric Foam Insulation | |
| Issues | Description |
| Products covered | Flexible Elastomeric Foam based Insulation products |
| Relevant scenario(s) for intended use | Industrial & Equipment insulation e.g.: HVAC units, air ducts etc. “A2 , A3 category” |
| Typical composition of product(s) | Butadiene Acrylnitril (=rubber) based product with inorganic fillers and flame retardants (organic & inorganic) |
| Typical emissions of (groups of) substances | None , The product in question follows AgBB requirements (LCI) concept. |
| Related legislation | Not available |
| Relevant substances normally tested | See AgBB requirements VOC , SVOC…. |
| Available (standardized) test methods | ISO 16000 series |
| Available test data | Test report(s) against AgBB and other |
| Additional information | ------ |
| Volume of product(s) produced/used annually | ???? |
| Used schemes and labelling systems | AgBB |
| European organization | ????? |

| **CEN/TC 88 – WG4** Expanded polystyrene | |
|---|---|
| Scope: Insulation materials for thermal insulation of buildings, installed equipment and light weight fill in engineering applications | |
| Issues | Description |
| Products covered | Expanded polystyrene (EPS); EN 13163 / prEN 14390 / prEN 14933 |
| Relevant scenario(s) for intended use | Not in direct contact with air |
| Typical composition of product(s) | $C_8H_8$ |
| Typical emissions of (groups of) substances | None |
| Related legislation | None |
| Relevant substances normally tested | None |
| Available (standardized) test methods | Not relevant |
| Available test data | Not relevant |
| Additional information | Not relevant |
| Volume of product(s) produced/used annually | 1 Mio Ton per annum in EU+ |
| Used schemes and labelling systems | Not relevant |
| European organization | EUMEPS |

| Mineral Wool | |
|---|---|
| Scope: Mineral Wool products are used to provide thermal insulation in building constructions, building equipments and industrial applications. Common applications for buildings include: loft insulation, cavity wall insulation, internal wall insulation, external wall insulation, internal and external roof insulation for flat and pitched roofs. Common applications for building equipment include: insulation of heating systems, hot and cold water services. Common industrial applications include: pipe insulation, insulation of tanks and vessels, insulation for boilers and turbines, marine and offshore installations. Outside the scope of TC88, mineral wool products are also used for acoustical purposes and passive fire protection. The Standardisation Committee is CEN/TC88 'Thermal insulation materials and products'. The harmonised technical specification EN 13162 (thermal insulation products for buildings – factory made mineral wool (MW) products – specification) | |
| Issues | Description |
| Products covered | See above |
| Relevant scenario(s) for intended use | In building construction applications, thermal insulation mineral wool is generally installed as part of an overall system not directly in contact with indoor air. The uses of mineral wool exclude exposure to rain and direct contact with water, including ground water.<br>Examples of it use includes: insulation behind concrete walls or floors: behind bricks: behind plasterboard or other internal surface coverings: under roof tiles behind vapour barrier membranes and separated from rooms by coverings: under flooring: under concrete or similar screeds: on flat roofs over steel or concrete decks on vapour barrier membranes: on external walls covered with render or rain screen cladding etc.<br>Ceiling tiles for acoustical purposes are covered with paintings or coatings. |
| Typical composition of product(s) | Mineral wool fibres are the main components of the product. The remaining 2 % - 8 % organic content is generally a thermo setting resin binder (an adhesive) and a bit oil |
| Typical emissions of (groups of) substances | There are no typical emissions during intended use of mineral wool insulation. Possible emissions to indoor air: formaldehyde and radiation |
| Related legislation | There is no European or national legislation related to the emission of dangerous substances |
| Relevant substances normally tested | None |
| Available (standardized) test methods | There are no standardised test methods for mineral wool insulation products. Data concerning the emission of formaldehyde were obtained in accordance with the EN ISO 16000 series |
| Available test data | Formaldehyde, radiation |
| Recycling | Recycled materials are used as input for the production of mineral wool products. All constituents are embedded in the glass matrix |
| Additional information | All mineral wool products produced in the EU fulfil the requirements of Nota Q of Directive 97/69/EC, i. e. there are no bio persistent fibres (defined according to Nota Q) in the products |
| Volume of product(s) produced/used annually | Immense |
| Used schemes and labelling system | M 1, fulfilling also the criteria of AgBB |
| European organisation | EURIMA |

| **CEN/TC 112 Title "Wood-based panels"** | |
|---|---|
| **Scope:** Preparation of standards for wood-based panels and panels of other lignocellulosic materials covering: terminology - classification – requirements – product specifications – methods of tests. | |
| **Issues** | **Description** |
| Products covered | Wood-based panels<br>- particle boards<br>- fibre boards (medium density boards, hardboards, soft boards)<br>- oriented strand boards<br>- plywood |
| Relevant scenario(s) for intended use | Fields of application:<br>- Constructive purposes in buildings (walls)<br>- Construction material for floors and ceilings<br>- Insulations (walls)<br>- Decorative and functional interiors (doors, decorative panels and ceilings, furniture)<br>Relevant scenarios:<br>- Covered with card boards, wall papers and indirectly with paints (walls, ceilings)<br>- Coated with laminates and foils (floors, interiors)<br>- Coated with veneers and lacquers (floors, interiors, doors)<br>- Coated directly with paints and lacquers (interiors, doors) |
| Typical composition of product(s) | - Organic matter (wood or other lignocellulosic particles, fibres, strands or veneers: 85 to 99 % of dry weight)<br>- Organic adhesives and glues:<br>- urea-formaldehyde resins, urea-melamine-formaldehyde resins (7 to 12 %)<br>- phenol-formaldehyde resins, resorcinol-formaldehyde resins (9 to 15 %)<br>- polymeric methane-diphenol-diisocyanate (2 to 5 %)<br>- Additives such as hardeners or paraffins (0.1 - 1.5 %)<br>- Wood preservatives only exceptional for special types of boards with special labels and approvals<br>- The adhesive content of plywood is mostly lower than given above<br>- Soft boards are often free of adhesive<br>- Wood-based panels have moisture contents depending on the climate conditions. A typical range is 6 to 12 % |
| Typical emissions of (groups of) substances | - Formaldehyde<br>- Natural volatile organic compounds of wood: terpenes (alfa-pinene, delta-3-carene, delta-limonene), aldehydes (hexanal, butanal) and carbonic acids (acetic acid)<br>- Other VOC emissions are only be given for products covered with organic lacquers |
| Related legislation | - Various national formaldehyde regulations in European countries fall into emission classes E1 and E2<br>- Several European countries require only emission class E1 (A, CZ, D, DK, FI, NL, SE …). |
| Relevant substances normally tested | - Formaldehyde<br>- PCP pentachlorophenol (only for particle boards produced from recycled wood; no detectable emission but trace contamination possible: < 0.1 to 3 mg/kg) |
| Available (standardized) test methods | Formaldehyde:<br>- EN 717-1 Chamber test method (reference method)<br>- EN 717-2 Gas analysis method<br>- EN 717-3 Flask method<br>- EN 120 Perforator method<br>PCP:<br>- CEN/TR 14823 Determination of content |
| Available test data | - Various papers, publications, presentations and reports |
| Additional information | - Emission class E1 is mandatory in some European countries |

| | |
|---|---|
| | (Austria, Czech, Germany, Denmark, Finland, Sweden etc.)<br>- Emissions class E1 is the voluntary standard for wood-based panel producers organized in EPF European Panel Federation, Brussels |
| Volume of product(s) produced/used annually | Annual production in Europe 2006 (without Russia and Ukraine):<br>- Particle boards 37.2 Mio. m³<br>- Medium density fibre board 13 Mio. m³<br>- Hardboard 1 Mio. m³<br>- Soft board 1.5 Mio. m³<br>- Oriented strand board 3.5 Mio. m³<br>- Plywood 3.5 Mio. m³<br>There are some other unknown production capacities for mineral bonded particle and fibre boards |
| Used schemes and labelling system | - A few companies use for parts of their products environmental labels such as “Blauer Engel” or indoor air emission classification systems such as “M1”<br>- Most panels used for construction purposes are CE marked on the basis of harmonized standards or have national approvals for construction purposes |
| European organization | EPF European Panel Federation, Brussels<br>FEIC European Plywood Federation of the Plywood Industry, Brussels<br>NLF FEROPA Natural Fibre Board, Lorgues/France |

Notes: The most relevant emission of wood-based panels is formaldehyde. In countries such as Denmark or Germany it is regulated since about 1980. Most panels fulfil nowadays the requirements of emission class E1 which is an equilibrium concentration of 0.1 ppm (= 0.124 mg/m³) in a chamber test standardized by EN 717-1. The production is internally or externally controlled by derived methods, mostly by EN 120 Perforator method (uncoated boards) or EN 717-2 Gas analysis method (coated boards, plywood).

# Annex M. Categorised standards for Indoor Air

**VOCs, VVOC and SVOC of furnishing and construction products**

| Standard | Title |
|---|---|
| EN ISO 16000 | Indoor air: Determination of the emission of volatile organic compounds from building products and furnishing emission |
| EN ISO 16000-3 | Part 3 – Determination of formaldehyde and other carbonyl compounds – Active sampling method: Collection from air onto cartridges coated with 2,4 dinitrophenylhydrzine (DNPH) and analysis by HPLC with detection by ultraviolet absorption |
| EN ISO 16000-6 | Part 6 – Determination of volatile organic compounds in indoor and chamber air by active sampling on TENAX TA, thermal desorption and gas chromatography MSD/FID: Non polar and slightly polar VOCs; some VVOC and some SVOC |
| EN ISO 16000-9 | Part 9 – Emission test chamber method: Area specific emission rate of VOCs; replaces ENV 13419-1: |
| EN ISO 16000-10 | Part 10 – Emission test cell method: Area specific emission rate of VOCs; replaces ENV 13419-2 |
| EN ISO 16000-11 | Part 11 – sampling, storage of samples and preparation of test specimens: For solid, liquid and combined products; replaces ENV 13419-3 |
| EN ISO 16017 | Indoor, ambient and workplace air – sampling and analysis of volatile organic compounds by sorbent/thermal desorption/capillary gas chromatography |
| EN ISO 16017-1 | Part 1: Pumped sampling: For a wide range of VOCs, using different sorbents |
| EN ISO 16017-2 | Part 2: Diffusive sampling |
| EN 1250-1 | Wood preservatives – Methods for measuring losses of active ingredients and other preservative ingredients from treated timber – Part 1 : Laboratory method for obtaining samples for analysis to measure losses by evaporation to air |
| DIBT | Principles for health assessment of construction products used in interiors, Notification n°2005/255/D. |
| VDA | Verband der Automobileindustrie- Method 278 Thermal desorption analysis of organic emissions from car trim components |
| EN 14041 | Resilient, textile and laminate floor covering – Essential requirements |

| Standard | Title |
|---|---|
| EN 14412 | Indoor Air – Diffusive samplers for the determination of concentrations of gases and vapours –guide for selection, use and maintenance |
| EN 13999 | Adhesives – short term method for measuring the emissions properties of low-solvent or solvent-free adhesives after application |
| EN 13999-1 | Part 1: General procedure: emission test chamber (ENV 13419-1) |
| EN 13999-2 | Part 2: Volatile organic compounds |
| EN 13999-3 | Part 3: Volatile aldehydes |
| EN 13999-4 | Part 4: Volatile organic isocyanates |
| ÖNORM M 5700 | Determination of indoor air pollutants – Gas chromatographic determination of organic compounds |
| ÖNORM M 5700 -1 | Part 1 Fundamentals |
| ÖNORM M 5700 -2 | Part 2: Active sampling by accumulation on activated charcoal-solvent extraction |
| ÖNORM M 5700 -3 | Part 3: Active sampling by accumulation on sorbents – thermal desorption |
| ASTM D 5116 | Small-scale environmental chamber determinations of organic emissions from indoor material/products |
| ASTM D 6330 | Determination of VOCs (excl formaldehyde) emissions from wood-based panels using small environmental chambers |
| ASTM D 6670 | Full-scale chamber determination of VOCs from indoor materials/products |
| ASTM D 7143 | Emission cells for the determination of VOCs from indoor materials/products |
| ASTM D 9196 | Selection of sorbents, sampling and thermal desorption analysis procedures for VOCs in air (and material emissions chambers) |
| ASTM WK 2617 | Environmental chamber determinations of indoor-relevant emissions of VOCs and aldehydes from small samples of building products |
| ASTM WK 2618 | Analysing emissions from carpet using small environmental chambers |
| California Dept of Health services | The collaborative for high performance schools section 01350; Testing of VOC emissions from various sources using small-scale chambers |
| JIS A 1901 | Determination of the emission of VOCs and aldehydes for building products – Small chamber method; Modified version of ISO 16000-9 to 11 |

| Standard | Title |
|---|---|
| JIS A 1902-1,2,3,4 Tentative | Building products - Procedures for sampling and storage of samples and preparation of test specimens |
| JIS A 1903 Tentative | Determination of the emissions of VOCs for building products – Passive method |
| JIS A 1904 Tentative | Determination of the emissions of VOCs for building products – Micro-chamber method |
| JIS A 1912 tentative | Determination of the emission of VOCs and aldehydes (except formaldehyde) for building materials and building related products – Large chamber method |

**Formaldehyde from wood-based panels**
(perhaps also more products and other substances?)

| Standard | Title |
|---|---|
| EN 1250-1 | Wood preservatives – Methods for measuring losses of active ingredients and other preservative ingredients from treated timber – Part 1 : Laboratory method for obtaining samples for analysis to measure losses by evaporation to air |
| EN 717 | Wood-based panels – determination of formaldehyde release ISO/DIS 12460 part 1 to 5 is same as CEN EN 717 part 1 to 3 + CEN EN 120 |
| EN 717-1 | Part 1: formaldehyde emission by the chamber method: Not only for wood-based panels; |
| EN 717-2 | Part 2: Formaldehyde release by the gas analysis method |
| EN 717-3 | Part 3: Formaldehyde release by the flask method |
| EN 120 | Wood based- panels; Determination of formaldehyde content – Extraction method called the perforator method: |
| ISO/DIS 12460 | Wood-based panels – Determination of formaldehyde release |
| ISO/DIS 12460-1 | Part 1: Formaldehyde emission by the 1 cubic metre chamber method |
| ISO/DIS 12460-2 | Part 2: Small scale chamber method |
| ISO/DIS 12460-3 | Part 3: Gas analysis method |
| ISO/DIS 12460-4 | Part 4: Desiccator method |
| ISO/DIS12460-5 | Part 5: Perforator method |
| ASTM D 1333 | Determining formaldehyde concentrations in air and emission rates from wood-based products using a large chamber |
| ASTM D 5172 | Test method for determination of formaldehyde and other carbonyl compounds in air (active sampler methodology) |
| ASTM D 5582 | Determining formaldehyde levels from wood products using a desiccator |

| Standard | Title |
|---|---|
| JIS A 1460 | Building boards –Determination of formaldehyde emission – Desiccator method |
| JIS A 1911 Tentative | Determination of the emission of formaldehyde for building materials and building related products – Large chamber method |

**Others**

| Standard | Title |
|---|---|
| EN ISO 16000-7 Currently CEN enquiry/DIS stage not relevant for emissions | Part 7: Sampling strategy for determination of airborne asbestos fibre concentrations: May also be applicable to measurement of other airborne mineral fibres |
| EN ISO 16000-13 Currently CD stage not relevant for emissions | Part 13: Measurement of PCB: And PCDD and PCDF in indoor air: gas-phase and particulate phase by collection on a combination fine-particle filter and sorbent trap, followed by gas chromatography combined with high-resolution mass spectrometry (CF/HRMS) |
| EN 13964 | Suspended ceiling – requirements and test methods Covering a.o.: release of asbestos (content), release of formaldehyde, shatter properties |
| DIN VDI 4300 | Measurement of indoor air pollution |
| DIN VDI 4300-2 | Measurement of PCP and y-hexachlorocyclohexane – GC/MS method |
| DIN VDI 4300-3 | Measurement of PCB and y-HCH – GC/ECD method |
| DIN VDI 4300-6 | ? |
| ÖNORM M 9405 not relevant for emissions | Determination of asbestos concentration in air |
| ÖNORM S 5200 | Radioactivity in construction materials |
| ÖNORM S 5280 | Radon |
| ÖNORM S 5280-1 | Part 1: Measuring methods and their range of applications |
| NEN 5697 or 5699? | Radioactivity measurement – Determination of the rate of radon exhalation of dense building materials |
| European commission – Radiation protection 112 | Radiological protection principles concerning the natural radioactivity of building materials – DG Environment, Nuclear Safety and civil protection |
| ASTM WK 3118 | Determination of VOC emission factors from spray-applied rigid polyurethane cellular plastic thermal insulation using small chambers under defined test conditions |

| Standard | Title |
|---|---|
| ASTM WK 3119 | Determination of VOC emission factors from sealant products using small environmental chambers under defined test conditions |
| ASTM WK 3464 | Determination of VOCs in carpet using a specific sorbent tube and thermal desorption/gas chromatography |
| EU 2002/271/FIN not relevant for emissions | Ministry of the environment Decree on indoor air and ventilation in buildings, the Finnish Building regulations, Directive 98/34/EC |

# Annex N. Regulatory and voluntary schemes

**N.1 DIBt Principles for health assessment of construction products used interiors**
Available under:
http://ec.europa.eu/enterprise/tris/pisa/app/search/index.cfm?fuseaction=pisa_notif_overview&iYear=2005&inum=255&lang=EN&sNLang=EN
For precisions see also: http://www.dibt.de/en/Referat_II4.html

**N.2 Voluntary schemes**
For many years, chemical substances in indoor air have been under discussion with regard to their possible health effects. A number of voluntary schemes have been deveoped - partly by national authorities, partly by industry.

Most of the voluntary schemes used today in the EU Member states, apply the newly developed EN ISO 16000 parts 3, 6 ,9, 10, 11 or very similar methods for emission testing and analysis. Most schemes, or labels, apply a short-term test for initial emissions after 1 or 3 days, and all labels apply a test for characterising long-term emissions after 28 days – or even earlier (after 10 or even 3 days) if the initial emissions of all covered products will decrease very fast.

In report 24 of the European Collaborative action “Urban air, Indoor environment and human exposure – Environment and Quality of life” (Kephalopoulos et al., 2005), the currently used labelling systems and concepts have inventoried, compared and discussed. The report is available under:
http://www.aivc.org/frameset/frameset.html?../ECA/eca_publications.html~main

The intention of the 1997 report no.18 of the European Collaborative Action “Indoor Air Quality and its Impact on Man” (“Evaluation of VOC Emissions from Building Products”) was to serve as a guideline and has in fact laid good grounds for harmonising systems.

Only some labels are applying an odour test, the M1 (http://www.rts.fi/emission_classification_of_building_materials.htm) and the Danish ICL (http://www.dsic.org/dsic.htm), and documentation on reliability and reproducibility of such tests is still lacking. A large variety of odour testing methods are applied. These tests are described in (Bluyssen, 2007), Nordtest Standard (Hansen, et al., 1999) and ECA report no. 20 on sensory evaluation (ECA, 1999). A number of labels do not include any odour testing at all. Some of the schemes include control of labelled products in certain intervals or frequency. Most labels require involved testing laboratories to apply for approval. Only some labels organised round-robin tests for checking the quality of the testing labs.

The M1 labelling system is the oldest system, was established in 1995, and is regarded as one of the voluntary schemes with most experience today. The system uses the emission scenario as defined in the EN ISO 16000 series (based on more than 20 years of research). More than one thousand products have been given the M1 label and it has been shown that the indoor air environment has improved (lower TVOC concentrations: 1/5 of before) in the indoor air scenario (see figure N.1).

Most testing protocols are quite similar, here illustrated by the M1 testing protocol:

1. *Sampling of the material or product*
2. *Transport of sample*
3. *Storage of the sample before testing*
4. *Test specimen preparation*
5. *Testing age and conditioning of the test specimen*
6. *Chamber technique*
7. *Air sample collection from the test chamber*
8. *Analyses*
9. *Reporting documents for application for the classification*

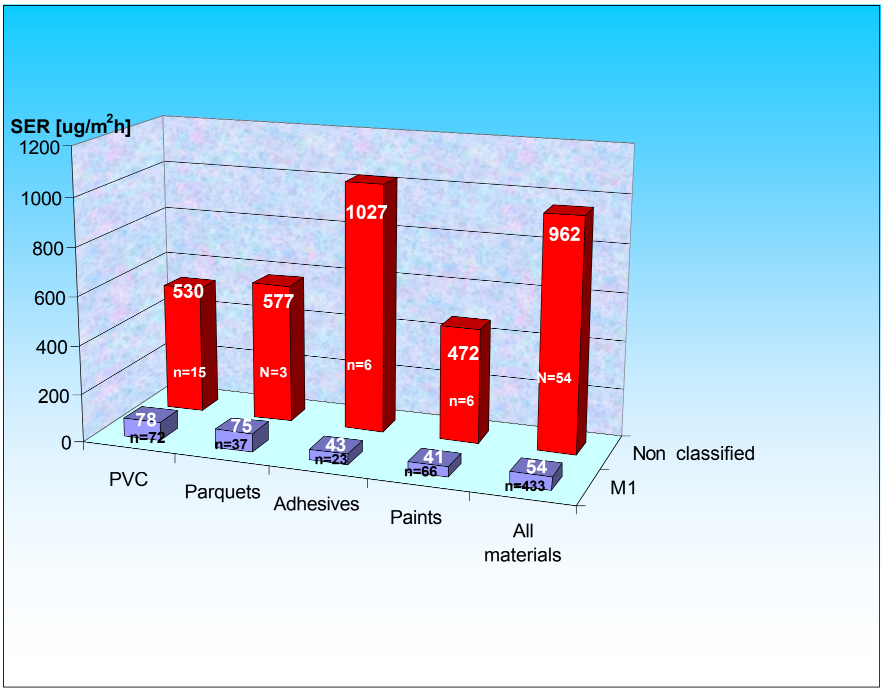



*Figure N.1 TVOC emission rate from classified and non-classified products tested by M1 system (from Kristina Saarela)*

# Annex O. Comparison of standards

| | **EN 717-1** | **EN ISO 16000** |
|---|---|---|
| **Origin** | | |
| **Legal status** | EN | EN |
| **Based on** | ECA report 2 | ECA report 18 |
| **Product types covered** | Mainly wood-based panels | All relevant to indoor air |
| | | |
| **Sampling and test specimen preparation** | EN 717-1 | EN ISO 16000-11 |
| **Test chamber size** | 12, 1 and/or 0.225 $m^3$ | Test chamber EN ISO 16000-9<br>Test cell EN ISO 16000-10 |
| **Test chamber conditions** | EN 717-1 | EN ISO 16000-9 |
| **- temperature** | 23˚C ± 0.5 | 23˚C ± 2 |
| **- rel. humidity** | 45% ± 3 | 50% ± 5 |
| **- air exchange** | 1.0 $h^{-1}$ ± 5% | 0.5 $h^{-1}$ ± 3% |
| **Loading factor** | 1.0 $m^2/m^3$ ± 2% | |
| **- flooring** | | 0.4 $m^2/m^3$ |
| **- all walls** | | 1.4 $m^2/m^3$ |
| **- sealants** | | 0.012 $m^2/m^3$ |
| **Sample (material) size** | Specified: depends on chamber | According to loading factor; depends on whether wall, floor or sealant material |
| **Substances tested/analysed** | | |
| **- analysis/VOC** | - | EN ISO 16000-6 |
| **- analysis/aldehydes** | EN 717-1 (formaldehyde only) | EN ISO 16000-3 (DNP method) |
| **- SVOC** | - | Guidance from EN ISO-16000-6 |
| **- VVOC** | - | Guidance from EN ISO 16000-6 |
| **Test duration/testing** | 7 to 14 days, up to 28 days | 3 days and 28 days |
| **- until steady state concentration in test chamber is reached** | Yes | Possible, but not relevant |
| **- number of analysis** | Twice a day for up to 28 days | Duplicate sampling/analysis tests after 3 and 28 days |
| **Test results** | | |
| **- expressed in** | µg/$m^3$ (concentration in chamber) | µg/$m^2$h (emission specific rate) |