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Implementation of Health and Environmental Criteria in Technical Specifications for Construction Products

by

Dipl.-Ing. Renate Ehrnsperger
Dipl.-Chem. Wolfgang Misch

Deutsches Institut für Bautechnik (DIBt)

On behalf of the Federal Environmental Agency

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15. Zusätzliche Angaben

16. Zusammenfassung

Gegenwärtig und in den nächsten Jahren wird – im Zuge der Umsetzung der EG-Bauproduktenrichtlinie (BPR) – eine Vielzahl von harmonisierten europäischen Normen und technischen Zulassungen für Bauprodukte von den zuständigen europäischen Gremien erarbeitet und der öffentlichen Hand zur Prüfung vorgelegt. Nach den Vorgaben der BPR müssen dabei neben den traditionellen wesentlichen Anforderungen wie Standsicherheit oder Brandverhalten, auch Anforderungen an Hygiene, Gesundheit und Umweltschutz gleichberechtigt berücksichtigt werden.

Zur Einbringung dieser Aspekte in den oben erwähnten Prozess wurde im Rahmen des Forschungsvorhabens ein **Konzept zur Umsetzung der wesentlichen Anforderung Nr. 3 "Hygiene, Gesundheit und Umweltschutz"** entwickelt, das auf den gegenwärtigen Stand der europäischen und nationalen Aktivitäten aufbaut.

Im Rahmen des Forschungsvorhabens wurden für ausgewählte Bauprodukte ausgehend von der Zusammensetzung und der Freisetzung von gefährlichen Stoffen konkrete Handlungsempfehlungen erarbeitet, die in der zweiten Generation der harmonisierten europäischen Normen und technischen Zulassungen berücksichtigt werden sollten.

Als Beispiel für eine Freisetzung von gefährlichen Stoffen in Boden und Grundwasser wurden die mandatierten **Betonausgangsstoffe** Zement, Gesteinskörnungen, Betonzusatzstoffe und Betonzusatzmittel betrachtet. Anhand der Zusammensetzung der einzelnen Ausgangsstoffe, dem bekannten Einsatz von Abfällen und den Ergebnissen von Auslaugversuchen wurde die Freisetzung von gefährlichen Stoffen dargestellt. Die Ergebnisse der Auslaugversuche werden mit Hilfe des für den deutschen Zulassungsbereich geltenden DIBt-Merkblatts zur Bewertung der Auswirkungen von Bauprodukten auf Boden und Grundwasser bewertet. Aufgrund dieser Bewertung wurden Aussagen zur Umweltverträglichkeit, dem weiteren Untersuchungsbedarf und konkrete Empfehlungen zur Berücksichtigung des Gesundheits- und Umweltschutzes in der zweiten Generation der technischen Spezifikationen getroffen. Für die Freisetzung von gefährlichen Stoffen in den Innenraum wurden beispielhaft die **Bodenbeläge** ausgewählt. Die Vielzahl der eingesetzten Materialien wird anhand der Zusammensetzung der Beläge dargestellt. Die Auswertung von Emissionsmessungen liefert Hinweise auf eine Freisetzung von gefährlichen Stoffen aus Bodenbelägen. Anhand des deutschen Konzepts zur Vorgehensweise bei der gesundheitlichen Bewertung der Emissionen von VOC und SVOC aus Bauprodukten werden ebenso wie bei den Betonausgangsstoffen konkrete Empfehlungen für die Berücksichtigung von Gesundheits- und Umweltschutzkriterien in den technischen Spezifikationen ausgesprochen. Eine tabellarische Übersicht aller mandatierten Bauprodukte liefert Hinweise zu einer möglichen Freisetzung von gefährlichen Stoffen aus der Vielzahl der eingesetzten Materialien.

17. Schlagwörter

Bauproduktenrichtlinie, technische Spezifikation, Mandat, wesentliche Anforderung Nr. 3, Betonausgangsstoffe, Zement, Gesteinskörnungen, Betonzusatzstoffe, Betonzusatzmittel, Auslaugung, Schwermetalle, Bodenbeläge, Emissionen, flüchtige organische Verbindungen, VOC, SVOC, AgBB-Bewertungsschema, Handlungsempfehlungen

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16. Abstract

At present and also within the next years a variety of harmonised European standards and technical approvals for construction products is being and will be – in the scope of the implementation of the Construction Products Directive (CPD) – elaborated by the relevant European bodies and submitted to the public for examination. As stipulated in the CPD equal consideration has to be given to both the traditional essential requirements, such as stability and reaction to fire, and to the requirements for hygiene, health and the environment.

For the purpose of including these aspects into the above process this research project concentrated on the development of an approach for the implementation of the essential requirement N° 3 "Hygiene, health and the environment" basing on the current situation of European and national activities.

Within the framework of the research project concrete recommendations were elaborated for selected construction products for handling them with regard to their composition and release of dangerous substances, which should be taken into consideration in the second generation of the harmonised European standards and technical approvals.

The mandated **materials of concrete** - cement, aggregates, concrete additives and concrete admixtures - were considered with regard to their release of dangerous substances into soil and ground water. The release of dangerous substances was evaluated on the basis of the composition of the material, the known use of waste materials and the results of leaching tests. The results of the leaching tests were assessed by means of the DIBt-Guideline "Assessment of the effects of construction products on soil and groundwater". Based on this assessment, statements on the environmental effects and on the further need for examinations as well as concrete recommendations for taking into account health and environmental criteria in the second generation of the technical specifications are made. **Floorings** were examined as an example for the release of dangerous substances into the indoor air. The variety of the materials used is demonstrated on the basis of the composition of the coverings. The evaluation of emission tests gives evidence of a release of dangerous substances by floorings. Based on the German concept for a health-related evaluation procedure for volatile organic compounds emission from construction products, specific recommendations are made – as in the case of the materials of concrete – for taking into account health and environmental criteria in the technical specifications. A tabular survey of all mandated construction products points to a possible release of dangerous substances from the variety of the materials used.

17. Keywords

Construction Products Directive, Essential requirement No. 3, mandate, technical specification, materials of concrete, cement, aggregates, concrete additives, concrete admixtures, leaching, heavy metals, floorings, emissions, volatile organic compounds, VOC, SVOC, AgBB-Assessment scheme, recommendations

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ABSTRACT

Introduction

As part of the implementation of the EC Construction Products Directive (CPD), a diverse range of harmonised European standards and technical approvals for construction products are currently being drawn up by the respective bodies. In addition to the traditional requirements such as stability and reaction to fire, the provisions of the CPD also require that equal consideration be given to hygiene, health and environmental protection as essential requirements.

The different construction traditions in the Member States of the European Union, the lack of – or differing – regulations for health and environmental protection, the lack of knowledge on the environment and health by the experts in the technical committees and working groups concerned with European standardisation and approvals, and the lack of harmonised test methods have led to the postponement of the specification of health and environmental requirements into the second generation of harmonised technical specifications. The first generation contains either just rudimentary environmental and health requirements or none at all, referring instead to nationally applicable regulations. It is planned to harmonise the the fields of health and the environment only in the second generation by adopting concrete requirements.

In order to incorporate these health and environmentally relevant aspects in the process of European regulation, specific substance-related requirements for selected construction products were elaborated and substantiated within the framework of this research project. Here, the requirements and their justification presented in this report are based on the one hand on the provisions of the CPD, with its respective interpretative documents and guidance papers, as well as on the level of protection that applies in Germany; on the other hand, the considerations may even go beyond that if it is necessary in the light of the aims of health and environmental protection. With this project, an implementation concept was developed in the form of recommendations for harmonising the Essential Requirement No. 3 "Hygiene, Health and the Environment". The study focussed on developing recommendations to take account of health and environmental criteria for selected construction products.

As an example for the release of dangerous substances in soil and groundwater, the mandated concrete constituents cement, aggregates, concrete additions and admixtures were selected as these mass-produced construction materials are used on a significantly large scale. With regard to the release of dangerous substances in indoor spaces, the floorings mandate was chosen (textile, resilient, laminate, solid wood/wood-based panel floorings) as floorings can represent a substantial emission source as a result of their large surface area in indoor spaces. In terms of the choice, it should be noted that it was necessary to restrict the number due to the diversity of construction products. However, it should not be inferred that the selected construction products are potentially very hazardous to health or the environment. For all other mandated construction products, information on dangerous substances that could be potentially released has been collected.

Approach for transposing the Essential Requirement No. 3 into technical specifications

In terms of the Essential Requirement No. 3 "Hygiene, Health and the Environment", the Construction Products Directive and the more specific Interpretative Document No. 3 require that building users and the immediate environment shall not be endangered by the construction works. A tiered approach should be taken in order to take full account of the Essential Requirement No.3 in the technical specifications. In order to evaluate the possible release of dangerous substances knowledge on both the chemical composition and structure as well as on the planned use of the products in construction works (e.g. direct or no contact with indoor air) are required. In this way it is for instance quite possible to recognise application areas that present no risk to health or the environment even for a product classified as "critical".

Taking into account the composition and area of application, the mandated construction products should be classified into products that, due to existing experience, can be deemed as obviously harmless and for which no additional tests are required (WFT products – Without Further Testing) and products for which the health and environmentally relevant effects can only be evaluated by using specific individual tests as part of approval procedures. For products falling between these two cases, which are therefore subject to standards, stipulations should be made in the standards that ensure that a risk for users and the environment can be excluded with a sufficient degree of certainty.

The following chart illustrates the approach of dividing the diverse range of mandated construction products into various groups. This division has been applied to the examples of "concrete constituents" and "floorings", which are examined in detail as part of this research project.

WFT products	Standardised products	Products subject to approval
• Composition can be precisely specified • Release behaviour known • Well proven products → no further testing necessary	• Composition can be described • Possible reduction of the range of chemical constituents • Specification of the dangerous substances to be tested possible → Test of the release of dangerous substances necessary. Declaration of the results in CE mark.	• Large range of applied substances • Innovative products: release behaviour unknown • Use of waste materials without long-term experience → Test of the release of dangerous substances based on information on the chemical composition of the product.

Overview of the recommendations for the second standard generation for concrete constituents

The following charts provide a summary of the studies on the health and environmental compatibility of concrete constituents described in the study and summarises the recommendations for revising the technical specifications.

Data	Recommendations for second standard generation
M 114: Cement — Harmonised product standards DIN EN 197-1, DIN EN 197-3, DIN EN 197-4, DIN EN 14216, DIN EN 14217	
Content/Release of heavy metals: Increased heavy metal content for arsenic, lead, zinc and chromium in Portland cement relative to natural stone. ***With the batch test to DIN 38414-S4, only the insignificance thresholds ("no effect levels") for chromates are exceeded.*** With long-term static tests, all the insignificance thresholds are complied with for concrete constituents; however there is only a small data basis. Until now there have only been results from leaching processes for Portland cement and blastfurnace cement (CEM III).	***To create a broad data basis, leaching tests for all cement types should be conducted and assessed by comparing with the insignificance thresholds of the DIBt Guideline "Assessment of the effects of construction products on soil and groundwater" [1].***
Release of organic substances: No release of leachable organic substances such as PAH, dioxins/furanes from Portland cement clinker due to high kiln run temperatures. No study results for leaching of organic substances from cement additives such as grinding aids.	***The leaching of organic substances from cement (additives) should be examined using leaching tests.***
Use of wastes as secondary fuel/raw material: ***Increased heavy metal content possible in Portland cement through using waste as secondary fuel or secondary raw material.***	When using wastes as secondary raw material, the content and leaching of heavy metals should be examined on the original substance. The range of parameters to be examined should be based on the requirements of the Working Group of the German Länder on Waste Issues (Länderarbeitsgemeinschaft Abfall, LAGA) for using mineral wastes/residues. When using wastes as secondary fuel, the heavy metal content should be determined in the waste and cement. LAGA [2], the SAEFL Guidelines [3] and the Gütegemeinschaft für Sekundärbrennstoffe [4] provide a basis for the range of parameters to be examined. A positive list with wastes that are admissible when manufacturing cement should be prepared. If no heavy metal examinations are specified, mandatory labelling for the use of wastes is necessary.

Data	Recommendations for the second standard generation
M 125: Aggregates — Harmonised product standards DIN EN 12620, DIN EN 13055-1	
Release of heavy metals:	
Natural aggregates Differing statements on the heavy metal content of natural stone relative to uncontaminated soil and the lithosphere.	General discussion necessary as to whether additional requirements should be made for natural stone in terms of leaching of heavy metals.
Manufactured (artificial) aggregates: Possible to have increased heavy metal content. Batch tests to DIN 38414-S4 have shown that the insignificance thresholds ("no effect levels") of the DIBt Guideline are complied with. Statements on chromates and cadmium not possible. No results from long-term static tests for concrete test specimens with the slags used.	When using mineral materials that are by-products of industrial processes, the content and leaching of heavy metals should be examined on the original substance. The range of parameters should be based on the Z 2 values of the respective waste-specific regulations of LAGA. There is a need to examine whether concrete produced with manufactured aggregates also complies with the insignificance thresholds of the DIBt Guideline Soil/Groundwater. There is a need to examine, whether it is sufficient to determine the content in order to infer the release.
Heavyweight aggregates: Heavy metal content very high in comparison with normal and lightweight aggregates. No results available from leaching tests.	Further leaching tests necessary in order to determine the environmental compatibility.
Lightweight aggregates: With batch tests to DIN 38414-S4 for bricks and expanded clay, the insignificance thresholds ("no effect levels") according to the DIBt Guideline were exceed for a series of heavy metals. There have been no examinations of leaching using long-term static tests.	When using mineral waste such as furnace sand (coal ash), the Z2 values of LAGA should be complied with for the original substance (solids and leachate). There is a need for further examination as only a few results exist from leaching tests. The test results should be assessed using the insignificance thresholds of the DIBt Guideline. When using waste glass, environmentally dubious waste glass, such as lead glass, should be excluded.
Recycled aggregates:	Indicate the source of the recycled aggregates. The use of recycled aggregates from suspected contamination sites should be excluded. Recycled aggregates from sites not suspected of being contaminated should be examined in terms of the leaching of inorganic and organic parameters. The parameters being examined should be based on the Technical Rules of the LAGA for building rubble (Z 2 values), the DIN 4226-100 [5] for recycled aggregates and the Dutch Building Materials Decree [6]. The proportion of foreign matter should be specified. Guidelines here can be found in the Technical Rules of the LAGA for building rubble and DIN 4226-100. Further test need for recycled aggregates complying with the leachate values of DIN 4226-100 in batch test: check compliance with the insignificance thresholds in long-term static test with concrete test specimens made of recycled aggregates.

Data	Recommendations for the second standard generation
M 128: Products related to concrete, mortar and grout — Harmonised product standards DIN EN 12878 (Draft), DIN EN 13263-1 (Draft), DIN EN 450-1 (Draft), DIN EN 934-2	
Release of heavy metals:	
Fillers Heavy metal content comparable with those for sand and gravel and limestone. With limestone intercalated with ores, higher contents of certain heavy metals have been measured in single cases.	Presumably no release of dangerous substances when using fillers from quartz or limestone. Leaching tests should be conducted if there are indications that ores are intercalated in the limestone.
Pigments Use of heavy metals with oxidic bonds or as other stable compounds. The stability of pigments in the alkaline environment shall be proved when testing the suitability of the pigments. No results from leaching tests.	Need for further examination using leaching tests, particularly for organic pigments.
Fly ash Heavy metal content of fly ash clearly elevated (considerably dependent on fuel used). With batch tests to DIN 38414-S4 with fly ash, the insignificance thresholds were exceeded for antimony, arsenic, lead, cadmium, chromium, selenium and zinc. The Z2 values (leachate) of LAGA for fly ash were exceeded for arsenic and chromium. With the long-term static tests, the insignificance thresholds were complied with for concrete and mortar.	When using coal fly ash as a concrete addition, the Z2 values of *LAGA* for fly ash should be examined on the original substance. The use of secondary fuels when producing fly ash should be declared and the insignificance thresholds of the DIBt Guideline should be examined using a leaching test. When using petroleum coke, the nickel and vanadium content should be determined and declared.
Silica fume Content of heavy metals is less than for Portland cement.	A release of heavy metals is not to be expected.
Release of organic substances to soil and groundwater:	
Fly ash Little data. Results of batch tests show very little leaching of organic substances except in single case for phenol.	There is a need for further investigation as only a few results exist.
Concrete admixtures *Plasticisers and liquefiers:* Results from batch and short-term static tests, analyses of pore water in concrete and an examination of the sorption behaviour of liquefiers on cement particles show only slight elution of organic substances. No results exist yet from long-term static tests. There is no information on degradation products. *Retarders, sealants and injection aids:* Substances toxicologically unobjectionable. No results from leaching tests. Retarders and injection aids firmly bonded in hardened cement paste. *Accelerators:* Bonded in the cement matrix. Leaching of alkalis. No results from leaching tests. *Air-entraining agents and stabilisers:* No results from leaching tests.	Because there have only been a few leaching tests, there is a need for further investigation. Here the results of the leaching tests should be assessed using the DIBt Guideline Soil/Groundwater.

Proposals for implementing the Essential Requirement No. 3 for concrete constituents

Cement

Cement is a mandated construction product for which there has been many years of experience in terms of its composition and use as a concrete constituent. Here, however, it needs to be differentiated between cement that is manufactured without using wastes and cement that is manufactured with the use of wastes.

- Cement that is manufactured without wastes is suitable for inclusion in the list of WFT products (WFT – Without Further Testing), as existing studies on the content and leaching give no cause for concern that there might be an environmentally relevant release of dangerous substances. However, this still needs to be verified for all types of cement and for the release of organic substances. If cement is included in the WFT list, the composition of the cement needs to be precisely specified in the product standard and the standard should state that no wastes may be used.
- Cement that is manufactured with the use of wastes requires far more extensive provisions in the product standard. If wastes are used as secondary raw material or secondary fuel, and if there is also sufficient practical experience in the form of existing test parameters, then these wastes should be listed in the product standard with the corresponding test parameters to be determined. It should be indicated in the standard that the scope only refers to the wastes listed. If wastes are used with little or no experience, the manufacture of such cement shall be classified as being subject to approval. An appropriate scope of testing for the product to be approved can then be specified by an expert committee on a case by case basis.

Aggregates

The term "aggregates" encompasses a construction product group that can consist of very different materials.

- Natural aggregates of mineral origin are suitable for inclusion in the list of WFT products. However, the radioactivity of natural stone such as granite must still be taken into account, which was not taken into consideration by this research project. The fact that the heavy metal content of natural stone sometimes exceeds the quality criteria for soil needs to be discussed.
- The manufactured aggregate crystalline blastfurnace slag may fulfil the requirements for a WFT product as existing studies on content and leaching provide no indication that there is a relevant release of dangerous substances. Test parameters should be specified in the product standards for the aggregates melting chamber granulates and non-ferrous slag. The scope of the product standard should indicate that the standard is only to be used for the named aggregate. If slags from waste incineration plants are used as aggregate, these should be classified as requiring approval due to their enormously varying composition. This classification as requiring approval also applies to all other wastes for which there is no experience and, correspondingly, no test parameters.
- Lightweight aggregates from natural materials and products which are manufactured without the use of wastes can be discussed in terms of being

WFT products. The same restrictions apply as with the aforementioned natural aggregates. If wastes are used for which experience and test parameters already exist, such as furnace sand, then these wastes and the specification of the parameters should be listed in the product standard. Wastes for which no test parameters are available should be made subject to approval.

- Various specifications are required in the product standard for using recycled aggregates. Recycled aggregates from suspected contamination sites should be excluded from the scope of the product standard. Due to the considerably varying composition of contamination sites, these should be made subject to approval, as here the scope of the testing can be specified by an expert committee for the specific product. For all other recycled aggregates, the test parameters should be listed in the product standard. In order to avoid contamination by organic substances the maximum foreign matter content for non-mineral material should be specified in the product standard.

Concrete additions

Fillers, pigments and fly ash were examined as concrete additions.

- Fillers are suitable for inclusion in a list of WFT products, since, with the exception of limestone intercalated with ores, there was no indication of any risk to the environment. Exceptional cases should be listed in the product standard and the respective procedure indicated, such as the carrying out of leaching tests.
- Inorganic pigments should be discussed in terms of inclusion in the WFT list as there was no indication of there being any risk to the environment. However, this does not apply to organic pigments since, because of the lack of leaching tests, no statements can be made. One possibility here would be to specify the product standard only for inorganic pigments and make organic pigments subject to approval until enough experience has been gained on the leaching behaviour of these substances.
- When using coal fly ash without the co-combustion of wastes, test parameters must be specified in the product standards. If wastes (secondary fuels) are co-combusted during the production of fly ash, this fly ash should be classified as being subject to approval. If there has already been many years of experience in co-combusting wastes such as sewage sludge and petroleum coke, it should be discussed whether a positive list of wastes can be included in the product standard. Owing to the highly differing composition, fly ash from domestic or commercial waste incineration plants should be made subject to approval.

Overview of the recommendations for the second standard generation of floorings

Dangerous substances	Recommendations for the revision of technical specifications for floorings
All floorings (textile, resilient, laminate and wood floorings)	
Content of CMR substances (Category 1 and 2) and of toxic (T) or very toxic (T+) substances	Category 1 and 2 CMR substances and substances classified as T or T+ according to Council Directive 67/548/ EEC [7] should not be actively used.
Content of pentachlorophenol	The content of pentachlorophenol should be determined and declared in the CE marking.
Release of formaldehyde	When using materials containing formaldehyde, the release of formaldehyde should be determined.
Release of VOC and SVOC	Determination of VOC and SVOC emissions after 3 days and 28 days, calculation of the TVOC value
Release of odorous substances	The odour emission should be determined.
Use of wastes	The use of wastes should be declared.
In addition for textile and resilient floorings	
Content of azodyes that release carcinogenic amines	Azodyes that release carcinogenic amines (Council Directive 76/769/ EEC [8]) may not be used.
Content of flame retardants	Use of polybrominated diphenyl ethers to be phased out. Phase out of HBCD, TCPP to be considered.
For textile floorings only	
Content of pesticides in textile floorings made of natural fibres	Permethrin content to be limited. The use of pesticides as moth and beetle protection for wool carpets should be declared. Information required on health risks from pesticide residues in natural fibre carpets.
Content of benz(a)pyrene	When using bitumen, BaP content to be determined.
For PVC floorings only	
Content of plasticizers	Avoidance of DEHP, DBP and BBP. The use of medium chain chlorinated paraffins to be scrutinised.
Content of heavy metals from stabilisers	Avoidance of stabilisers based on lead. Cadmium stabilisers already Europe-wide forbidden.
For rubber floorings only	
Release of N-nitrosamines	Avoidance of nitrosatable substances.
For floorings made of wood-based panels only	
The use of used wood	The use of used wood to be declared. The parameters of the German Waste Wood Ordinance [9] to be determined.

Proposals for implementing the Essential Requirement No. 3 for floorings used in indoor spaces

Floorings form a construction product group that can consist of a variety of different materials and substances. Due to this diversity and the few test results available for release behaviour, it is not considered sensible to include this product group in the WFT product list (Without Further Testing).

For floorings that are manufactured according to harmonised European standards, the description of the composition should be as detailed as possible. Substances that are nationally prohibited or restricted (like formaldehyde and PCP) must be listed in the product standards. For restricted substances a harmonised European test method must also be indicated. Further substances currently under critical assessment should also be tackled on a voluntary basis in the product standards. The dangerous substances that can be released from the respective floorings, and which should therefore be specified in the product standards, are described in the previous chart. Examples include CMR substances, polybrominated diphenylethers, VOC and SVOC.

Floorings for which there is insufficient knowledge about their release behaviour, and/or for which wastes are used in their manufacture, should be classified as requiring approval as here the scope of the testing can be specified by an expert committee for the specific product.

Conclusions

This research project considers the release behaviour and/or content of dangerous substances from/in construction products for which mandates to CEN for developing harmonised European product standards have been issued. The mandates issued to EOTA could not be considered in the scope of this study. By stating the materials used and the intended use of the construction products the CEN mandates provide information on both the possible release of dangerous substances in the environmental media of soil, groundwater and indoor spaces and on the content of dangerous substances. However, it is generally only possible to assess the leaching and emission behaviour of dangerous substances from construction products adequately, when test results are available.

By using specific examples of selected construction products, this research project provides the first steps for a systematic incorporation of health and environmental protection in European technical specifications. The study has shown that a detailed examination is required for all construction products. Here it needs to be born in mind that the construction products considered in this study were selected as examples due to the fairly ample knowledge available on their release behaviour. Generally the release of dangerous substances from construction products has attained far too little attention. This is especially obvious for the many substances without any test procedures. On the other hand within the European Union many different national test procedures exist for individual substances. If the health and environmental requirements are to be adequately formulated, it is necessary that all Member States agree on harmonised European test methods.

More intensive research is necessary on the often unknown release behaviour of dangerous substances from construction products and for the development of the lacking test methods. Mandates for harmonised test methods are currently being drawn up. However, the test methods are unlikely to be adopted before 2008. Therefore, it is urgent that interim solutions are developed for the intermediate period.

Finally, one should keep in mind that only the phase of use of the construction products has been covered until now within the scope of the Construction Product Directive. From the point of view of environmental and health aspects, however, the entire life cycle of a product should be evaluated. In addition to the phase of use, the manufacture and disposal of the respective construction products deserve an equal consideration.

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4 Güte- und Prüfbestimmungen für Sekundärbrennstoffe, Bundesgütegemeinschaft Sekundärbrennstoffe e.V., Köln, Juni 2001

5 DIN 4226-100, Februar 2002, Gesteinskörnungen für Beton und Mörtel - Teil 100: Rezyklierte Gesteinskörnungen

6 Building Materials (Soil and Surface Waters Protection) Decree. For more information see under soil policy at: http://www.vrom.nl/international

7 Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (Official Journal P 196 16.8.1967, p. 1. Information on an updated version is available at: http://europa.eu.int/comm/environment/dansub/main67_548/index_en.htm

8 Council Directive 76/769/EEC of 27 July 1976 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (Official Journal, Nr. L 262 27.9.1976, p. 201). A consolidated version is available at: http://europa.eu.int/eur-lex/en/consleg/main/1976/en_1976L0769_index.html

9 Ordinance on the Management of Waste-Wood from 15. August 2002, Federal Law Gazette I 2002, S. 3302 (in German). English version available for download at: http://www.bmu.de/en/800/js/download/waste/eng_b_wastewood/

1 Introduction and definition of the task

The large group of construction products represents a central economic factor within the internal market of the European Union. According to the Council of European Producers of Materials for Construction, the annual turnover for construction materials amounts to around EUR 200 billion. The German construction product industry is the market leader with a market share of almost 60 % [1].

Construction products (comprising more than 20,000 different materials and products) are manufactured using a diverse range of organic and inorganic substances, whose emission behaviour and effects on health and the environment are often unknown. Collectively, construction products create considerable material flows. For instance, approximately 40 % of the German consumption of mineral raw materials is used in civil engineering works, while 25 % of the plastic produced and 8 % of the chemical products are used in the construction industry.

In the past, the release of dangerous substances from construction products, whose most well known examples are asbestos, formaldehyde and pentachlorophenol (PCP), has been the subject of considerable public disquiet and attention, and at the same time has required extensive remedial measures to protect the environment and health. Viewed in retrospect, it becomes clear that such harm can only be countered by taking preventive measures or at least by attempting to minimise possible harm in advance.

A corresponding approach would be to take account of the release of dangerous substances and their content already during the manufacture of products. Existing legislation, however, stipulates health and environmentally related requirements for construction products only in specific areas. This legislation includes media related limit values in soil, water and waste law, European and national restrictions and prohibitions of certain substances, as well as the German building regulations with their inherent principle of hazard avoidance.

At European level, with the adoption of the EC Construction Products Directive – CPD (89/106/EEC) in 1988, the responsibility for fulfilling the Essential Requirement No. 3 "Hygiene, Health and the Environment" (ER 3) contained in the Construction Product Directive was delegated to the spheres of standardisation and approvals. This means that the development of harmonised European technical specifications (standards and approvals) takes on enormous importance if the previous level of protection in terms of national health and environmental requirements is to be maintained, developed and/or adapted. The importance given to environmental protection in the European standards is also demonstrated by a decision of the Council and the European Parliament, which in Article 3 demands that the integration of ecological aspects be promoted and strengthened in European standardisation [2].

As part of the implementation of the EC Construction Products Directive, a diverse range of harmonised European standards and technical approvals for construction products are currently being drawn up by the respective bodies, which will continue for the next few years. In addition to the traditional requirements such as stability and reaction to fire, the provisions of the CPD also require that equal consideration be given to hygiene, health and environmental protection as essential requirements.

After the transitional period has expired, construction products many only be placed on the market in the European Union if they accord with the harmonised technical specifications and bear the European conformity label – the CE mark.

The different construction traditions in the Member States of the European Union, the lack of – or differing – regulations for health and environmental protection, the lack of knowledge on the environment and health by the experts in the technical committees and working groups concerned with European standardisation and approvals, and the lack of harmonised test

methods have led to the specification of health and environmental requirements being postponed to the second generation of harmonised technical specifications. The first generation contains either just rudimentary environmental and health requirements or none at all, referring instead to nationally applicable regulations. It is planned to harmonise the Essential Requirement No. 3 only in the second generation by adopting concrete requirements for the fields of health and the environment.

In order to incorporate these health and environmentally relevant aspects in the process of European standardisation, specific substance-related requirements for selected construction products were elaborated and substantiated within the framework of this research project. Here, the requirements and their justification presented in this report are based on the one hand on the provisions of the CPD, with its respective interpretative documents and guidance papers, as well as on the level of protection that applies in Germany; on the other hand, the considerations may even go beyond that if it is both reasonable and necessary in the light of the aims of health and environmental protection.

With this project, an implementation concept was developed in the form of precise recommendations for harmonising the Essential Requirement No. 3 "Hygiene, Health and the Environment", in which current European developments have also been incorporated. The study focussed on health and environmental criteria for selected construction products. As an example for the release of dangerous substances in soil and groundwater, the mandated concrete constituents cement, aggregates, concrete additions and admixtures were selected as these mass-produced construction materials are used on a significantly large scale. With regard to the release of dangerous substances in indoor spaces, the floorings mandate was chosen (textile, resilient, laminate, solid wood/wood-based panel floorings) as floorings can represent a substantial emission source as a result of their large surface area in indoor spaces. In terms of the choice, it should be noted that it was necessary to restrict the number due to the diversity of construction products. However, it should not be inferred that the selected construction products are potentially very hazardous to health or the environment. For all other mandated construction products, information on dangerous substances that could be potentially released has been collected. These are described in Annex A4 in the form of a list of mandated construction products.

Against this background, this report should also be understood as a reference work for selected construction products. For the corresponding construction products, it provides specific information on the composition, release behaviour of dangerous substances and recommendations for taking account of the dangerous substances in the technical specifications. The description of more extensive concepts for assessing the effects of construction products on soil, groundwater and indoor spaces and the description of test methods for determining leaching into soil and groundwater provide a comprehensive overview of the subject area.

Assumptions for conducting the project

The research project was conducted by the *Deutsches Institut für Bautechnik* – DIBt ('German Institute for Building Technology'), and was commissioned by the *Umweltbundesamt* – UBA ('Federal Environmental Agency') using funding from the environmental research programme as part of the subject area "Environmental and health requirements for construction products".

For the purposes of providing expert support for the project, intermediate results were presented to expert committees and project groups within the DIBt and, by including corresponding experts, the current state of discussion on research and policy aspects was integrated. For example, the "Concrete constituent" section was made available to the DIBt "Concrete and cement-bound construction materials" project group and members of the subcommittee "Environmental compatibility of concrete" of the *Deutscher Ausschuss für Stahlbeton* – DafStb ('German Committee for Reinforced Concrete'), while the "Floorings" section was made available to the DIBt "Floorings and adhesives" project group. The

comments provided by the members provided valuable information that was taken into account in the research project.

An integral part of the research project was a workshop that was organised together with the *Bundesministerium für Verkehr, Bau- und Wohnungswesen* – BMVBW ('Federal Ministry of Transport, Building and Housing') and the *Umweltbundesamt* – UBA ('Federal Environmental Agency'). At the workshop "Implementation of the Essential Requirement No 3 'Hygiene, Health and the Environment' in European Technical Specifications for Construction Products", harmonisation in the field of health and environmental protection was discussed by representatives from the European Commission, the European standardisation and approval bodies, the European building material industry as well as, on behalf of the EU Member States, members of the Standing Committee for Construction (SCC). The focus was on activities, problems and the planned implementation strategies for harmonising the Essential Requirement No 3. As a result of the discussions, eight recommendations were developed and adopted, which have been incorporated into this report and are listed in Annex A1.

The approach and the structure of the report

In addition to the introduction (Section 1) and the summary and outlook (Section 7), the report is divided into five differently weighted main sections. By way of introduction, the legal framework is outlined (Section 2). In Section 3 a concept for transposing the Essential Requirement No 3 'Hygiene, Health and the Environment' is presented and respective approaches are described. The next section explains the procedure for drawing up health and environmental criteria for the selected construction products (Section 4). Finally, the substance-specific sections describe and analyse concrete constituents as an example for the release of dangerous substances into soil and groundwater (Section 5) and floorings as an example for the release of dangerous substances in indoor spaces (Section 6). For both sections, more extensive evaluation concepts are presented in order to be able to reflect upon and extend existing knowledge.

Definitions

Since with the implementation of the Essential Requirement No. 3, the release of dangerous substances is taken into consideration and the regulations of the Member States and the European Union for these substances play an important role, these two terms are defined below.

Dangerous substances

Within the framework of this research project, "dangerous substances" shall be defined as follows:

Substances described as dangerous fulfil at least one of the following criteria:

- The release or content of the substance from/in construction products is regulated at European level or at least in one Member State. This concerns regulations for dangerous substances whose use is forbidden or restricted either generally or specifically for construction products.
- Classification of the substance according to Council Directive 67/548/EEC (Dangerous Substances Directive) [3]
- Substances that groups of experts in the Member States consider to be harmful to humans and/or the environment, but for which, however, there are not yet any regulations. These can also include substances that are formed in and are released from the construction product only through decomposition and reaction processes.

Country-specific regulations

Within the framework of the project, the definition of country-specific regulations will be adopted that is given by Directive 98/34/EC, which lays down procedures for the provision of information in the field of technical standards and regulations [4]:

According to this, country-specific regulations are all de-jure and/or de-facto regulations of the EU and Member States, such as legal and administrative regulations, as well as voluntary agreements where the State is the contracting party and which provide, in the public interest, for compliance with technical specifications and other requirements.

2 Legal framework

This section shall present important European regulations for the implementation of the Essential Requirement No. 3 "Hygiene, Health and the Environment". The German building regulations shall be explained as an example for the transposition into national regulations.

2.1 European regulations

2.1.1 EC Construction Products Directive (CPD)

Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (EC Construction Products Directive – CPD – 89/106/EEC) [5] is aimed at removing trade barriers for construction products in the common market of the European Union and permitting the free movement of goods. This is to be achieved by harmonising the different technical regulations in the Member States. The Construction Products Directive is an instrument of the Treaty establishing the European Community (ECT), which is aimed at harmonising the single European market. In addition to the free movement of goods, the treaty also stipulates that the free trade must take into consideration health and environmental protection, and that a high level of protection is to be striven for based on the principles of precaution and prevention [6]

The Construction Products Directive is a "New Approach" directive [7], i.e. products concerned are only subject to a general objective and the essential requirements. The technical details are specified by CEN and EOTA [1] in the harmonised standards and technical approvals.

The Directive regulates construction products and defines these as any products that are produced for incorporation in a permanent manner in construction works, including both buildings and civil engineering works. These products may be traded freely in the European Economic Area if they are fit for their intended use. A construction product is classified by the Directive as fit for its intended use if it fulfils the following essential requirements listed in Annex I of the Directive [5]:

1. Mechanical resistance and stability
2. Safety in case of fire
3. Hygiene, health and the environment

[1] CEN: Comité Européen de Normalisation / European Committee for Standardisation
EOTA: European Organisation for Technical Approvals

4. Safety in use
5. Protection against noise
6. Energy economy and heat retention

The Essential Requirement No. 3 "Hygiene, Health and the Environment" is intended to contribute to protecting the health of occupants and neighbours as well as the immediate environment. Thus the Directive states in Annex I that the construction works must be designed and built in such a way that it will not be a threat to the hygiene or health of the occupants or neighbours, in particular as a result of any of the following [5]:

- the giving-off of toxic gas
- the presence of dangerous particles or gases in the air
- the emission of dangerous radiation
- pollution or poisoning of water or soil
- faulty elimination of waste water, smoke and solid or liquid wastes
- the presence of damp in parts of the works or on surfaces within the works

Spatially, this takes into consideration the construction works and the work's immediate environment, which essentially comprises the indoor air, supply and disposal systems as well as the adjacent soil and groundwater. In terms of time, the requirements of the Directive are limited to the phase of use of the building.

The Construction Products Directive regulates the marketing and use of construction products. Because this is a directive, however, it must be transposed into national law. Due to existing legislative powers, in Germany this transposition falls under the *Bauproduktengesetz* ('Construction Product Act') for placing products on the market and the *Landesbauordnungen* ('Building Laws of the Laender') for the use of products.

In order to take account of the different levels of protection in the Member States, the Construction Products Directive allows the incorporation of levels and classes in technical specifications. The Directive defines the term "technical specification" as referring to both standards and technical approvals. In accordance with the Safeguard Clause (Art. 21 CPD), Member States can prohibit the marketing of products if they fail to comply with the harmonised standards or technical approvals, conflict with national laws or present a danger to health and the environment.

The Member States can represent their interests in the "Standing Committee on Construction", which was established on the basis of Art. 19 CPD. This acts in an advisory and regulatory capacity. Two representatives are appointed by each Member State. The voting on proposals presented by the European Commission is by qualified majority[2].

2.1.2 Interpretative Document No. 3 "Hygiene, Health and the Environment"

The Interpretative Document No. 3 "Hygiene, Health and the Environment" [8] gives concrete form to and interprets the essential requirement according to Art. 3 and 12 of the Construction Products Directive. It stipulates that the harmonised technical specifications for construction products must cover the following characteristics for the period of use of the construction works:

- Release of pollutants to indoor air (e.g. VOC, inorganic and organic particles and radioactive substances)

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2 The votes of the Member States are weighted in accordance with the size of their respective population (c.f. Article 205, Paragraph 2, EC Treaty) [6].

- Release of pollutants to outdoor air, soil and water in the immediate environment of the works

The technical specifications must also include information that enables the manufacturer to complete the CE marking of the product in terms of the emission of dangerous substances. If possible, harmonised testing or calculation procedures should be specified that enable the manufacturer to state the emission as a numeric value.

The technical specifications are elaborated using a mandate procedure. The European Commission issues the mandate to CEN or EOTA to elaborate harmonised European standards or guidelines for technical approvals (ETAG[3]).

To verify the conformity of a product with the technical specifications, conformity attestation procedures are specified by the European Commission. In a series of levels, these allow for initial type testing, product testing and factory production control by means of a simple manufacturer declaration and/or by means of independent, notified testing, control or certification bodies.

If the construction product conforms with a harmonised standard or technical approval and is therefore fit for its intended use, and if the conformity procedure has been conducted, it can be labelled with the CE mark, placed on the EU internal market and traded freely.

2.1.3 Guidance Paper H

Since, in the mandates for producing harmonised technical specifications, there is only a relatively generalised addendum (Annex 4) concerning the release of dangerous substances, in practice it is difficult to transpose the Essential Requirement No. 3 into the technical specifications. Guidance Paper H, "A harmonised approach relating to dangerous substances under the Construction Products Directive", is therefore intended to provide writers of technical specifications with help in transposing the Essential Requirement No. 3 [9]. Although it is not legally binding, the Guidance Paper has a high status. The Commission services also instruct that the Guidance Paper must also be taken into consideration when its requirements go beyond those in the mandates.

Guidance Paper H provides various steps for transposing the Essential Requirement No. 3 into the technical specifications:

1. Identify dangerous substances that are regulated for the products concerned

Writers of technical specifications should identify all legal requirements that concern the dangerous substances used in the construction product. A starting point here is the respective product mandate that lists dangerous substances that could be potentially contained in the product (e.g. asbestos, formaldehyde, cadmium) or the database set up by the European Commission for regulated substances (c.f. Section 3.1.1). Further, own expert knowledge is required.

2. Verify, whether the dangerous substance has to be addressed in the technical specification and in the CE marking

The dangerous substances are regulated in three different ways to ensure an adequate level of protection:

- Substances that are regulated at Community level no longer have to form part of the CE marking as the producer always has to satisfy these harmonised requirements.

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3 ETAG: European Technical Approval Guideline

- For substances that are regulated at Community level but for which there are national derogations, corresponding information must be included in the CE marking, as there are different levels of requirements.
- For substances that are only regulated nationally, the different requirements must be taken into account in the CE marking. The different test methods must be harmonised.

Regulations that do not fall within the scope of the Construction Products Directive, such as work safety, should be taken into account appropriately as Guidance Paper H welcomes a common approach in this area. This could, for example, be included in the harmonised standard in an informative Annex ZA [4], but does not accompany the CE marking.

3. Determine the "state of the art"

Regarding test methods or other methods of determination, writers of technical specifications should determine the current "state of the art" for the dangerous substances concerned. This should also consider descriptive solutions. If there is a lack of suitable methods for determining the release, a pragmatic approach should be taken such as determining the content.

4. Select a harmonised method of determination for each dangerous substance

The characteristics of the respective dangerous substance should preferably be expressed in terms of the release of the substance or in terms of radiation. The release of the substance should be treated in the technical specifications like every other performance characteristic of the product (e.g. bending strength, thermal conductivity). That is, it should be subject to a harmonised method of determination, have a prescribed form of declaration to accompany the CE marking and, if necessary, use the "no performance determined" option. If possible, horizontal test methods should be used.

Guidance Paper H refers to the possibility of using descriptive solutions, such as limits on the content of the dangerous substance, where a clear relationship between the content and release exists in end-use conditions and where, because of the lack of methods, it is not possible, or very expensive, to determine the rate of release or emission of the dangerous substance. However, even if no relationship can be established between the content and release, a declaration of the content can be acceptable to accompany the CE marking if it concerns substances that are regulated in Council Directive 76/769/EEC [10]. Another descriptive solution would be to check the constituents of the construction product since it can be assumed that a construction product does not release dangerous substances if all the constituents used have been controlled in this respect. When using descriptive solutions, it is pointed out that these should be used with construction products for which there is sufficient experience.

5. Define levels and classes

The technical specifications must take account of the different levels of protection provided by European and national legislation, e.g. in the form of levels or classes for different emission levels. If necessary, "zero content" or "substance banned" situations should be listed in the specifications.

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4 Annex ZA of a harmonised standard identifies the sections of the standard that transpose the mandate of the European Commission. Only these sections form the basis of the CE marking. The other sections have a voluntary character.

6. Specify the information to accompany the CE marking

The technical specifications must specify a means of declaration to accompany the CE marking for identifying and presenting the release of dangerous substances, whereby the "no performance determined" option must also be possible.

2.2 National regulations

Building regulations in Germany

The European Constructions Product Directive 89/106/EEC was transposed into German law by the ***Bauproduktengesetz*** – BauPG ('Construction Products Act') [11]. As with the Construction Products Directive, the Construction Products Act regulates the marketing of construction products while their use is stipulated in the *Musterbauordnung* – MBO ('Model Building Code') [12].

The German Model Building Code is based on the principle of hazard prevention. In terms of health and environmental requirements, it regulates in § 3 that construction works shall be designed, constructed, modified and maintained in such a way that they will not be a threat to public safety or order, in particular to life, health or to the "natural basis of existence". In § 13, the MBO specifies these requirements to the effect that water, humidity, plant and animal pests, as well as other chemical, physical or biological influences, may not be a threat or unacceptable nuisance.

The *Bauregelliste* – BRL ('Building Regulation List') [13] of the *Deutsches Institut für Bautechnik* – DIBt ('German Institute for Building Technology') regulates the use of individual construction products in detail by publishing valid technical rules. When preparing the list of *Technische Baubestimmungen* ('Model List of Technical Building Regulations'), and when compiling and publishing the Building Regulation List, the national level of protection for standardised products is determined by indicating corresponding technical regulations and guidelines. Construction products which are relevant for building regulation and for which no generally accepted technical rules exist must prove their fitness for the intended use with an *allgemeine bauaufsichtliche Zulassung* ('national technical approval'), a test certificate or by approval in individual cases. An attestation of conformity confirms the serviceability of the product. The product is labelled with the attestation of conformity mark (*Ü-Zeichen*).

3 Implementation of the Essential Requirement No. 3 "Hygiene, health and the environment"

3.1 State of implementation

To remove trade barriers caused by non-harmonised technical specifications for construction products, the European Commission issued around 30 mandates to CEN, the European Committee for Standardisation between 1993 and 1999, and around 20 mandates to EOTA, the European Organisation for Technical Approvals, for respectively developing harmonised European standards and technical approval guidelines. The mandates issued to CEN and EOTA are listed in annexes A2 and A3.

Within the framework of these mandates, around 500 harmonised construction product standards need to be elaborated within the jurisdiction of CEN. Since the publication of the

first harmonised standard for cement in January 2001[5], around 150 harmonised construction product standards have been cited in the Official Journal of the European Union by October 2004, and, in the area of technical approvals, 26 harmonised European Technical Approval Guidelines (ETAGs) have been endorsed by the EC services. The references of the harmonised standards are published online at:

http://www.cenorm.be/cenorm/businessdomains/businessdomains/construction/index.asp.

However, the Essential Requirement No. 3 "Hygiene, Health and the Environment" has not yet been harmonised in this first generation of harmonised technical specifications. There are diverse reasons for this. On the one hand the Member States have different regulations and levels, but also different concepts for incorporating health and environmental protection. On the other hand the technical committees from CEN and EOTA also initially lacked the corresponding expertise and, lastly, there is still a lack of uniform test methods for determining the dangerous substances in the construction products.

In order not to cause any further delay to the transposition of the Construction Product Directive, the CEN decided in agreement with the European Commission to adopt the harmonised standards without making specifications as to health and environmental protection [14]. Instead a standard clause [6] in Annex ZA points out that it is also necessary to comply with all European and national regulations on dangerous substances.

All those involved are aiming, however, to harmonise the Essential Requirement No. 3 in the second standard generation. This shall occur as part of the revision of the standards by CEN that takes place every 5 years. Nevertheless there is concern that for many product standards, not all the required harmonised test procedures will be available even after this period. Before suitable test methods are available, the information required in the product standards for health and environmental protection could at least be temporarily provided descriptively, e.g. by limiting the materials to be used.

For the technical approvals, EOTA has adopted the standard clause of CEN in the Model Clauses of the European Technical Approval Guidelines (ETAGs). Furthermore, these Model Clauses require a written declaration from the manufacturer as to whether the product contains dangerous substances according to relevant European or national regulations. If such dangerous substances are included, test methods are listed in the respective ETA[7] with which these substances are to be determined. If these substances are not dealt with in the ETA, then the option "No performance determined" (NPD) should be indicated. The Model Clauses also stipulate that the product needs to be clearly identified. Five possibilities for identification are given by way of example:

- Fingerprint (normally infra-red spectrum)
- Formulation information
- Parameters for the manufacturing process
- Testing of physical characteristics
- Calculations, plans and details

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5 Official Journal of the European Communities C 20/5, 23 January 2001

6 In addition to any specific clauses relating to dangerous substances contained in this standard, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the EU Construction Products Directive, these requirements need also to be complied with, when and where they apply. Note: an informative database of European and national provisions on dangerous substances is available at the Construction web site on EUROPA (CREATE, accessed through http://europa.eu.int).

7 ETA: European Technical Approval

These are selected by the manufacturer in consultation with the approval bodies and depend on the type of product, the relevance of the Essential Requirement, practical tolerances and the intended use of the product [15].

Activities of the European Commission

In order to deal with the harmonisation of the Essential Requirement No. 3, in January 2003 the European Commission (Enterprise Directorate-General) initiated the "Working group on regulated substances" (WGRS), which includes representatives from the Commission, the industry and the construction and environmental authorities of the Member States. Up to now the task of this working group has been to update the EU database for regulated substances and to issue mandates to CEN for developing harmonised test methods for dangerous substances. In the future it will also monitor the implementation of these work results.

3.1.1 EU database for regulated substances

The current mandates for construction products provide either insufficient or no information as to which dangerous substances can be released from construction products or are contained in them. Therefore the European Commission is currently setting up an EU information database as a means of support for determining the dangerous substances to be tackled in technical specifications. This is intended to contain European and deviating national regulations on dangerous substances. This EU database can be accessed online at http://europa.eu.int/comm/enterprise/construction/internal/dangsub/dangmain.htm. It is aimed at the writers of technical specifications and the manufacturers of construction products.

The latest version of the database (not available online yet) contains regulations of the Member States and the European Union on dangerous substances that are relevant for construction products, with the corresponding limit values, information on release behaviour and test methods. The following queries can be used for retrieving the information:

- Substance name
- Construction product
- Member State/EU
- Release scenario (indoor and outdoor air, groundwater, surface water, drinking water, soil, radioactivity)
- Emission behaviour (release by degassing, leaching, radioactivity, microbial growth, content)

The European Commission is responsible for maintaining the database, while the Member States are responsible for providing up-to-date data.

3.1.2 Mandate to CEN for developing horizontal test methods for dangerous substances

Due to the enormous diversity of substances that are used in construction products, the European Commission advocates a step-by-step approach for implementing the Essential Requirement No. 3. As a first step, "regulated substances" (instead of all used substances) and construction products are given priorities on the basis of their potential risk to health and the environment and their quantity respectively. Technical reports are intended to provide assistance in identifying the most common construction products and their constituents. These are to be elaborated by CEN within the framework of the issued mandate.

According to the current state of discussion, the European Commission considers "regulated substances" to be substances that are regulated in the Dangerous Substances Directive 67/548/EEC [3] and in other EU Directives and national regulations that are relevant for construction works and products.

The Commission Expert Group on Dangerous Substances in the field of Construction Products elaborated a first draft mandate for developing harmonised test methods for regulated substances. In the mandate the release of dangerous substances from construction products is structured using possible release scenarios to soil, ground and surface water, as well as to indoor and outdoor air.

In order to reduce the amount of testing required for determining the release of substances, construction products shall also be identified that, in terms of the release of regulated substances, do not require additional testing. In the current mandate, products with a well known composition and release behaviour are considered to be eligible as **WFT products** (Without Further Testing). For all other construction products that can release dangerous substances and that therefore cannot be included in the WFT product list, harmonised test methods shall be developed for determining the content or release of these substances. However, it should be noted that the European Commission is currently only having test methods drafted for substances that are regulated at the European level or nationally ("regulated substances").

A horizontal Technical Committee (TC) at CEN shall be responsible for developing the horizontal test methods. This shall collaborate, however, with the already existing product and environment TCs. Since the harmonised test methods shall also be implemented in European Technical Approvals, the European Commission is also striving for the involvement of the relevant EOTA bodies.

As an official body of the Commission, it is currently assumed that the EC Working group on regulated substances shall monitor the work of CEN, elaborate other necessary mandates such as for the release scenario to outdoor air and radioactivity, and amend the mandates in accordance with the latest scientific findings, new test methods or new policy developments.

3.1.3 Discussion on the current implementation activities

Which substances that can be potentially released shall be taken into account?

In the European Union, around 30,000 chemicals with an annual production of more than 1 ton and around 2,700 chemicals with an annual production of more than 1,000 tons are marketed [16]. Only around 100 of these chemicals have been assessed in terms of possible health and environmental risks in accordance with the EC Existing Substances Regulation [17]. The time plan of the new European chemicals policy currently envisages that the aforementioned 30,000 substances shall be registered, and substances with dangerous characteristics evaluated in terms of their potential risk to health and the environment, by 2012.

These figures show that numerous substances can be used in products – and therefore in construction products – that to a large part have not yet been assessed by any independent body in terms of their potential risk to health and the environment. This has to be seen alongside the fact that there are only a few regulations for dangerous substances that are relevant for construction products. Most of these regulations are included in Directive 76/769/EEC [10] on restrictions on the marketing and use of dangerous substances. Of the 47 regulations for individual substances or total parameters that are listed there, only around 20 prohibitions or restrictions are relevant to the use in construction products. More than half of the regulations apply to dangerous substances in other applications and therefore do not cover a possible use in construction products.

In addition to the few substance-related regulations for construction products, there are also provisions for individual environmental areas, which are often formulated, however, in very general terms. An example here is the German *Wasserhaushaltsgesetz* – WHG ('Water Resources Act'), which in § 1a requires that waters (including groundwater) shall be managed so that they serve the well-being of the general public with no avoidable impairment to their ecological functions [18]. Another example is the *Kreislaufwirtschafts- und Abfallgesetz* – Krw-/AbfG ('Closed Substance Cycle Waste Management Act'), which among other things regulates the recycling of wastes that can also be used in construction products. For instance, § 5 (3) KrW-/AbfG states that the recycling of wastes, in particular their integration in products, must not impair the well-being of the general public, i.e. it requires harmless recycling that, in particular, must not cause any accumulation of harmful substances in the cycle of reusable materials [19].

In addition to the legal regulations, there are often technical building regulations available. Although they provide for a safe construction through specifying the field of application, principles and verification rules, the required level of protection is not precisely quantifiable, it is accepted by the authorities, industry and general public that the products are "sufficiently safe" on the basis of experience. In many cases, however, this only concerns the level of protection in technical terms. Health and environmental requirements are often not included in the technical building regulations.

In the current discussion on the mandate for test methods, "regulated substances" are defined as substances regulated in the Dangerous Substances Directive 67/548/EEC [3] and in other EU Directives and national regulations that are relevant for construction works and products. Another definition that is also being discussed only considers "regulated substances" to be substances that are restricted or prohibited nationally or at European level. This would mean, however, that the overall majority of substances classified as dangerous according to the EU's Dangerous Substances Directive 67/548/EEC would not be considered since only a small fraction of the substances in the Dangerous Substances Directive are restricted or prohibited for applications relevant to construction products.

The research project's definition of "dangerous substances" is much broader than the definitions for "dangerous substances" described above. Here, substances are also defined as "dangerous" that have not yet been regulated but for which there is enough scientific evidence to assume that the use of such substances in construction products would pose a risk to the users and/or the immediate environment of a building (c.f. definition Section 1). This definition is based on the provisions of the Construction Products Directive that require that a construction work should not present a risk to the users and the immediate environment if regulations apply to the works that contain corresponding requirements. This also accords with the provisions of the German building regulations, according to which construction works may not present a threat to life, health or to the "natural basis of existence". Thus both the Construction Products Directive and German building regulations apply not just to hazards presented by regulated substances.

Which regulations should be considered?

The European Commission stipulates that for the implementation of Essential Requirement No. 3 "Hygiene, Health and the Environment" only notified[8] regulations shall be adopted as regulations for the Member States. The reason for this requirement is that the Commission considers national protection requirements to be justified if they have been declared and approved within the framework of the notification procedure. The aim of this notification procedure is to avoid trade barriers within the internal market. However, according to the "New Approach" for standardisation [7] and the Treaty establishing the European

8 Notified regulations are provisions that have been declared to the European Commission by the Member States within the framework of Directive 98/34/EC [4] or according to Article 95 EC Treaty [6], and which have been approved by the Commission.

Communities [6], existing and justified protection in the Member states may not be reduced. Therefore, in order to maintain the existing level of protection in the Member States with free movement of goods in accordance with the "New Approach", the European Commission must be notified of this level of protection by the authorities from the Member States.

Here it should be noted, however, that the national level of protection is also represented by regulations that are not mandatory but merely recommended. According to Directive 98/34/EC [4], no notification is necessary for voluntary regulation, although they are adhered to in the respective Member States. Thus limiting the level of protection to notified regulations does not always accord with the practice in the Member States.

In order to be able to take account of new knowledge regarding the potential health and environmental risks of construction products, the technical specifications should point out that not only existing regulations must be taken into account but that, with corresponding evidence, additional requirements can be made to avoid endangering users of construction works or their environment.

3.2 Approach for transposing the Essential Requirement No. 3 into technical specifications

In terms of the Essential Requirement No. 3 "Hygiene, Health and the Environment", the Construction Products Directive and the more specific Interpretative Document No. 3 require that building users and the immediate environment shall not be endangered by the construction works.

A tiered approach should be taken in order to take full account of the Essential Requirement No.3 in the technical specifications. In order to evaluate the possible release of dangerous substances, this requires knowledge on both the chemical composition and structure as well as on the planned use of the products in construction works (e.g. direct or no contact with the indoor air). For instance, it is quite possible for a product classified as "critical" to be used in application areas that present no risk to health or the environment.

Taking into account the composition and area of application, the mandated construction products should be classified into products that, due to existing experience, can be deemed as obviously harmless and for which no additional tests are required (WFT products – Without Further Testing) and products for which the health and environmentally relevant effects can only be evaluated by using specific individual tests as part of approval procedures. For products falling between these two cases, which are therefore subject to standards, stipulations should be made in the standards that ensure that a risk for users and the environment can be excluded with a sufficient degree of certainty.

WFT products (Without Further Testing)

Construction products whose constituents are known and which, based on many years of experience, are not expected to release any dangerous substances should be included in a list of WFT products (Without Further Testing) for which no additional requirements are made in terms of testing for release behaviour. The corresponding product standards should indicate that they are WFT products. The composition and areas of application for the corresponding construction product should be precisely specified in the standards. As has already been described in Section 3.1.2, the new Mandate for horizontal test methods for dangerous substances includes the elaboration of a technical report to specify criteria for classifying WFT products.

Standardised products

Construction products that are not suitable for inclusion in a WFT product list should be tested within the domain of standardisation as far as they fulfil specific prerequisites. Even the manufacturers themselves are often insufficiently aware of the chemical composition of their respective products; when specific raw materials are used, this information is often only known to the suppliers, i.e. the producers of the individual substances. Furthermore, in terms of the materials used, the standards generally provide either very generalised information or none at all. It should be required in this context that the respective construction products are described in the product standards as precisely as possible in terms of their chemical composition and that, if necessary, the range of substances be reduced. The longstanding experience with the standardised products means that the release of dangerous substances should be known and in many cases also regulated. The dangerous substances that can be released from construction products, or whose content is problematic, must be listed in the product standards together with the corresponding harmonised test methods. In order to enable evaluation by the Member States, levels, classes or declared values should be given in the CE marking for these pollutant parameters.

The current mandates for construction products provide either insufficient or no information as to which dangerous substances can be released from construction products or are contained in them. In order to specify the substances to be considered, a list should be drawn up of dangerous substances that can be released from construction products or whose content is classified as problematic. It is important to note here that it cannot be assumed that the list of dangerous substances is exhaustive and that if corresponding information becomes available, other dangerous substances must be taken into account in the technical specifications. The specification of substances deemed to be dangerous should be subject to intensive discussion. However, it will not be sufficient to consider just regulated substances as described in Section 3.1.3.

Depending on the complexity of the respective product, a comprehensive evaluation of all substances will always be very difficult in the field of standardisation. For this reason, and as is already practised in the German approval procedures, more extensive testing and evaluation schemes should be drawn upon such as the DIBt Guideline: "Assessment of the effect of construction products on soil and groundwater" [20] or the "Health-related Evaluation Procedure for Volatile Organic Compounds Emissions (VOC and SVOC) from Building Products" [21] (see also sections 5.3 and 6.1). The DIBt Guideline also prescribes biological testing procedures and requires compliance with insignificance thresholds for the release of heavy metals and organic substances to soil and groundwater. By testing the ecotoxicological effects, it is also possible to draw conclusions as to the potential risk to the environment of the construction products without having precise knowledge of the substances contained.

Products subject to approval

Test for construction products for which there is no experience concerning the release behaviour of dangerous substances should be harmonised within the framework of European technical approvals. This generally concerns innovative and, in terms of health and environmental protection, product groups that have not yet been comprehensively described and which contain a diverse range of substances. Construction products should also be subject to approval that use wastes whose composition cannot be defined and for which there is no long-term experience available.

As technical approvals are issued for defined construction products, it is both permissible and realisable for the respective approval body to demand details on the chemical composition of construction products submitted for approval so that it can evaluate the constituents. Whether products are to be subject to standards or approval should be determined by the European Commission at the mandate level.

The following diagram illustrates the approach of dividing the diverse range of mandated construction products into various groups. This division is applied by using the example of "concrete constituents" and "floorings", which are examined in detail as part of this research project (see also sections 5.7 and 6.3).

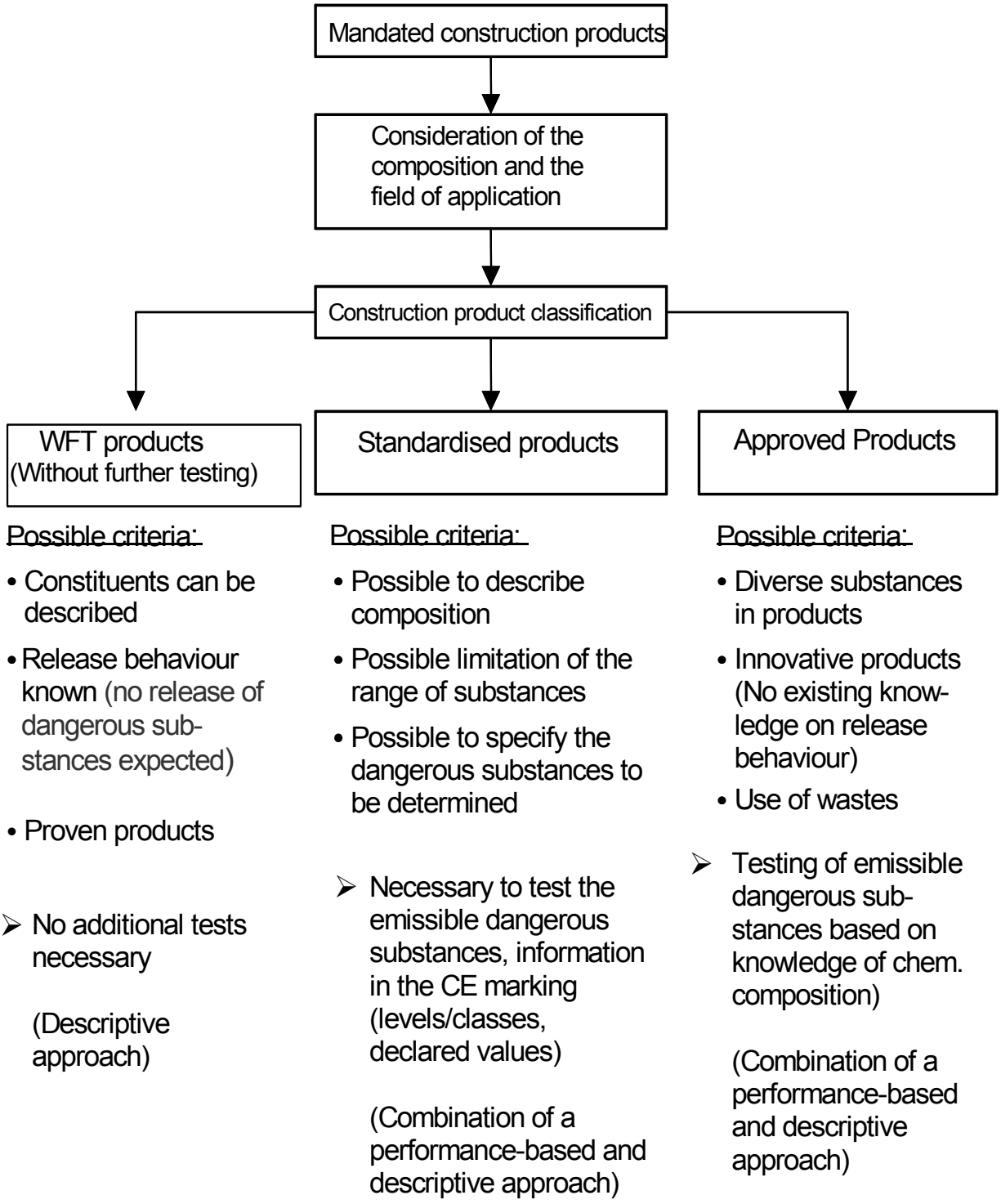

Fig. 1: Approach for transposing the Essential Requirement No. 3 into technical specifications

4 Procedure for developing health and environmental criteria for selected construction products

According to the Council of European Producers of Materials for Construction (CEPMC), more than 20,000 different products and materials are used in Europe for constructing buildings and infrastructure. For the purposes of the research project, the diverse range of construction products used was limited to products for which a mandate has been issued by the European Commission to the European standardisation and technical approval organisations, CEN and EOTA, for respectively drawing up harmonised European standards and technical approval guidelines. The mandates that have been issued until now (28 mandates to CEN and 20 mandates to EOTA) are structured similarly. For the purposes of specifying dangerous substances whose release and/or content could endanger health and the environment, they provide the following important information:

- Intended use of the construction product
- Field of application of the construction products with the materials used (exemplary)
- Requirements concerning the performance characteristics to be defined by the harmonised technical specifications such as hygiene, health and the environment, stability and safety in case of fire
- Attestation of conformity systems
- General passage on dangerous substances (Annex 4)

The release of dangerous substances is referred to in the part of each mandate that deals with the requirements concerning the performance characteristics for "hygiene, health and the environment" and that are to be defined by the respective standard or technical approval. Some mandates also list specific dangerous substances that are to be considered in the technical specifications. These always only concern, however, the substances asbestos, formaldehyde, pentachlorophenol (PCP), cadmium, heavy metals, polycyclic aromatic hydrocarbons (PAH) and/or radioactivity.

Annex 4 states that all legal provisions (including national provisions) for dangerous substances are to be complied with. Furthermore, it also stipulates that, if applicable, legal provisions for materials used in construction products shall also be complied with even if they are outside the scope of the Construction Products Directive, such as occupational health and safety regulations. For assisting writers of technical specifications, it also refers to the EU database, which lists regulations of the Member States and the European Union on dangerous substances from/in construction products.

In terms of the release behaviour and/or content of dangerous substances from/in construction products, this research project only considers the mandates issued to CEN for developing harmonised European product standards. Due to the extent of the material it was not possible to consider the mandates issued to EOTA as well.

By stating the materials used and the intended use of the construction products, the assessment of the CEN mandates provides information on the possible release of dangerous substances to the environmental media of soil, groundwater and indoor spaces and/or on the content of dangerous substances. However, it is generally only possible to make a real assessment of the leaching and emission behaviour of dangerous substances from construction products by evaluating tests that have been carried out. The following sources were drawn upon for determining the release and/or content of dangerous substances:

- Published research material (e.g. research reports on the release behaviour of dangerous substances from construction products; databases such as Ecobis 2000 –

ökologisches Baustoffinformationssystem ('Ecological Construction Material Information System')).

- Information from construction product trade associations (e.g. *Verein deutscher Zementwerke*, *Deutsche Bauchemie*, European Panel Federation)
- Product information from manufacturers
- Expert committees at the DIBt and other specialist bodies
- Own knowledge concerning the field of technical approvals

The large number of CEN mandates meant that although they were evaluated, within the framework of the project it was only possible to research some of the mandated construction products in detail. As an example for the release of dangerous substances to soil and groundwater, the concrete constituents cement, aggregates, concrete additions and admixtures were selected as these are construction products that are used on a large scale and are practically ubiquitous. The main focus was on evaluating studies on the leaching behaviour of dangerous substances. With regard to the leaching behaviour, there is a potential risk to the environment due to the release and/or content of inorganic substances such as heavy metals.

Floorings were selected as an example for the release of dangerous substances in indoor spaces as these are used on a large scale in indoor spaces and thus represent a potential source of emissions. With floorings, volatile organic compounds present a particular risk to the health of building users.

CEN mandates for road construction materials have also been issued by the European Commission. In Germany, according to § 1 (2) of the *Musterbauordnung* – MBO ('Model Building Code'), public transport works (including ancillaries such as road construction materials) are not the responsibility of the *Laender* as is the case with construction works and products. Because they come under a separate area of regulations, these products were not taken into consideration in this research project.

The following table lists the CEN mandates. Construction products that were considered in detail are highlighted in bold.

Table 1: CEN mandates for developing harmonised European construction product standards (not including public transport works and reaction to fire)

No.	Mandate No.	Mandate
1	M 100	Precast concrete products
2	M 101	Doors, windows and related products
3	M 102	Membranes
4	M 103	Thermal insulating products
5	M 104	Structural bearings
6	M 105	Chimneys, flues and specific products
7	M 106	Gypsum products
8	M 107	Geotextiles
9	M 108	Curtain walling
10	M 109	Fixed fire fighting systems
11	M 110	Sanitary appliances
12	M 112	Structural timber products and ancillaries
13	M 113	Wood-based panels and related products
14	**M 114**	**Cements, building limes and other hydraulic binders**
15	M 115	Reinforcing and prestressing steel for concrete
16	M 116	Masonry products
17	M 118	Waste water engineering products
18	**M 119**	**Floorings**
19	M 120	Structural metallic products and ancillaries
20	M 121	Internal and external wall and ceiling finishes
21	M 122	Roof coverings, roof lights, roof windows and ancillary products
22	**M 125**	**Aggregates**
23	M 127	Construction adhesives
24	**M 128**	**Products related to concrete, mortar and grout**
25	M 129	Space heating appliances
26	M 131	Pipe-tanks and ancillaries not in contact with water intended for human consumption
27	M 135	Flat glass, profiled glass and glass block products
28	M 136	Construction products in contact with water intended for human consumption

The evaluation of the mandates that are not considered in detail is presented in the form of a list in Annex A4. The list provides information on:

- the intended use of the construction product
- possible materials used

- construction product standards that are already published in the Official Journal of the European Union
- dangerous substances that can be potentially released and
- voluntary regulations that include information on substance prohibitions and restrictions.

As already mentioned, it was not possible to consider all the construction products in detail due to the enormous range of material and substances. Nevertheless, the release behaviour of dangerous substances must be examined in detail for all construction products in order to ascertain which requirements regarding health and environmental criteria must be incorporated in the technical specifications.

It also needs to be taken into account that construction products are used in the European Union for which mandates for developing harmonised European standards have not yet been issued, but which nevertheless present a potentially high risk to health and the environment. In order to exclude a risk as defined by the Construction Products Directive, all product groups should be mandated that can be defined as construction products in accordance with the Construction Products Directive and for which at least one Essential Requirement from the Construction Products Directive applies. In terms of the Essential Requirement No. 3 "Hygiene, Health and the Environment", this affects, in addition to product groups that are already mandated, such as specific floorings and wall coverings, currently non-mandated product groups such as dyes, paints, anti-corrosive agents and adhesives in the non-load-bearing area as well as soil injection agents.

Thus the research project mainly presents a methodical approach for taking account of the Essential Requirement No.3 in technical specifications that, in principle, would be applied analogously to all construction products within the scope of the Construction Product Directive.

5 Concrete constituents as example for the release of dangerous substances to soil and groundwater

Concrete is a building material that is produced by mixing together its constituent materials – cement, coarse and fine aggregates and water, with or without adding additions or admixtures. It is the hydration of the cement that gives the concrete its properties [22]. Hydration describes the chemical reactions that occur when, after mixing water with cement, the cement paste hardens due to the water reacting with the cement clinker minerals to form hydrate phases.

5.1 Legal framework

This research project is concerned with the release of dangerous substances from concrete constituents, for which harmonised European product standards are being developed under a mandate issued by the European Commission to CEN. The table below provides an overview of the mandated concrete constituents.

Table 2: Mandated concrete constituents

Mandate	Concrete constituent	Materials
Mandate 114: Cements, building limes and other hydraulic binders	Cement	Portland cement clinker Granulated blastfurnace slag Burnt shale Calcium sulphate Additives
Mandate 125: Aggregates	Aggregates	Normal aggregates (natural, manufactured) heavyweight aggregates (natural, manufactured) Lightweight aggregates (natural, manufactured) Recycled aggregates
Mandate 128: Products related to concrete, mortar and grout	Additions	Fillers Pigments Fly ash Silica fume
	Admixtures	Plasticisers, liquifiers Retarders, accelerators Air-entraining agents Sealants Injection aids Stabilisers

The constituent materials described can be used for producing concrete, mortar, grout and other mixes (e.g. soil injection agents, base material in road building). This research project has only considered the constituents for concrete.

As the Construction Products Directive applies to the phase of use of construction works, only the release of dangerous substances from hardened concrete was studied as part of this research project [5].

During the phase of use of construction works, dangerous substances can be released via the following mechanisms [23]:

1. Leaching processes (emission via the hydrological pathway)
   Leaching of heavy metals, salts, acids/ alkalis and organic materials can cause contamination of soil and/or groundwater.
2. Evolution processes (emission via the air pathway)
   The evolution of volatile organic compounds can lead to pollution of the indoor and/or outdoor air.
3. Radiation contamination
   Radioactive emissions and/or the release of radioactive substances increase the radiation contamination of the indoor and/or outdoor air.

Since concrete constituents are being described as an example of the release of dangerous substances to soil and groundwater, only the emission via the hydrological pathway shall be considered in Section 5: "Concrete constituents".

Release of dangerous substances through leaching (emission via the hydrological pathway)

The leaching of heavy metals, salts and organic materials from mineral building materials takes place upon contact with water or aqueous solutions. Initially, soluble salts can be deposited on the surface of the building material after contact with water (wash-off effects). This process ends after a short period of time. During the rest of the leaching, it is mainly

diffusion processes that occur. The diffusion is caused by the particles' individual movements; the mass transport occurs on a concentration gradient. A pore system is essential if there is to be mass transport in the fixed matrix by means of diffusion. Here, the type, arrangement and interlocking of the pores is decisive and not the frequency of the pores [23]. The following factors influence the transport processes in concrete [23,24]:

1. Porosity and pore structure (impermeability of the hardened cement paste)
2. Hydration age
3. Carbonization

Porosity and pore structure

The porosity of the hardened cement paste depends mainly on the ratio of the water (W) contained in the concrete to the cement (C) – the water-cement ratio (W/C ratio). The impermeability of the hardened cement paste increases considerably as the water-cement ratio decreases and the degree of hydration increases. The cement content, the particle structure and particle scale of the aggregates and additions remain important for the impermeability of the concrete structure [23].

Hydration age

The impermeability of the hardened cement paste increases as the hydration age increases so that dangerous substances are incorporated within the hardened cement paste. An additional effect for some materials is that dangerous substances are chemically incorporated within the mineral phases of the cement stone. The solubility and mobility of the dangerous substances therefore decreases with increasing hydration age [23, 24].

Carbonization

The hardened cement paste is carbonised by reacting with carbon dioxide in the air. This causes the pH value to decrease in the pore water, which in turn can cause previously immobile material to be dissolved and washed out. Without carbonisation, the pH value in the pore water is generally above 12. As the carbonisation process continues, individual heavy metals are increasingly leached out. The leaching behaviour of heavy metals depends, however, on the ph-value, and differs according to the type of heavy metal. Metal ions that display amphoteric solution behaviour such as Al^{3+}, Zn^{2+}, Pb^{2+} and Cu^{2+}, are less soluble with pH values around 8. Chromates and alkalis display the same solution behaviour across the entire pH range. However, it is unlikely that carbonisation will occur when installing concrete in soil and groundwater unless the groundwater is highly carbonated [23, 24].

The following section lists German and European test methods for determining the release of dangerous substances to soil and groundwater by leaching. For assessing the released substances, reference shall be made to the more comprehensive concepts provided by the German DiBt Guideline: Assessment of the effect of construction products on soil and groundwater *(DIBt-Merkblatt zur Bewertung der Auswirkungen von Bauprodukten auf Boden und Grundwasser*), which shall be referred to here as the DIBt Guideline Soil/Groundwater [20], and the Dutch Building Materials Decree [25]. Specifically, using the three mandates for concrete constituents (M 114, M 125, M 128), the leaching of heavy metals and organic substances from concrete constituents shall be discussed and recommendations made for taking material-specific requirements into account in the second generation of harmonised European product standards. The discussion on the release of dangerous substances from concrete constituents is to a large extent based on a research project on the leaching behaviour of standardised concrete constituents that was financed by the *Deutsche Institut für Bautechnik* (DIBt) and was conducted by the *Institut für Bauforschung der RWTH Aachen* (Institute for Building Materials Research at the Technical University of Aachen (IBAC)). As part of the IBAC research project, the results of leaching tests were assessed by examining

existing literature and, using the DIBt Guideline Soil/Groundwater, evaluated in terms of environmental compatibility [26].

5.2 Test methods for determining the release of dangerous substances to soil and groundwater by leaching

The following section describes national and European test methods for determining the release of dangerous substances from concrete and concrete constituents by leaching.

5.2.1 Batch tests

To examine the leaching behaviour of concrete constituents, batch tests are used that were originally developed for examining waste and sludge. The method is based on the principle of mixing a defined sample amount for a specific particle size with an eluant. The mobilizable substances leach out during a specified time, supported by a horizontal or upside down shaking movement. After the solid material has separated by means of filtration, the respective components in the leachate are determined according to the predefined methods of analysis.

The disadvantage of batch tests is that they do not provide information on the long-term behaviour or allow any prognoses to be made on the release behaviour under real conditions. The crushing of the material and the abrasion caused through shaking the sample material create additional surfaces that, under real conditions, would not come into contact with soil and groundwater. This leads to increased leachate concentrations. However, the batch tests do provide information on the release potential of a material that exists under specific test conditions.

One advantage of the method is that it allows tests to be completed quickly. Another advantage is its long-term use, so that most existing limit values (e.g. *LAGA-Mitteilung 20, "*Requirements for Re-use/Utilization of Mineral Residues/Wastes") [27] are based on batch tests. The following section describes European batch tests for waste and sludge and two batch tests used in Germany that are implemented within the framework of the *LAGA-Mitteilung 20* [27] on the recycling of mineral waste.

DIN EN 12457-4 [28]

Under a mandate from the European Commission (DG Environment), the harmonised European standard series DIN EN 12457, Part 1 to 4, was developed to provide harmonised test methods for wastes, whereby it describes compliance tests for the leaching of granular waste materials and sludge. The four parts are mainly differentiated according to the liquid to solid ratio (2 l/kg, 10 l/kg, 8 l/kg) and the maximum particle size of the samples (< 4 mm, < 10 mm). Part 4 of the standard series (DIN EN 12457-4) closely corresponds to the batch test according to DIN 38414-S4 [29] that is widely used in Germany.

According to DIN EN 12457-4, the material being examined shall be crushed to a particle size < 10 mm. 90 g of this sample is mixed with distilled water with a liquid to solid ratio of 10:1, and shaken horizontally or upside down for 24 hours at ambient temperature.

DIN 38414-S4, modified [27]

In the Technical Rules of the Working Group of the German Länder on Waste Issues (*Länderarbeitsgemeinschaft Abfall* (LAGA TR 20)), the batch test to DIN 38414-S4 that is frequently used in Germany is modified for mineral wastes that are to be recycled [27].

According to the standard test to DIN EN 38414-S4, the material being examined shall be crushed to a particle size < 10 mm. 100 g of this sample is mixed with 1 l of distilled water and twisted upside down or shaken for 24 hours at ambient temperature. In the *LAGA-Mitteilung 20,* in deviation from this standard test, the material being examined is eluted in the condition in which it is to be recycled. It is only crushed in individual cases where this is absolutely necessary for conducting the test. Depending on the largest particle size, the sample amount to be examined weighs between 100 and 2500 g. The liquid to solid ratio is always 10:1.

The batch test in *LAGA-Mitteilung 20* closely corresponds to the batch method according to TP Min StB, Part 7.1.1 that has so far been used as a routine method as part of the quality control of road construction materials [30].

LAGA EW 98 S [31]

The Working Group of the German Länder on Waste Issues (*Länderarbeitsgemeinschaft Abfall – LAGA*) has stipulated a batch test (LAGA EW 98 S) for waste, contaminated soil and material from contaminated sites that shall supersede the modified DIN 38414-S4 test in the current revision of the *LAGA-Mitteilung 20*. According to LAGA EW 98 S, the sample material shall be examined in its original condition. There is only crushing for the particle size fraction > 40 mm. 100 g of the sample is mixed with 1 l of distilled water and shaken upside down or horizontally for 24 hours at ambient temperature.

The table below provides an overview of the parameters for the test methods described.

Table 3: Batch tests to DIN EN 12457-4 [28], DIN 38414-S4, modified [27] and LAGA EW 98 S [31]

Parameter	Test methods		
	DIN EN 12457-4	**DIN 38414-S4, modified**	**LAGA EW 98 S**
Area of application	Granular waste materials and sludges	Mineral waste for recycling	Wastes, contaminated soil, materials from contaminated sites
Test specimen size	Particle size < 10 mm	Normally no crushing of the material	Particle size < 40 mm
Weighed portion	90 g $\pm$ 5 g	100 g to 2500 g (depending on largest particle size)	100 g
Liquid to solid ratio [l/kg]	10:1	10:1	10:1
Type of eluant	Distilled, demineralised, deionised water or water with comparable purity	Demineralised water	Distilled, demineralised, deionised water or water with comparable purity
Duration	24 hours $\pm$ 0.5	24 hours	24 hours
Type of motion	Upside down or horizontal shaking	Shaking	Upside down or horizontal shaking
Temperature	Ambient temperature (20 °C $\pm$ 5 °C)	Ambient temperature	Ambient temperature
Vessel/apparatus	Bottles made of glass or HDPE or PP	Wide-mouth bottle made of glass	Bottles made of glass or PE or PP

5.2.2 Static tests (tank leaching method)

Static tests are also used for examining the leaching behaviour of concrete constituents. The method consists of mixing a defined sample amount for a specific particle size or a defined sample on a sieve insert with an eluant. The mobilizable substances leach out during a specified time. In contrast to the batch test, with the static test only the eluant is moved above or below the sample through stirring or, as with the Dutch static test, there is no movement of the eluant. After the solid material has been separated by filtration, the respective components in the leachate are determined according to the predefined method of analysis.

With static tests, the material being examined is generally not crushed. If there is crushing, this is done only for the particle size class > 32 mm. As the sample material remains in the original condition and only the eluant is moved, the static test is considered to be a leaching test that has high practical relevance and which is also suitable for solidified test specimens [23].

A distinction is made between short-term and long-term static tests depending on the duration of elution. With the short-term static test for lumpy material with a leaching duration of 24 hours, it is essentially wash-off effects, dissolution and separation mechanisms that dominate [24]. With this short-term static test, however, it is not possible to record diffusion processes that, for a series of heavy metals, determine the leaching mechanism after around seven days. To that end it is necessary to use long-term static tests that also provide information on the time-dependence of the leaching.

For assessing the results of long-term static tests, there is often a lack of corresponding limit values, as most limit values (e.g. *LAGA-Mitteilung 20*) refer to batch testing. Limit values that require the long-term static test as a test method can currently only be found in the DIBt Guideline Soil/Groundwater for assessing the effects of construction products [20] and in the Dutch Building Materials Decree for assessing the release of inorganic parameters from mineral building materials (emission values) [25].

Long-term static tests can be used as compliance tests for materials, since here the long-term release of dangerous substance is examined. This enables an assessment to be made of the impact of construction products on soil and groundwater under realistic conditions.

5.2.2.1 Short-term static tests

The following section describes the standard short-term static tests used in Germany. When comparing batch tests according to DIN 38414-S4 or DIN EN 12457-4, and short-term static tests according to, for example, DIN EN 1744-3, it has been shown that both methods provide results with a **good** compliance when using the same samples and liquid to solid ratio [23, 32]. However, because the short-term static test to DIN EN 1744-3 uses larger sample amounts, the reproducibility of the results is better, particularly with heterogeneous materials. This method is therefore deemed to be more practice-oriented [32].

DIN EN 1744-3 [33]

The leaching methods according to the European Standard DIN EN 1744-3 was developed by CEN/TC 154 "Aggregates" as a test method for determining the leaching of aggregates and applies for unbound aggregates with a particle size < 32 mm. The method is suitable for testing the compliance with an already characterised material.

In accordance with DIN EN 1744-3, the material being examined is generally not crushed. Particles > 32 mm are sieved out and broken separately. 2000 g of the sample are mixed in a sieve with distilled water with a liquid to solid ratio of 10:1 for 24 hours. The eluant above the sample is moved during the leaching period with a motor-driven stirrer.

LAGA EW 98 S [31]

The tank leaching test (LAGA EW 98 T) from the Working Group of the German Länder on Waste Issues (LAGA) is suitable for unbound, bound and solidified materials. It is used for materials with a particle size > 40 mm. The material is normally eluted in the condition in which it is supplied and, if applicable, in which it is to be recycled. Materials whose largest particle size < 40 mm must be examined with a batch test (LAGA EW 98 S). 2000 g of the sample are mixed in a sieve with distilled water with a liquid to solid ratio of 10:1 for 24 hours. The eluant below the sample is moved during the leaching period with a magnetic stirrer.

TP Min-StB, Part 7.1.2 [34]

The tank leaching method in accordance with the technical test specifications for mineral materials used in road construction is also suitable for unbound, uncompressed mineral materials and compressed or solidified test specimens. With the exception of the smaller particle sizes (< 32 mm), the parameters for this method are analogous to the LAGA EW 98 T method.

The table below provides an overview of the parameters for the test methods described.

Table 4: Tank leaching methods to DIN EN 1744-3 [33], LAGA EW 98 T [31] and TP Min-StB, Part 7.1.2 [34]

Parameter	Test methods		
	DIN EN 1744-3	**LAGA EW 98 T**	**TP Min-StB, Part 7.1.2**
Area of application	Unbound aggregates	Unbound, bound and solidified materials	Unbound, uncompressed mineral material, compressed or solidified test specimens
Test specimen size	Particle size < 32 mm	Particle size > 40 mm (non-solidified materials), normally no crushing	Particle size < 32 mm (unbound mineral material) or test specimen
Weighed portion	2000 g	2000 g (unbound materials)	2000 g (unbound mineral material)
Liquid to solid ratio [l/kg]	10:1	10:1	10:1
Type of eluant	Distilled, demineralised, deionised water or water with comparable purity	Distilled water or water with the same degree of purity	Demineralised water
Duration	24 hours $\pm$ 10 min.	24 hours	24 hours
Type of motion	Stir eluant above specimen	Stir eluant below specimen	Stir eluant below specimen
Temperature	Ambient temperature (20 – 25 °C)	Ambient temperature (20 – 25 °C)	No information
Vessel/apparatus	Glass container with sieve unit (tank)	Container made of glass or PP with sieve unit (tank)	Container with sieve unit (tank) made of glass or PP (for inorganic material only)

5.2.2.2 Long-term static tests

Long-term tests are conducted over a period of 56 or 64 days. The multiple leachate change during this time provides information on time-dependent leaching behaviour. Various examinations have shown that the release of various heavy metals from cement-bound building materials is controlled by diffusion. During the first seven days, the dissolution processes (wash-off effects) predominate; afterwards it is diffusion processes that determine the leaching of the substances [24].

The currently existing long-term static tests only provide information on the release behaviour of inorganic parameters. Since, according to the IBAC research project, the leaching of dangerous substances from concrete constituents is mainly related to heavy metals, this is also generally sufficient [26]. In practice, the organic parameters are generally determined from the leachate gained through leaching methods for inorganic parameters.

At the European level, CEN/TC 292 WG 6 is currently developing a long-term static test for the leaching of wastes similar to the Dutch diffusion test NEN 7345 [35]. A draft version of the European method has not yet been presented. The planned long-term static test also only applies for inorganic parameters. There has not yet been any discussion about developing a leaching method for organic parameters at the European level [32].

The following section describes the long-term static test used by the *Deutscher Ausschuss für Stahlbeton – DafStb* ('German Committee for Reinforced Concrete') in accordance with the DIBt Guideline Soil/Groundwater as well as the diffusion test used in accordance with the Dutch Building Materials Decree.

DAfStb draft standard [36]

The long-term static test in accordance with the draft standard of the *Deutscher Ausschuss für Stahlbeton – DafStb* ('German Committee for Reinforced Concrete') is concerned with the time-dependent leaching of inorganic substances from monolithic, solidified, cement-bound building materials. The test specimen to be examined with dimensions of 100 x 100 x 100 mm is mixed with demineralised water, with a liquid to surface area ratio of 80 : 1, which is slowly stirred during the test. The leachate is changed six times at specified time intervals and the concentrations of the emitted substances in the eluant are determined. The method shows the amount of a substance released in mg/m² relative to time.

NEN 7345[35]

The long-term static test (diffusion test) in accordance with the Dutch NEN 7345 standard is suitable for determining the time-dependent leaching behaviour of inorganic components from formed and monolithic substances. This is predominantly concerned with building materials and waste substances. A test specimen with a minimum diameter of 40 mm is mixed with an eluant that has a pH value of 4, with a liquid to volume ratio of 5:1. The leachate is changed seven times at specified time intervals and the concentrations of the emitted substances in the eluant are determined. As with the DafStb draft standard, the method shows the amount of a substance released in mg/m² relative to time.

The table below provides an overview of the parameters for the test methods described.

Table 5: Long-term static tests in accordance with the draft standard DAfStb [36] and NEN 7345 [35]

Parameter	Test methods	
	DAfStb draft standard	**NEN 7345**
Area of application	Monolithic, hardened, cement bound building materials; only for inorganic substances	Formed (not crushed) and monolithic materials (predominantly building materials and wastes); only for inorganic substances
Test specimen size	100 mm x 100 mm x 100 mm (for concrete mixtures)	Diameter > 40 mm
Liquid to surface/volume ratio	Liquid/surface ratio (l/m²) 80:1	Liquid/volume ratio (l/dm³) 5:1
Type of eluant	Demineralised water	Deionised Water + HNO_3: pH 4 (at beginning)
Duration	Total of 56 days, 6 leachates (change on 1st, 3rd , 7th, 16th, 32nd and remvoval on 56th day)	Total of 64 days, 8 leachates (changed after 0.25, 1, 2.25, 4, 9, 16 and 36 days)
Type of motion	Stir eluent	No stirring
Temperature	Ambient temperature (20 $\pm$ 3 °C)	18 – 22 °C
Vessel/apparatus	Container made of glass, PTFE or PE	Container made of plastic without plasticiser.

In conclusion it can be said that long-term static tests are more realistic in terms of their release behaviour, however the predominant release mechanism of the substance being examined must be diffusion-controlled [24].

5.3 Concepts for assessing the effects of construction products on soil and groundwater

5.3.1 General

Although there are European and national regulations for assessing the effects of construction products on soil and groundwater, these usually consist, however, of prohibitions or restrictions on individual substances or total parameters.

More comprehensive concepts for assessing the effects of construction products on soil and groundwater are provided by the DIBt Guideline Soil/Groundwater of the *Deutsches Institut für Bautechnik* ('German Institute for Building Technology') [20] and the Dutch Building Materials Decree [25], which shall be described and compared in the next section. The

insignificance thresholds ("no effect levels") used in the DIBt Guideline for assessing the effects of construction products on soil and groundwater, and the guideline values used in the *LAGA-Mitteilung 20 "Anforderungen an die stoffliche Verwertung von mineralischen Reststoffen/Abfällen"* (LAGA Rules "Requirements for recycling mineral waste") [27], which are applicable for the use of mineral waste, represent the German level of protection in terms of the release of dangerous substances from construction products to soil and groundwater and its assessment.

5.3.2 DiBt Guideline: Assessment of the effects of construction products on soil and groundwater (DIBt Guideline Soil/Groundwater)

The DiBt Guideline: "Assessment of the effects of construction products on soil and groundwater" was developed by the *Deutsches Institut für Bautechnik* – DIBt ('German Institute for Building Technology') as an assessment basis for granting *allgemeine bauaufsichtliche Zulassungen* ('national technical approvals') for construction products with the involvement of relevant parties such as the building material industry and environmental authorities. It applies to construction products that are bedded directly on the ground or are in contact with the ground (so-called 'ground-touched' components), and takes into account requirements from all relevant legal fields (construction, water, soil conservation, waste and ambient air protection law).

It is also intended to introduce the DIBt Guideline's assessment system into the field of European technical approvals with the EOTA and the UEAtc[9] . The purpose for this is to assess construction products that are developed in accordance with the European Technical Approval Guidelines (ETAGs) or the Common Understanding of Assessment Procedures (CUAPs) for individual approvals in accordance with Art. 9.2 of the Construction Products Directive. It is also intended to introduce the concept within national and European standardisation.

The DIBt Guideline Soil/Groundwater is divided into two parts. Part I provides a general description of the concept for assessing construction products in terms of harmful changes to soil or groundwater. Part II is tailored to selected construction products and specifies the general concept in more concrete terms as to the test methods to be used and special requirements. Until now the product-specific Part II has been developed, or is being prepared, for the construction products "concrete and concrete constituents", "sewage pipe cleaning agents" and "soil injection agents". The following section describes the general concept of assessment (Part I) and then the product-specific Part II for the construction product group "concrete and concrete constituents" [20].

DIBt Guideline Soil/Groundwater, Part I (General)

To avoid any risk to soil and groundwater, the DIBt Guideline Soil/Groundwater lays down basic requirements for construction products. In order to be able to assess the effects on groundwater, the place of assessment is determined and it is defined as to when a risk to groundwater is to be presumed.

The place of assessment refers to the site where the construction product is installed, and it can be *above* groundwater or *in* groundwater. The *Länderarbeitsgemeinschaft Wasser – LAWA (*'Working Group of the German Länder on Water Issues') presumes that there is only an insignificant change and therefore no risk to groundwater when no relevant ecotoxicological effects occur in groundwater (e.g. for an assumed use or due to

9 UEAtc: Union européenne pour l'Agrément technique dans la Construction (European Union of Agreement)

groundwater outflow to surface waters), and when the requirements of the German *Trinkwasserverordnung* ('Drinking Water Ordinance') [37] are complied with. The term "insignificance threshold " ("no effect level") has been introduced for this insignificant change. The numerical values for these insignificance thresholds ("no effect levels") currently correspond to the test values for assessing the exposure pathway soil/groundwater [38] of the German *Bundes-Bodenschutz- und Altlastenverordnung* ('Ordinance on Soil Conservation and Abandoned Polluted Areas') and are listed in Annex A5.

These insignificance thresholds ("no effect levels") have been revised by the Working Group of the German Länder on Water Issues' (LAWA) as part of the so called "Principles for precautionary groundwater protection for waste recycling and the use of products" ("*Grundsätze des vorbeugenden Grundwasserschutzes bei Abfallverwertung und Produkteinsatz*", GAP-Papier) [39]. The new insignificance thresholds (available online in German at: http://www.lawa.de/pub/kostenlos/gw/GFS-Bericht.pdf) have recently been approved by the *Umweltministerkonferenz* – UMK ('Conference of the Laender Ministers' for Environment), and will also be incorporated into the DIBt Guideline Soil/Groundwater.

The DIBt Guideline's assessment system is divided into two phases. The first phase is concerned with the substances included in the product: information on the substances is provided by the chemical composition of the construction product, which the applicant submits with information on the manufacturing process. The substances are assessed using exclusion criteria such as

- Use-bans and restrictions for specific substances (e.g. according to the German *Chemikalienverbotsverordnung* ('Prohibition of Chemicals Ordinance').
- Substances that, according to Council Directive 67/548/EEC [3], are marked with N, T+ or T should be avoided. If such substances are technically unavoidable, an assessment according to Phase 2 shall be carried out.
- Carcinogenic (R 45), mutagenic (R 46), and teratogenic substances (R 60, R 61) may not be actively used.
- Any mineral wastes used must comply with the requirements of *LAGA-Mitteilung 20* [27]. The substance concentrations contained in the leachate must at least comply with the Z 2 classification values[10] of the respective waste-specific technical rules of *LAGA-Mitteilung 20*.

Even if just one exclusion criterion is fulfilled, the construction product does not comply with the requirements of the DIBt Guideline Soil/Groundwater. However, a construction product already meets the requirements after the first phase if it is proven that its use will not pose a risk to soil or groundwater or if construction products of a very similar composition have already been tested after the second phase and have been found to comply with the requirements.

The second phase of the assessment concept considers the mobilizable substances. The construction products are assessed as unobjectionable for soil and groundwater if the insignificance thresholds ("no effect levels") at the place of assessment are not reached and no relevant ecotoxicological effects occur. As the basis for this assessment, leachates of construction products shall be produced under realistic conditions. These shall be examined and assessed in terms of the following parameters in three steps:

1. General parameters
   (e.g. pH value, electric conductivity, smell, colour)
2. Material parameters

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[10] According to *LAGA Mitteilung 20*, it is possible to incorporate waste with defined technical safety measures if the waste complies with the prescribed z2 classification values. The Z2 values must be complied with when suing wastes in (construction) products [27]

The parameters to be examined are specified on the basis of the chemical composition of the construction product. The building product already conforms with the requirements of the Guideline after the second phase if insignificance thresholds ("no effect levels") exist and are adhered to all parameters to be determined. The same applies if verification methods exist for the substances without "no effect levels" that prove that the concentrations in the leachate can be classified as only having a slight effect from the ecotoxicological point of view and that the total parameter TOC < 20 mg/l. As part of the current revision of the DIBt Guideline Soil/Groundwater, it is being discussed whether to dispense with the total parameter for TOC due to it being insufficiently explicit.

3. Biological parameters
   If ecotoxicological unobjectionability could not be proven during the preceding phase, the degradation behaviour and ecotoxicological effects of the released substances on soil and groundwater must be examined by means of biological test methods. Aquatic and terrestrial test methods are used.

The following flow chart illustrates the two-phase assessment concept of the DIBt Guideline Soil/Groundwater.

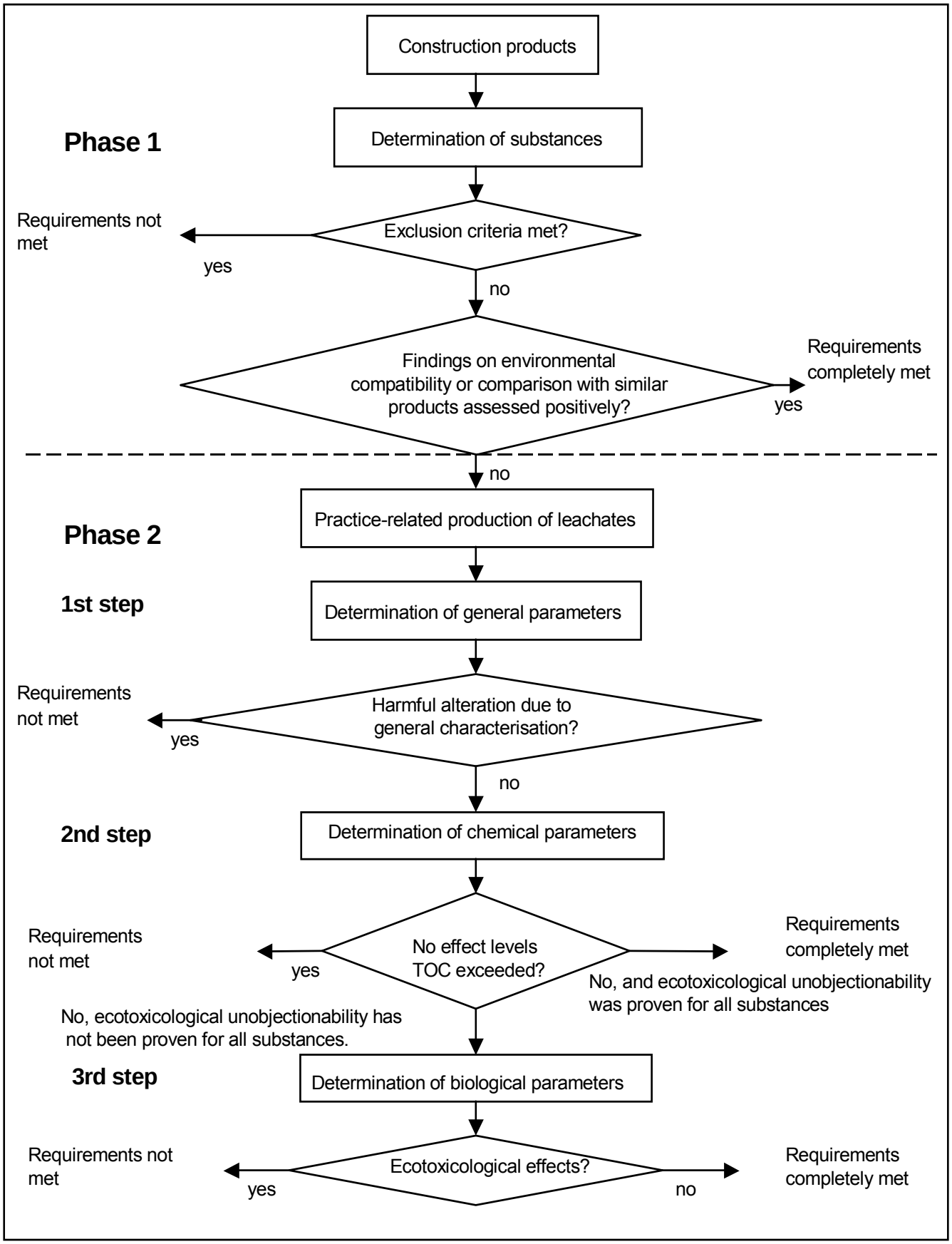

Figure 2 : Flow diagram from the DIBt Guideline Soil/Groundwater for assessing construction products in terms of the protection of soil and groundwater

DIBt Guideline Soil/Groundwater,
Part II: Product specific section on concrete and concrete constituents

The product-specific Part II of the DIBt Guideline describes the procedure for determining and assessing the environmental impact on soil and groundwater for the approval of individual construction products, including concrete and concrete constituents. Concrete constituents refer to cement, aggregates, additions and admixtures for manufacturing concrete.

For the release of dangerous substances from concrete to soil and groundwater, the place of assessment shall be specified. Concrete can be installed above the groundwater level or in groundwater. According to the DIBt Guideline Soil/Groundwater, the installation of concrete *above the groundwater level* is generally unproblematic. Apart from a short-term release that is attributable to wash-off effects, no relevant contamination of soil and groundwater is to be feared. Further consideration need only be made if, when determining the substances in the first phase, and because of the field of application, there are indications of a relevant mobilization of substances.

When installing concrete *in groundwater*, dangerous substances are frequently released due to diffusion-controlled processes. The concentration of the substances depends on the rate of release, the groundwater volumetric flow rate and the contact distance, and decreases by a relatively significant extent with increasing distance from the material surface and increasing time. For short periods of time, increased concentrations of dangerous substances can occur in the thin boundary layers between the surfaces and the groundwater. This is not, however, legally relevant because the overall very low concentrations and the limited time mean that they do not cause any lasting or substantially harmful changes to the groundwater. When assessing the concentrations of dangerous substances caused by the leaching of concrete in groundwater, it is therefore entirely admissible to take the mean of the harmful substance concentration both for a small area (30 cm) and timewise (six months).

In the first phase of the assessment concept for concrete and concrete constituents, the parameters to be examined are specified using the manufacturer's data on the type, manufacturing process and chemical composition of the construction products.

Mineral waste recycled for use as a concrete constituent such as, for example, recycled aggregates and fly ash, must comply with the limit values for solid materials and leachates given in the respective waste-specific technical rules of *LAGA-Mitteilung 20 "Anforderungen an die stoffliche Verwertung von mineralischen Abfällen – Technische Regeln"* (LAGA Rules "Requirements for recycling mineral waste – Technical Rules") [27]. *LAGA-Mitteilung 20* provides a modified batch test for manufacturing the leachate according to DIN 38414-S4 [29]. When recycling waste that is not contained in the Rules, the scope of the examination must be specified by an expert committee. The table in Annex A6 lists the limit values of *LAGA-Mitteilung 20* for mineral waste that can be used in concrete constituents.

Concrete constituents that are suspected of having an increased concentration of radio nuclides due to their origin or the manufacturing process must also be examined for radioactivity using gamma-ray spectrometry (specific activity of the radio nuclides ^{40}K, ^{226}Ra, ^{232}Th).

The first phase of the DIBt Guideline Soil/Groundwater for concrete and concrete constituents is considered met if none of the criteria for exclusion apply. In drawing up the DIBt Guideline Part II, it is currently being discussed whether the concrete and concrete constituents being tested can already be classified as harmless for soil and groundwater after the first phase if the leachate from a batch test, e.g. according to DIN 38414-S4, already complies with the insignificance thresholds ("no effect levels") of the Guideline. The reason behind this discussion is that increased leachate concentrations occur as a result of the sample material being crushed during the batch test. Under the more realistic conditions of the long-term static test – the method prescribed for determining the insignificance thresholds ("no effect levels") – there should always be a smaller amount of released

dangerous substances. This conclusion must, however, be verified through corresponding tests.

The second phase of the assessment concept for concrete and concrete constituents considers substances that are leached out. For the approval of concrete constituents and concrete, a long-term static test in accordance with the draft standard of the *Deutscher Ausschuss für Stahlbeton – DafStb* ('German Committee for reinforced concrete') is required as the leachate method [36]. The leaching is conducted on a test specimen made of standard concrete which has been manufactured with the respective concrete constituent as well as on a test specimen made of reference concrete in order to be able to attribute the changes in the leachate to the concrete constituent.

High pH values and high electric conductivity are typical when eluting concrete using long-term static tests. This must be taken into account when assessing the general parameters. The parameters stipulated in the first phase of the assessment concept must comply with the insignificance thresholds ("no effect levels") at the place of assessment for the assessment after the second phase. For concrete installed in groundwater, the insignificance thresholds ("no effect levels") for heavy metals (in µg/l) whose release is diffusion-controlled are converted using a model calculation to provide the maximum admissible release (in mg/m²). The model calculation takes into account the admissible spatial (30 cm) and temporal averaging (6 months) for the heavy metal content.

Table 6: For direct contact with groundwater, the maximum admissible release from cement-bound building materials through elution in the long-term static test.

Parameter	Maximum admissible release in the static test after 56 days [mg/m²]
Arsenic	5.0
Lead	12.0
Cadmium	2.4
Chromium (total)	24.0
Chromium (VI)	4.0
Cobalt	24.0
Copper	24.0
Nickel	24.0
Zinc	150.0

Should insignificance thresholds ("no effect levels") be lacking for specific inorganic parameters, these values would need to be specified by the Working Group of the German Länder on Water Issues (LAWA).

If no insignificance thresholds ("no effect levels") exist for the release of organic substances, the ecotoxicological unobjectionability shall be proven by means of biological tests. A fish test shall be conducted when using tensides whose chemical composition provides information on the potential toxicity to fish and which can be leached out in relevant amounts. In the current revision of the DIBt Guideline Soil/Groundwater, it is being discussed whether to replace the fish test with a fish egg test.

The decisive step in assessing the construction products is to specify the substances to be examined in the first phase of the assessment concept. For this reason, knowledge of the chemical composition and information on the manufacturing process of the construction product are basic prerequisites for the assessment. Ultimately, it is only on this basis that it will be possible to classify substances as unobjectionable for soil and groundwater. Because

of the lack of experience with the release behaviour and with assessing dangerous substances from construction products, an accompanying discussion of new facts within an expert committee forms an integral part of the assessment system according to the DIBt Guideline Soil/Groundwater.

5.3.3 Dutch Building Materials Decree

The Dutch Building Materials Decree [25] was introduced as a statutory provision in 1999 by the Dutch Ministry of Housing, Regional Planning and the Environment and the Ministry of Transport and Water Management in order to regulate the requirements for the environmental compatibility of mineral building materials and thus prevent contamination of soil, groundwater and surface water.

The Dutch Building Materials Decree only considers materials that meet the following requirements:

- Stony materials (min. 10 % silicon, calcium or aluminium)
  e.g. concrete, asphalt, clay, sand, roof tiles, tiles, bricks, tarry asphalt aggregate, earth and dredging sludge, fill sand, bituminous roof coverings, bottom ash from waste incineration plants
- Use in works
  Works are defined as buildings and civil engineering works, e.g. houses, bridges, offices, roads, dykes, harbour basin fills, riparian works, viaducts and aqueducts
- Outside use (foundations, walls, roofs, road embankments). It is necessary that there is contact with rainwater, groundwater or surface water.

Just as with the Construction Products Directive, the Building Materials Decree only regulates the phase of use of a building. Storage, transport, work safety or other aspects are not taken into consideration.

The environmental compatibility of the building materials used is assessed using the limit values introduced for solids content and leachate concentrations. Here, the limit values for inorganic dangerous substances refer to leaching whereas, due to a lack of leaching methods for organic substances, the limit values for dangerous organic substances refer to the solids content. The input (immission) of inorganic, leachable substances into soil and groundwater is determined by converting emission values into immission values. The immission value depends on the leaching behaviour of the building material (emission) and from parameters such as temperature, degree of contact with the water, thickness of the building material and isolation measures, and is measured in mg/m² and 100 years. The immission values describe the maximum input of the dangerous substances into the adjacent soil. The immission values for heavy metals are derived from the solids content of a standardised soil. A maximum input of 1 % of the solid content of heavy metals is tolerated for a standardised soil within a time period of 100 years. The standard solids contents are considered as averaged background contents [40].

The Building Materials Decree stipulates that the long-term static test in accordance with NEN 7345 [35] should be used to determine the leaching. The building materials are divided into various categories according to their composition and leaching behaviour. Category 1 building materials comply with the content and immission values in Annex 2 of the Building Materials Decree (for values, see Annex A7). It is possible to use these building materials without any additional measures.

Category 2 building materials comply with the content values in Annex 2 of the Building Materials Decree (for values, see Annex A7). The immission values, however, would be exceeded if additional isolating measures were not taken (e.g. use at least 0.5 m above the groundwater level, provisions providing protection from rainwater). Building materials that do not fall into Category 1 or 2 may not be used as a building material.

In addition to the two categories for building materials, there is also a category for "clean earth" as well as two special categories for tarry asphalt aggregate and ash from waste incineration plants. Soil corresponds to the "clean earth" category if it complies with the content values in Annex 1 of the Building Materials Decree. If the soil exceeds the content values, it is treated like building materials in Category 1 and 2. Special regulations for protecting soil apply for both special categories.

Suppliers or producers must prove the building materials' environmental compatibility. It is possible to provide individual proof with each individual delivery or continuous quality control. Apart from proving the environmental compatibility of the building materials used, the act also stipulates that there is a duty to report classified building materials to the competent authorities and the owner has a duty to remove all building materials when dismantling construction works after their use.

5.3.4 Comparison of the DIBt Guideline Soil/Groundwater with the Dutch Building Materials Decree

The DIBt Guideline and the Dutch Building Materials Decree are compared below. The listed properties only apply to mineral construction products

Table 7: Comparison of the DIBt Guideline Soil/Groundwater [20] with the Dutch Building Material Decree [25]

Feature	DIBt Guideline, Part I and Part II "Concrete and concrete constituents"	Dutch Building Materials Decree
Area of application	Concept of assessment concerning the impact on soil and groundwater for **construction products bedded directly on the ground or in contact with it (ground-touched components)**. For the purposes of comparison with the Building Materials Decree, only the product-specific Part II "Concrete and concrete constituents" will be considered here.	Assessment only for **mineral building materials** in terms of their impact on soil and groundwater. In addition to assessing mineral construction products, the Building Materials Decree includes further regulations such as the Duty of Removal when demolishing construction works.
Concept of assessment		
Assessment of the substances	Specifies **exclusion criteria** (compliance with legal provisions and restrictions, no use of N, T+, T and CMR substances, compliance with limit values for solids and leachates for mineral wastes)	Compliance with **limit values for solids applies only for organic parameters**, otherwise no other exclusion criteria
Assessment of mobilizable substances	Specifies general parameters (e.g. pH value, electrical conductivity) Specifies maximum admissible **emission** for heavy metals (As, Cd, Co, Cr(total), Cr(VI), Cu, Ni, Pb, Zn) **in mg/m²** (values apply only for concrete and concrete constituents) Specifies biological test methods if no limit values exist for constituent, relevant organic contaminants	Specifies maximum admissible **immission** into the soil for heavy metals (As, Ba, Cd, Cr, Co, Cu, Hg, Mo, Ni, Sb, Se, Sn, Pb, V, Zn) **in mg/m² and 100 years**
Derivation of limit values for determining mobilizable substances	Insignificance thresholds ("no effect levels") are determined from only a trivial change in the groundwater (no relevant ecotoxicological impact, values for the *TrinkwasserVO* must be complied with).	Immission limit values are determined from the **background values of a standardised soil** (maximum input 1 % of the solid content of heavy metals for a standardised soil within 100 years)
Leachate method for determining mobilisable substances	**Long-term static test** according to the draft standard of the DAfStb (56 days)	**Long-term static test** according to NEN 7345 (64 days)

5.4 Mandate 114 – Cements, building limes and other hydraulic binders

Cement, building lime and other hydraulic binding agents are used for producing concrete, mortar, grout and other mixes for construction and for manufacturing construction products. Mandate 114 lists the following product families with the materials usually used [41].

Table 8: M 114: Product families and examples of materials used [41]

Construction product families	Materials used
Common cements (normal cements) Special cements	Portland cement clinker Granulated blastfurnace slag Natural pozzolana Fly ash Burnt shale Limestone Silica fume Minor additional constituents Calcium sulphate Admixtures
Masonry cements	Portland cement clinker Inorganic mineral materials Organic materials
Calcium aluminate cements (Aluminous cement)	Calcium aluminate clinker Grinding aids
Building limes	Burnt limestone Burnt shell Burnt dolomitic limestone Hydraulic lime Pozzolanic or hydraulic materials Admixtures
Hydraulic base binders for road construction	Portland cement clinker Granulated blastfurnace slag Natural pozzolana Fly ash Burnt shale Limestone Lime Silica fume Minor additional constituents Calcium sulphate Admixtures

Mandate M 114 does not identify any specific dangerous substances to be taken into account in the harmonised European standards being developed by CEN. It only contains a general passage (Annex 4) that points out that all relevant (European and national) legislation for dangerous substances must be complied with.

Since cement is quantitatively the most relevant construction product family within the mandate and the majority of materials listed for cements are also used in other product families, the term "cement" in the following section only refers to the product families "common cements" and "special cements". Cements according to Mandate 114 can be used for manufacturing concrete, mortar and grout. Apart from these mandated fields of application, cement is also used in cement suspensions. Because of the relevance of the amounts used, the following section will only deal with cement used for manufacturing concrete.

European harmonised product standards for common and special cements in accordance with Mandate 114

The table below lists European product standards for cement that are to be supplemented in the second standard generation with health and environmental criteria.

Table 9: Harmonised European product standards for cement

No.	Title	Issue (as of: 01/2004)
DIN EN 197-1	Cement: Part 1: Composition, specifications and conformity criteria of common cements	February 2001
DIN EN 197-3 (Draft standard)	Cement: Part 3: Composition, specifications and conformity criteria for low heat common cements	September 2001
DIN EN 197-4 (Draft standard)	Cement: Part 4: Composition, specifications and conformity criteria for low early strength blastfurnace cements	CEN survey (under approval)
DIN EN 14216 (Draft standard)	Cement: Composition, specifications and conformity criteria for very low heat special cements	September 2001
DIN EN 14217 (Draft standard)	Cement: Composition, specifications and conformity criteria for low early strength low heat cements	September 2001

The listed cement product standards of the first generation only contain the general passage in Annex ZA that the Members States' national regulations on dangerous substances shall be complied with. In addition, the product standards point out that in Germany and other countries, substitute procedures and usage limits for chromate-containing cements and chromate and cement-containing mixtures shall comply with TRGS 613[11] [42].

[11] A harmonised European limit value for the chromate content in cement was specified after the standards were elaborated (Council Directive 2003/52/EC), which is applicable from 17 January 2005 [57].

5.4.1 Cement - General

Cement is used as a hydraulic binder for manufacturing concrete and primarily consists of calcium oxide, silicon dioxide, aluminium oxide and iron oxide. When mixed with water, the finely ground inorganic material constituents form a paste that sets and hardens by means of hydration reactions and processes and which, after hardening, retains it strength and stability even under water.

The most important constituent of cement is Portland cement clinker, which is manufactured by mixing and grinding raw materials containing lime, silicates, clay and ferrites that are then burnt in shaft or rotary kilns with material temperatures of around 1,450 °C. Portland cement clinker is ground with other components such as calcium sulphate, hydraulic-acting substances (e.g. granulated blastfurnace slag, fly ash), and/or limestone to form cement.

Common cements are manufactured according to the specifications and definitions of the harmonised cement standard EN 197-1 [43]. The standard defines 5 types of cement (CEM I to CEM V), which are classified into 27 product groups. Common cement is composed of main constituents (> 5 %) and minor additional constituents (< 5 %). The cement standard DIN EN 197-1 [43] identifies the main constituents as:

- Portland cement clinker (K)
- Granulated cinder (granulated blastfurnace slag) (S)
- Pozzolanic materials (P, Q)
- Fly ashes (V, W)
- Burnt shale (T)
- Limestone (L, LL)
- Silica fume (D)

Minor additional constituents are admissible in a proportion not exceeding 5 % by mass and are used to improve the physical properties of the cement. Inorganic mineral materials are mainly used.

In addition to the main and minor additional constituents, cement also contains calcium sulphate for regulating the hardening process as well as additives. The proportion of additives may not exceed 1 % by mass (relative to the cement). The proportion of organic admixtures may not exceed 0.5 % (relative to the cement). The table in Annex A8 provides an overview of the standard cements in accordance with DIN EN 197-1.

In 2002, around 193.5 million tons of cement were produced in the European Union. The following types and percentages of cement were used in the EU (2001) [44]:

- Portland-composite cement (CEM II) 53.3 %
- Portland cement (CEM I) 33.7 %
- Blastfurnace cement (CEM III) 6.5 %
- Pozzolanic cement (CEM IV) 5.0 %
- Composite cement (CEM V) 1.5 %

5.4.2 Content/Release of dangerous substances from cement

This section describes the release of dangerous substances from cement derived from Portland cement clinker, granulated blastfurnace slag, burnt shale, calcium sulphate and additives. The cement constituents pozzolana, fly ash, limestone and silica fume are also used as concrete additions and are also described in Section 5.6.1.

In particular, the release of dangerous substances from cement was examined as part of the IBAC research project [26] by assessing leaching tests for cement or concrete manufactured with the cement being examined. The release was assessed by comparing the results of batch tests and static tests with the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater [20]. When using mineral waste, reference was made to the guideline values in the respective waste-specific technical rules of the *LAGA-Mitteilung 20* "*Anforderungen an die stoffliche Verwertung von mineralischen Reststoffen/Abfällen*" (LAGA Rules "Requirements for recycling mineral waste – Technical Rules") [27].

With cement, the release of heavy metals, organic substances and the use of waste in manufacturing cement are all relevant in terms of the risk posed to soil and groundwater.

Because of the considerable relevance to health and for work safety reasons, the content of chromates is taken into account when examining concrete. In this respect, Interpretative Document No. 3 also requires other guidelines to be considered that are relevant to hygiene, health and the environment [8].

When examining the release of dangerous substances from cement, recommendations are given as to which substances should be taken into account when revising the technical specifications for harmonising the Essential Requirement "Hygiene, Health and the Environment".

5.4.2.1 Content/Release of heavy metals

Heavy metals can be introduced to the cement via main and minor additional constituents, calcium sulphate and additives. The heavy metal content of Portland cement (CEM I) lies within the range of natural stone for most elements. Only the content of arsenic, lead, zinc and chromate can be increased due to the raw material composition and the combustion conditions. Up to 20 % of chromium can occur as chromate (chromium (VI)), which in contrast to chromium (III) has a high solubility and can thus leach out to a greater extent [24]. Blastfurnace cement (CEM III) contains less heavy metal than Portland cement as the heavy metal content of granulated blast furnace slag is generally less than of Portland cement clinker [26]. Annex A9 provides an overview of the average heavy metal content of cement.

To determine the release of heavy metals from cement, the IBAC research project [26] refers to the results of batch and static tests which were conducted at the Technical University in Aachen as part of a dissertation on the leaching behaviour of environmentally relevant inorganic substances from cement-bound building materials [24]. With a batch test in accordance with DIN 38414-S4 for Portland cement, only the chromium parameter exceeded the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater [20]. As the batch test provides increased leachate values as a result of the increased surface area (grinding sample, overhead shaking), it is presumed that the heavy metals examined in the batch test will also comply with the insignificance thresholds ("no effect levels") when conducting a long-term static test. Long-term static tests conducted with Portland cement have shown this to be the case. All heavy metals managed to comply with the limit values derived from the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater, Part II for concrete and constituent materials.

The results of the batch and long-term static tests showed that existing heavy metals in Portland cement clinker mostly remain there and are bound.

However, an increased heavy metal content can occur through co-combustion of waste when producing Portland cement clinker. This problem will be discussed in detail in Section 5.4.2.3 "Release of dangerous substances through using wastes".

With the other cement constituents – granulated blastfurnace slag, burnt shale and calcium sulphate – the total heavy metal content is less than the heavy metal content of Portland cement so that there is no fear of an increased release of heavy metals from these constituents [26].

Recommendations for the release of heavy metals

Until now, results have only been produced from leaching methods for Portland cement and blastfurnace cement (CEM III). In order to determine the unobjectionability for soil and groundwater for all standard cements, leaching tests for all cement types should be conducted to provide a broad data basis and assessed by comparing the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater [20].

5.4.2.2 Release of organic substances

Leachable organic compounds in Portland cement clinker such as, for example, polycyclic aromatic hydrocarbons (PAH), dioxins and furans are destroyed as a result of the high material temperatures of 1450 °C and are practically undetectable in Portland cement clinker [45].

Apart from Portland cement clinker, additives, which in Germany consist almost exclusively of grinding aids, are also used in cement to improve the manufacture or the properties of cement. In Germany, glycol and triethanolamine are mainly used as grinding aids [45]. The IBAC research project [26] did not consider the leaching of organic substances from cement which is caused by these grinding aids.

Recommendations for the release of organic substances

According to these studies, no increased release of organic substances is to be expected from Portland cement clinker. However, further leaching tests should be conducted to examine whether the use of grinding aids can cause organic substances to be leached from cement.

5.4.2.3 Release of dangerous substances through using wastes

When manufacturing cement, wastes can be used as:

- Fuel substitute (secondary fuel) or raw meal substitute (secondary raw material) when producing Portland cement clinker
- Blending agent substitute when processing Portland cement clinker to form cement (secondary raw material)

Use of wastes as a secondary fuel

When manufacturing Portland cement clinker, the raw materials used are burnt in shaft or rotary kilns at material temperatures of around 1450 °C to form Portland cement clinker. In 2000, the following percentages of materials were used in the European cement industry as fuels for this process: [44]

- Petroleum coke 45.4 %
- Coal 30.6 %
- Fuel oil 5.8 %
- Brown coal 6.2 %
- Natural gas 0.9 %
- Secondary fuels 11.1 % (various waste types)

In 2000, the German cement industry used the following fuels [46]:

- Coal 31.6 %
- Brown coal 30.3 %
- Petroleum coke 8.5 %
- Fuel oil 2.2 %
- Natural gas 0.7 %
- Secondary fuels 25.7 % (various waste types)

As the figures show, secondary fuels are being increasingly used for cement manufacture, particularly in Germany. Here these are mainly used tyres, fractions from industrial/commercial wastes, animal meal and fat, residual oil, processed fractions from municipal waste and used wood [47]. The use of wastes for combustion in cement plants is likely to increase in future as a result of two judgements by the European Court of Justice (C-228/00 and C-458/00), which classify the incineration of wastes in cement plants as a recycling measure but the incineration of these wastes in waste incineration plants as a disposal measure.

The co-combustion of wastes for manufacturing Portland cement clinker can cause the heavy metal content in cement to increase [26, 48]. This is also confirmed by a research project conducted by the Forschungszentrum Karlsruhe on the heavy metal input into cement through using wastes in cement plants. This has shown that using secondary fuels causes the content of antimony and zinc to clearly increase [49].

According to the precautionary principle from Article 4 of the EC Waste Framework Directive [50] and the basic obligations in closed substance cycle waste management laid down by § 5(3) paragraph 3 of the German Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (KrW-/AbfG) [19], the recovery of wastes may not lead to an accumulation of harmful substances within the recovered substance cycle. In order to prevent contaminants accumulating in cement, various bodies have issued guideline values for heavy metals when using wastes as a secondary fuel in cement works [51, 52, 53].

In Germany, the Working Group of the German Länder on Waste Issues (LAGA) produced draft regulations in 1997 that lay down guideline values for the heavy metal content in wastes for combustion in cement plants [51]. These draft regulations were, however, never adopted by LAGA. Instead, in Germany a label was introduced on a voluntary basis by the *Bundesgemeinschaft Sekundärbrennstoffe (*Federal Association for Secondary Fuels). The quality and testing regulations of the label for secondary fuels only apply to wastes collected separately (monofractions) and for part fractions from mixed municipal waste. An RAL quality

label can be awarded according to predefined criteria such as limit values for heavy metal content and self and external monitoring [52].

Much more far-reaching are the guidelines from the *Bundesamt für Umwelt, Wald und Landschaft – BUWAL (*Swiss Agency for the Environment, Forests and Landscape – SAEFL) for disposal of wastes in cement works [53]. These contain a list of wastes that are permitted for combustion in cement plants. The positive list contains additional conditions and restrictions for using the following wastes:

- Hydraulic oils, non-chlorinated insulating oils
- Motor and gear oils, mineral oil mixtures, other lubricating oils
- Used wood
- Sewage sludge from municipal sewage treatment plants
- Car tyres and other rubber waste
- Paper, cardboard
- Petroleum coke
- Paper sludge (also from recycling paper production)
- Plastics (graded and mixtures)
- Polyester, PET
- Polyurethane, PUR foam.

All wastes that are not included in this list must comply with predefined guideline values for heavy metal content. Additional requirements apply for the use of special wastes (particularly waste in need of monitoring). Beside the guideline values for the heavy metal content of wastes, guideline values are also predefined for the heavy metal content of cement. These are based on the heavy metal content for raw materials from stone quarries in Switzerland. If the heavy metal content is exceeded in the cement, the mass flow rate of the wastes used should be reduced.

The Working Group of the German Länder on Waste Issues (LAGA) based the guideline values for the LAGA draft on the SAEFL guidelines so that the values are in a similar range. In the European context, however, the guideline values of the SAEFL guidelines are under discussion [54].

The table below shows the guideline values for the heavy metal content in wastes according to the SAEFL guidelines and the *Gütegemeinschaft für Sekundärbrennstoffe* ('German Association for the Quality Assurance of Secondary Fuels'). The guideline values for the LAGA draft cannot be compared because these are given in mg/MJ.

Table 10: Guideline values for heavy metal content in secondary fuels according to the SAEFL guidelines [53] and the Gütegemeinschaft für Sekundärbrennstoffe [52]

Parameters	**SAEFL Guidelines** **[in mg/kg]** [1]	**Gütegemeinschaft für Sekundärbrennstoffe** **[in mg/kg]** [2]	
Inorganic Parameters		**Median**	**80 percentile value**
Antimony	5	25	60
Arsenic	15	5	13
Barium	200		
Beryllium	5	0.5	2
Lead	200	70/190 [3]	200/- [3 4]
Cadmium	2	4	9
Chromium, total	100	40/125 [3]	120/250 [3]
Cobalt	20	6	12
Copper	100	120/350 [3]	-/- [4]
Manganese		50/250 [3]	100/500 [3]
Nickel	100	25/80 [3]	50/160 [3]
Mercury	0.5	0.6	1.2
Selenium	5	3	5
Silver	5		
Tellerium		3	5
Thallium	3	1	2
Vanadium	100	10	25
Zinc	400		
Tin	10	30	70
Organic Parameters			
TOX, org. substances	No general guideline values		

1 In mg/kg, related to the calorific value H_u of 25 MJ/kg

2 The heavy metal contents are applicable from a calorific value H_{uTS} of 20 MJ/kg for fractions with high calorific values from municipal waste and from a heating value H_{uTS} of 20 MJ/kg for production-specific wastes. If these calorific values are not reached, the values shall be accordingly lowered linearly; it is not admissible to increase them.

3 The first value applies for production-specific wastes, the second for fractions with high calorific values from municipal wastes.

4 Will be specified only when valid data is available from secondary fuel processing

In January 2002, the European Commission issued CEN with a mandate to develop standards for solid fuels recovered from wastes in order to promote the development of renewable energy sources and to remove trade barriers. The CEN/TC 343 "Solid Recovered Fuels" was established in July 2002. The CEN/TC will elaborate standards on terminology, fuel specifications and classes, quality assurance, sampling and sample preparation, as well as chemical and physical test methods. The provisional field of application of the European standards comprises non-hazardous combustible wastes that can be utilised as solid secondary fuels [55]. It should be pointed out that the mandate for elaborating standards in the field of solid fuels from wastes is only concerned with developing test methods for determining the heavy metal content. The specification of limit and target values will remain the sphere of responsibility of the Member States.

Use of wastes as a secondary raw material

In addition to using wastes as secondary fuels, wastes can also be used as raw meal substitute in manufacturing Portland cement clinker or as blending agents in manufacturing cement from Portland cement clinker. In Germany, the raw meal substitutes used include foundry sand, feedstock from the iron and steel industry (e.g. mill scale), paper raw material, incineration ash and mineral residues (e.g. oil contaminated soil) [47].

The use of wastes as secondary raw material can also lead to the input of heavy metals in cement. A study by the Forschungszentrum Karlsruhe on the heavy metal input in cement through using wastes in cement plants has primarily identified an increase in the cadmium, lead and cobalt content [49].

The SAEFL guidelines on incinerating wastes in cement works provide guideline values for the admissible heavy metal content of wastes used as secondary raw material [53]. This includes a positive list with wastes admissible for use as raw meal substitute or as blending agents. This positive list contains additional conditions and restrictions for using these wastes. All wastes that are not included in this list must comply with predefined guideline values for heavy metals in solid materials. Additional requirements apply for the use of special wastes. In addition to the heavy metal content of wastes, guideline values are also given for cement. These are based on the heavy metal content of raw materials from stone quarries in Switzerland. If the specified values are exceeded in the cement, the mass flow rate of the wastes used should be reduced if necessary [53].

<u>Recommendations for using waste in the manufacture of cement</u>

When using wastes as secondary raw material, the content and leaching of heavy metals should be examined on the original material before binding it to products. The range of parameters to be examined should be based on the requirements of the Working Group of the German Länder on Waste Issues (LAGA) for using mineral wastes/residues [27].

When using wastes as secondary fuel, the heavy metal content should be determined in the waste and the cement. *LAGA-Mitteilung 20* [27], the SAEFL Guidelines [53] and the *Gütegemeinschaft für Sekundärbrennstoffe* [52] provide a basis in terms of the range of parameters to be examined.

The product standards should specify levels and classes for the heavy metals to be determined in order to enable Member States to assess the release of dangerous substances.

It is also certainly reasonable to draw up a positive list with wastes that are admissible as secondary fuel and/or secondary raw material when manufacturing cement. The SAEFL Guidelines provide a basis here [53].

Should no heavy metal examinations be specified, a mandatory labelling for the use of wastes is necessary.

5.4.2.4 Chromate content

Cement can contain small amounts of chromium. Here, up to 20 % by mass of the chromium occurs as chromates (Cr(VI)). This is more water soluble than Cr(III), and its high toxicity means it is not just highly relevant in terms of leaching to soil and groundwater [24] but also in terms of work safety. Chromates are generated when burning Portland cement clinker containing trace amounts of chromium salts. Adding water to the cement can result in the release of chromates that can come into contact with human skin and permeate it.

European Directive 67/548/EEC classifies chromates as carcinogenic, allergenic and environmentally hazardous [3]. Water-soluble chromates can cause severe allergic eczema (cement chromate dermatitis (CCD) or "bricklayer's itch") with people whose skin comes into contact with wet cement. The chromate content is reduced by using chromate reducers. This demonstrably leads to a reduction of eczema through skin contact with cement [56]. Therefore, some countries such as Germany, Finland, Sweden, Denmark, Norway and Iceland have introduced national regulations for the chromate content in cement [43].

In July 2003, the European Commission adopted Directive 2003/53/EC, which stipulates that only cement with a chromate content < 2 ppm may be placed on the market and used. This does not apply though to cements that only come into contact with machines during use and for which there is therefore no risk of skin contact [57]. However, as the majority of cements used in Europe are silo products, i.e. cement where there is no risk of skin contact, this restriction on the content has little or no impact on the leaching of chromates to soil and groundwater. With concrete that comes into contact with soil and groundwater, cement is normally used as a silo product.

5.4.3 Overview of the recommendations for the second standard generation for cement

The table below provides a summary of the studies on the health and environmental compatibility of cement described in the previous section and summarises the recommendations for revising the technical specifications.

Table 11: Overview of the recommendations for revising the technical specifications for cement

Harmonised product standards	Content/Release of dangerous substances	Recommendations for second standard generation
M 114: Cement		
DIN EN 197-1 DIN EN 197-3 DIN EN 197-4 DIN EN 14216 DIN EN 14217	**Content/Release of heavy metals:** Increased heavy metal content for arsenic, lead, zinc and chromium in Portland cement relative to natural stone With the batch test to DIN 38414-S4, only the insignificance thresholds ("no effect levels") for chromates are exceeded. With long-term static tests, all the limit values derived from the insignificance thresholds ("no effect levels") are complied with for concrete constituents; however there is only a small data basis. Until now there have only been results from leaching processes for Portland cement and blastfurnace cement (CEM III).	To create a broad data basis, leaching tests for all cement types should be conducted and assessed by comparing with the insignificance thresholds ("no effect levels") of the DIBt Guideline.
	Release of organic substances: No release of leachable organic substances such as PAH, dioxins/furanes from Portland cement clinker due to higher material temperatures No study results for leaching of organic substances from cement additives such as grinding aids.	The leaching of organic substances from cement (additives) should be examined using leaching tests.

Harmonised product standards	Content/Release of dangerous substances	Recommendations for second standard generation
M 114: Cement		
DIN EN 197-1 DIN EN 197-3 DIN EN 197-4 DIN EN 14216 DIN EN 14217	**Use of wastes as secondary fuel/raw material:** Increased heavy metal content possible in Portland cement through using waste as secondary fuel or secondary raw material.	When using wastes as secondary raw material, the content and leaching of heavy metals should be examined on the original substance. The range of parameters to be examined should be based on the requirements of the Working Group of the German Länder on Waste Issues (LAGA) for using mineral wastes/residues. When using wastes as secondary fuel, the heavy metal content should be determined in the waste and cement. *LAGA-Mitteilung 20*, the SAEFL Guidelines and the *Gütegemeinschaft für Sekundärbrennstoffe* provide a basis for the range of parameters to be examined. A positive list with wastes that are admissible as secondary fuel and/or secondary raw material when manufacturing cement should be drawn up. Should no heavy metal examinations be specified, mandatory labelling for the use of wastes is necessary.

5.5 Mandate M 125 – Aggregates

Mandate M 125 defines aggregates as substances that are used for preparing concrete, mortar, grout and mixes for construction works, for manufacturing construction products and for other bound and unbound building material mixes for road and other civil engineering work. Mandate 125 lists the following product families with examples of the materials used [58].

Table 12: M 125: Product families and examples of materials used [58]

Construction product families	Materials used
Aggregates for concrete, mortar and grout Aggregates for bituminous mixtures and surface treatments Aggregates for unbound and hydraulically bound mixtures Armourstones Railway ballast Fillers	Natural: e.g. stone (round, crushed, ground), sand, gravel, lava, tuff Manufactured or by-products of industrial processes; e.g. ashes, clays, slags, vermiculite, perlite, brightening materials, incinerator residues Recycled: e.g. concrete, masonry, asphalt

For individual product families, the mandate specifies dangerous substances whose release needs to be taken account of in the standards being produced (see Table 13 below). With each product family, however, the release of other dangerous substances also needs to be taken into consideration should there be any indications of this. The general passage points out that all relevant provisions for dangerous substances must be complied with [58].

Table 13: M 125: Release of dangerous substances [58]

Construction product families	Release of dangerous substances
Aggregates for concrete, mortar and grout Aggregates for bituminous mixtures and surface treatments	Release of radioactivity (from aggregates from radioactive sources) Release of heavy metals Release of polycyclic aromatic hydrocarbons (PAH) Release of other dangerous substances
Aggregates for unbound and hydraulically bound mixtures	Release of heavy metals Release of other dangerous substances
Armourstones Railway ballast Fillers	Release of dangerous substances

The following section shall only deal with aggregates for concrete as the other construction product families named in the mandate are mainly used in road construction, which is not being considered as part of this research project. Fillers are described in Mandate M 128 – Products related to concrete, mortar and grout.

European harmonised product standards for aggregates (with the exception of road construction)

The table below lists previously published harmonised European product standards for concrete aggregates that are to be supplemented in the revision with health and environmental criteria.

Table 14: Harmonised European Product standards for aggregates

No.	Title	Issue (as of: 01/2004)
DIN EN 12620	Aggregates for concrete	April 2003
DIN EN 13055-1	Lightweight aggregates - Part 1: Lightweight aggregates for concrete, mortar and grout	August 2002

The first versions of the listed product standards contain only a general comment that aggregates from still unproven supply sources, e.g. recycled or specific manufactured aggregates, should be carefully tested. If necessary, regulations can be drawn upon that apply at the place of use. It is pointed out that the release of radioactivity, heavy metals and polycyclic aromatic hydrocarbons should be tested if this required for CE marking. Furthermore, as in the mandate, a general passage is included in Annex Z that stipulates that the Member States' national regulations on dangerous substances shall be complied with. A note in the scope of EN 12620 has been subject to a recent corrigendum. The new version of the note refers especially to recycled aggregates stating that not enough experience has been gathered in regard to certain secondary materials and reminding that national regulations on dangerous substances have to be complied with.

Aggregates - General

The non-harmonised European standard for concrete DIN EN 206-1 defines aggregates as granular, mineral material suitable for use in concrete. They can be natural or artificial or consist of recycled substances previously used in construction. Normal and heavyweight aggregates to DIN EN 12620 [59] and lightweight aggregates to DIN EN 13055-1 are considered to be generally suitable [60]. Until now there have been no regulations for recycled aggregates in European standards. Until they have been elaborated, national standards or regulations can be used that apply at the place of use of the constituent materials [22]. The following diagram illustrates the classification of aggregates according to DIN EN 206-1:

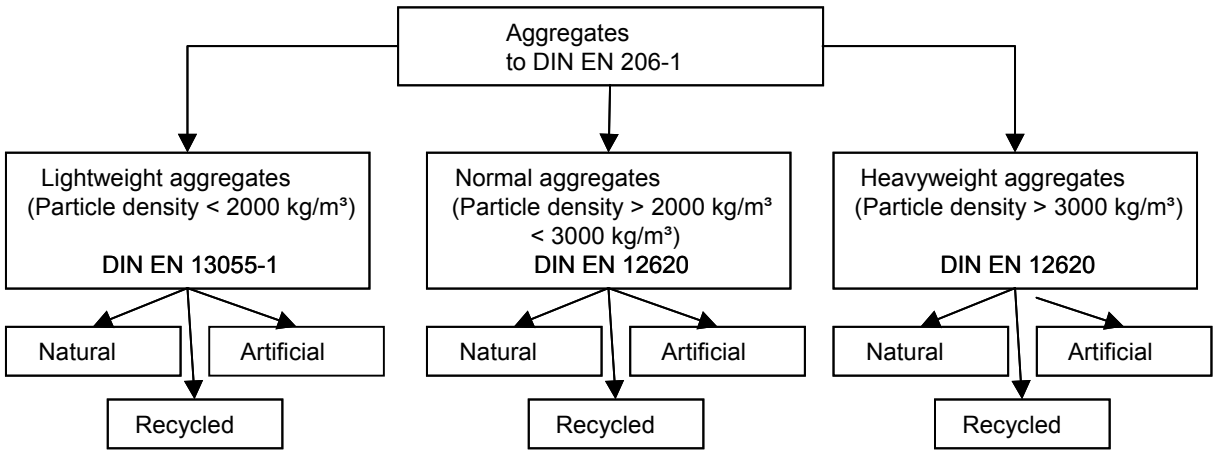

Fig. 3: Classification of aggregates according to DIN EN 206-1 [22]

5.5.1 Normal aggregates

For manufacturing concrete in accordance with DIN EN 206-1, normal aggregates in accordance with DIN EN 12620 shall be used with a particle density > 2000 kg/m³ and < 3000 kg/m³. Natural, manufactured (artificial) or recycled aggregates are suitable [22]. Recycled aggregates shall be dealt with in Section 5.5.4.

5.5.1.1 Natural aggregates for normal concrete

Natural aggregates are aggregates formed from mineral deposits that have only been mechanically processed [59]. Natural stone is mainly used such as quartzitic stone, limestone, granite, gabbro, basalt and greywacke [26]. In the European Union, around 50 % of the aggregate produced is natural aggregate [62].

Content/Release of heavy metals from natural aggregates

Natural stone can contain small amounts of heavy metals such as cobalt, barium, lead or vanadium. Annex A9 provides an overview of the average heavy metal content in natural aggregates.

The Technical Rules of the Working Group of the German Länder on Waste Issues (LAGA) lay down requirements for recycling mineral wastes and residues, including for soil. For natural soil, guideline values (Z0 values) are specified that cover the predominant part of the natural range of variations for heavy metals. If these Z0 values for soil (solid materials) are not exceeded, it is presumed that soil and groundwater are not affected as legally protected resources [27]. Comparing the heavy metal content of natural stone with the Z0 values for soil shows that almost all natural stone exceeds these values. Other sources, however, state that the heavy metal content in natural aggregates does not exceed the content in soil and in the lithosphere [24].

Recommendations for the content/release of heavy metals from natural aggregates

Because of the different assessments for the heavy metal content in natural stone, it should be discussed in general whether requirements for the possible leaching of heavy metals should be made of natural stone.

5.5.1.2 Manufactured (artificial) aggregates

DIN EN 12620 describes manufactured aggregates as aggregates of mineral origin resulting from an industrial process involving thermal or other modification [59].

In particular, slags are used for manufactured aggregates to be used in normal concrete. These can be divided into ferrous slag, melting chamber granulate, non-ferrous slag and waste incineration slag.

Ferrous slag is generated when manufacturing pig iron (blast furnace slag) and steel (steel slag). Blast furnace slag is generated when pig iron is produced from iron ore as a result of limestone reacting with gangue at high temperatures. Depending on the cooling conditions and cooling time, blast furnace slag hardens to form:

- crystalline blast furnace lump slag that can be used as concrete aggregate or

- vitreous, fine-particle, granulated slag, which is used in the manufacture of cement [23].

Steel slag is generated when producing crude steel and, depending on the respective steel production process, is described as:

- LD slag (Linz-Donawitz process)
- EF slag (electric furnace process)

In 2000, around 25 million tons of blast furnace slag and around 16.8 million tons of steel slag were produced in Europe. The recycling rate for blast furnace slag is almost 100 % in most countries [63]. In Germany, the slag is also almost completely recycled. For instance, in the year 2000 approximately 70 % of the blast furnace slag produced in Germany was used in manufacturing cement. The blast furnace lump slag is used in road construction and as concrete aggregate. Approximately 60 % of the steel slag is recycled as building material, and is particularly used in constructing highways, forest and rural roads and hydraulic structures [64].

Melting chamber granulate is generated when burning coal in melting chamber furnaces. The mineral stone accompanying the coal is rapidly cooled down and solidified by water quenching to form vitreous granulates. Slag from brown coal furnaces is not used as aggregate in Germany [26].

Non-ferrous slag is produced by melting lead, ferrochrome, copper, nickel or zinc ores or when extracting zinc oxide. Depending on the cooling time, this produces either crystalline lump slag or a vitreous, fine granulate [65].

Domestic waste incineration slag is generated from burning municipal waste. According to the definition of *LAGA-Mitteilung 20*, raw domestic waste incineration slag consists of a mixture of sintered combustion products, ferrous scrap, glass and ceramic shards, other mineral components and unburnt residue. The processed and stored raw slag is described in Germany as HMV slag (*Hausmüllverbrennungsschlacke*) [27]. Waste incineration slag is mainly used in Germany in civil engineering works (unbound base material).

In addition to the use of slags as manufactured aggregates, it is also possible to use other aggregates such as filtration and canal sand or foundry sand residue [66]. There is no information on the use of these or other materials as aggregates in the Member States.

The European Waste Catalogue lists some manufactured aggregates as waste and some as hazardous waste [67].[12] Whether and which manufactured aggregates will be classified as waste is still currently under discussion. The table below provides an overview of the manufactured aggregates listed in the European Waste Catalogue with their respective EWC codes.

Table 15: *EWC codes for manufactured aggregates according to the European Waste Catalogue [67]*

Manufactured aggregates	EWC code	Waste type
Melting chamber granulate	10 01 01	Bottom ash, slag and boiler dust from power stations and other combustion plants
	10 01 14*	Bottom ash, slag and boiler dust from co-incineration containing dangerous substances (classified as hazardous waste)
	10 01 15	Bottom ash, slag and boiler dust from co-incineration other than those mentioned in 10 01 14

12 When classifying aggregates as waste, it needs to be ensured that the definition according to Art. 1 a) of the Waste Framework Directive 75/442/EEC is met, whereby wastes are defined as any substance or object which the holder discards or intends or is required to discard [70].

Manufactured aggregates	EWC code	Waste type
Slag from waste incineration plants	19 01 11*	Bottom ash and slag containing dangerous substances from incineration or pyrolysis of waste (classified as hazardous waste)
	19 01 12	Bottom ash and slag other than those mentioned in 19 01 11
Non-ferrous slag	10 04 01*	Slags from primary and secondary production from lead thermal metallurgy (classified as hazardous waste)
	10 05 01	Slags from primary and secondary production from zinc thermal metallurgy
	10 06 01	Slags from primary and secondary production from copper thermal metallurgy
	10 08 08	Salt slag from primary and secondary production from other non-ferrous thermal metallurgy
Foundry sand residue	10 09 07*	Casting cores and moulds which have undergone pouring and contain dangerous substances
	10 09 08	Casting cores and moulds which have undergone pouring other than those mentioned in 10 09 07

In Germany the application standard DIN V 20000-102 (pre-standard) for the European standard DIN EN 12620 requires that only natural aggregates and the manufactured aggregates granulated blast furnace slag according to DIN 4301 [68], crystalline blast furnace slag and melting chamber granulate may be used [69]. If other aggregates are to be used in Germany, the environmental compatibility has to be proved by means of a *allgemeine bauaufsichtliche Zulassung* ('national technical approval') [13] in order to maintain the national level of protection.

Content/Release of heavy metals from manufactured aggregates

In some cases, steel slag and melting chamber granulate show an increased heavy metal content for chromium, cupper, mercury and vanadium relative to natural aggregates [26]. Annex A9 provides an overview of the average heavy metal content of slags.

As part of the IBAC research project, the results of batch tests for melting chamber granulates, blast furnace and steel slags were assessed. The batch test according to DIN 38414-S4 [29] was used as the leaching method. The assessment of the batch tests showed that the leachate values complied with the Z2 values of the respective waste-specific regulation of *LAGA-Mitteilung 20* [27] as well as with the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater [20]. However, the detection limits for chromate and cadmium were too high, so that it was not possible to reach any conclusions concerning these parameters.

There are no results from long-term static tests for the release of dangerous substances from concrete test specimens manufactured with the corresponding slag. For granulated blastfurnace slag and blast furnace lump slag, the IBAC study presumes that they have a positive influence on the leaching rates due to their properties [26].

The heavy metal content of melting chamber granulates depends on the fuel used. Thus the IBAC study recommends that the heavy metal content of melting chamber granulates should be tested before use. In the case of deviations from the usual heavy metal content (see Annex A9), more detailed examinations of the leaching behaviour should be conducted using

a batch test or, if necessary, a static test, and an assessment made according to the DIBt Guideline Soil/Groundwater [26].

Recommendations for the content/release of heavy metals from artificial aggregates

In Germany, there are requirements for the material recycling of mineral residues/wastes, which were elaborated by the Working Group of the German Länder on Waste Issues (LAGA) [27]. These Technical Rules have been introduced in various Länder[13] where they are therefore legally binding. The Technical Rules include requirements for recycling slag from iron, steel and casting foundries, slag from waste incineration plants for municipal waste, and foundry sand. The DIBt Guideline Soil/Groundwater also requires concrete constituents to comply with the requirements of the LAGA. To ensure that the German level of protection is maintained when using mineral materials that are by-products of industrial processes, the leaching of heavy metals should be tested on the original material. The leachate value of the mineral material should comply with the Z2 values of the respective waste-specific Technical Rule of the LAGA. An ordinance on federal level based on *LAGA-Mitteilung 20* is currently under discussion. This would lead to the specified values becoming binding in all Länder. The European standard for aggregates, DIN EN 12620, also recommends that specific manufactured aggregates should be carefully tested [59].

There is still a need to examine whether concrete produced with manufactured aggregate complies with the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater even if the aggregate does comply with the classification values of *LAGA-Mitteilung 20*.

When considering the release of dangerous substances, Guidance Paper H also refers to the possibility of restricting the content when there is a clear relation between the content and the release in the installed state. When using manufactured aggregates, the correlation between the content and the release of heavy metals could be tested using long-term static tests and thus reduce the amount of leaching tests necessary.

5.5.2 Heavyweight aggregates

As with normal aggregates, the properties of heavyweight aggregates with a particle density > 3000 kg/m³ are specified by DIN 12620 [59]. Heavyweight aggregates are mainly used for manufacturing radiation shielding concrete or ballast concrete. Natural heavyweight aggregates that are used include baryte, ilmenite, magnetite, haematite, ferrosilicon, ferrophosphorus and limonite. Examples of manufactured heavyweight aggregates include heavy metal slags, granulated iron and steel shot [26].

According to the IBAC study, there is very little data on the heavy metal content and no data on the leaching behaviour of heavyweight aggregates [26].

Recommendations for the content/release of heavy metals from heavyweight aggregates

Owing to the lack of data on the leaching behaviour of heavyweight aggregates, it is not possible to draw any conclusions as to the environmental compatibility. In order to assess the environmental compatibility, it will be necessary to test the leaching behaviour.

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13 Until now, the LAGA TR 20 has been introduced in the field of construction waste disposal in Bavaria, Brandenburg, Hamburg, Lower Saxony, Saarland and Schleswig-Holstein. The TR 20 is also used in several other Länder without having been officially introduced (As of 1999) [71].

5.5.3 Lightweight aggregates

The properties of lightweight aggregates with a particle density < 2000 kg/m³ are specified by DIN 13055-1 [60]. The following are mostly used as natural lightweight aggregates;

- Natural pumice
- Tuff
- Lava slag

Examples of manufactured lightweight aggregates include:

- Foamed slag (foamed blast furnace slag)
- Furnace sand (furnace bottom ash)
  Furnace sand is produced by the mechanical processing of furnace bottom ash. Furnace bottom ash (coal bottom ash) is generated when minerals undergo agglomeration and sintering in the combustion chamber when burning coal in pulverised coal combustion plants. Furnace bottom ash has roughly the same composition as fly ash, but a greater particle size.
- Brick chippings from unused bricks
- Expanded clay
- Expanded shale
- Expanded glass (frequently manufactured from waste glass)
- Bloated perlite
- Vermiculite

Lightweight manufactured aggregates are often produced from natural materials without the addition of additives [26].

As a lightweight aggregate, furnace sand (boiler dust from power stations), is listed by the European Waste Catalogue as waste and, with the co-combustion of special wastes, as hazardous waste [67]. [14] Whether and which manufactured aggregates will be classified as waste, is currently still under discussion.

In Germany, the application standard DIN V 20000-103 (pre-standard) defines which lightweight aggregates according to DIN EN 13055-1 may be used in Germany. This standard identifies the natural and manufactured lightweight aggregates listed above [72]. An *allgemeine bauaufsichtliche Zulassung* ('national technical approval') is required for expanded glass and for furnace sand, if it derives from co-combustion, as well as for all other manufactured lightweight aggregates not mentioned above [13]. For sintered coal fly ash the national technical approval is required only, if it derives from co-combustion.

Content/Release of heavy metals from lightweight aggregates

The heavy metal content of lightweight aggregates is comparable with the content of normal, natural aggregates as these generally consist of natural aggregates that are artificially expanded. An exception is the cadmium content in expanded clay. Here, in contrast to natural aggregates, an increased content was established. Annex A9 provides an overview of the heavy metal content in lightweight aggregates.

As part of the IBAC research project, it was only possible to assess results from batch tests for the leaching of heavy metals from expanded clay and brick. With the batch tests for brick, the insignificance thresholds ("no effect levels") from the DIBt Guideline Soil/Groundwater were exceeded for arsenic, lead, cadmium, chromium and mercury. There have been no examinations assessing the leaching using long-term static tests [26].

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14 When classifying aggregates as waste, it needs to be ensured that the definition according to Art. 1 a) of the Waste Framework Directive 75/442/EEC is met, whereby wastes are defined as any substance or object which the holder discards or intends or is required to discard [70].

Recommendations for the content/release of heavy metals from lightweight aggregates

When using mineral waste such as furnace sand (processed coal bottom ash), the Z2 classification values (leachate) of the respective waste-specific Technical Rules of the Working Group of the German Länder on Waste Issues (LAGA) should be complied with for the original material [27]. In conjunction with the currently discussed revision of the LAGA rules, values for the heavy metal content in solid material should also be specified for the use of waste in construction products. Such values would be necessary for future technical specifications. Should waste glass be used when manufacturing expanded glass, this should exclude the use of waste glass that is environmentally dubious, such as lead glass.

Only a few results from batch tests are available for assessing the environmental compatibility of lightweight aggregates. Here there is a further need to examine leaching using batch tests and, if necessary, static tests. The test results should be assessed using the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater.

Release of organic substances from lightweight aggregates

As manufactured lightweight aggregates are generally produced at high temperatures, according to the IBAC research project there will be no release of organic substances [26].

5.5.4 Recycled aggregates

According to the definition in DIN EN 12620, recycled aggregates consist of processed inorganic material previously used as building material [59].

The European Waste Catalogue lists individual materials that are used as recycled aggregates as waste [67][15]. The table below provides an overview of the wastes listed in the European Waste Catalogue that can be used as recycled aggregates.

Table 16: EWC codes for wastes listed in the European Waste Catalogue that can be used as recycled aggregates [67]

Aggregate	EWC Code	Waste type
Recycled aggregates	10 13 14	Waste concrete and concrete sludge from the manufacture of cement, limes and plaster and articles and products made from them
	17 01 01	Concrete from construction and demolition waste
	17 01 02	Bricks from construction and demolition waste
	17 01 03	Tiles and ceramics from construction and demolition waste
	17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06

The use of recycled aggregates for manufacturing concrete and mortar is regarded as waste recycling, which in Germany is subject to specific requirements made by the German *Kreislaufwirtschafts- und Abfallgesetz* – KrW-/AbfG (' Closed Substance Cycle Waste

15 When classifying aggregates as waste, it needs to be ensured that the definition according to Art. 1 a) of the Waste Framework Directive 75/442/EEC is met, whereby wastes are defined as any substance or object which the holder discards or intends or is required to discard [70].

Management Act'). For instance, Section 5, Paragraph 3 KrW-/AbfG states that the recycling of wastes should not impair the well-being of the general public, and in particular there should be no accumulation of pollutants in the cycle of reusable materials [19]. This means that requirements already have to be made for the content and leaching of dangerous substances for the constituent material "recycled aggregates". These requirements have been implemented in the national standard for recycled aggregates DIN 4226-100 [73]. The table below lists the limit values from Standard DIN 4226-100 for recycled aggregates. They accord with the Z2 values from *LAGA-Mitteilung 20* for construction and demolition waste (see Annex A6) [27]. As leaching methods, the standard specifies the modified method for the batch test provided by *LAGA-Mitteilung 20* [73].

Table 17: Limit values for recycled aggregates according to DIN 4226-100 [73]

Property	Maximum value	
Leachate		
pH-value	12.5 [a]	
Electrical conductivity	3000	µS/cm [a]
Chloride	150	mg/l
Sulphate	600	mg/l
Arsenic	50	µg/l
Lead	100	µg/l
Cadmium	5	µg/l
Chromium, total	100	µg/l
Copper	200	µg/l
Nickel	100	µg/l
Mercury	2	µg/l
Zinc	400	µg/l
Phenol index	100	µg/l
Solid materials		
Hydrocarbons (H18)	1000	mg/kg [b]
PAH according to EPA	75	mg/kg
EOX	10	mg/kg
PCB	1	mg/kg

[a] No exclusion criterion

[b] Exceeded values that are attributable to asphalt constituents do not represent an exclusion criterion

The IBAC study has assessed recycled aggregates that comply with the limit values according to DIN 4226-100 as being environmentally safe [26].

In Germany, recycled aggregates not covered by DIN 4226-100 require a national technical approval for application areas where safety aspects are relevant. To prove environmental compatibility here, the results of batch tests conducted on the original material must comply with the Z2 classification values for building rubble provided by *LAGA-Mitteilung 20* [27]. Furthermore, in the long-term static test the test specimen produced with recycled concrete must not exceed the insignificance thresholds ("no effect levels") of the DIBt Guideline

Soil/Groundwater [20]. If, however, the insignificance thresholds ("no effect levels") of the original substance are already complied with in the batch test, it is possible to dispense with the long-term static test.

The Technical Rules of the LAGA specify further requirements in addition to the classification values. For instance, it is necessary to estimate the contamination caused when rebuilding, refurbishing or demolishing construction works. Based on these findings, it shall be determined whether other analytical examinations are required in addition to the Z 2 values for building rubble. Building rubble with harmful contaminants must be cleaned in suitable treatment plants. Furthermore, only 5 % vol. of the non-mineral constituents may be made up of foreign matter. Building rubble with a higher proportion of foreign matter may not be used in this composition [27]. Standard DIN 4226-100 specifies that the foreign matter content of the non-mineral material shall be between 0.2 and 1 % by mass depending on the type of aggregate [73].

In addition to the German standard for recycled aggregates [73], the Dutch Building Materials Decree [25] provides limit values for stony material that can be drawn upon for assessing the environmental compatibility of recycled aggregates. Annex 2 of the Dutch Building Decree lists limit values for the content and immission of contaminants in stony materials. The immission values are calculated from emission values determined in an elution method which are then converted into the immission values [25] (see also Section 5.3.3).

Recommendations for the content/release of dangerous substances from recycled aggregates

The source of the recycled aggregates should be labelled. The use of recycled aggregates from suspected contamination sites should be excluded in the harmonised product standards. Recycled aggregates from sites not suspected of being contaminated should be examined in terms of the leaching of inorganic and organic parameters. The parameters being examined should be based on the Technical Rules of the LAGA for building rubble (Z 2 values) [27], the DIN 4226-100 for recycled aggregates [73] and the Dutch Building Materials Decree [25].

To exclude harmful contaminants, the proportion of foreign matter in non-mineral material should be specified. Likewise, guidelines here can be found in the Technical Rules of the LAGA for building rubble [27] and DIN 4226-100 [73].

It still needs to be examined whether recycled aggregates that comply with the leachate values according to DIN 4226-100 in the batch test also comply with the insignificance thresholds ("no effect levels") in the long-term static test with concrete test specimens made of recycled aggregates.

5.5.5 Overview of the recommendations for the second standard generation for aggregates

The table below provides a summary of the studies on the environmental compatibility of aggregates described in the previous section and summarises the recommendations for revising the technical specifications.

Table 18: Overview of the recommendations for revising the technical specifications for aggregates

Harmonised product standards	Content/Release of dangerous substances	Recommendations for the second standard generation
M 125: Aggregates		
DIN EN 12620 DIN EN 13055-1	**Release of heavy metals:**	
	Natural aggregates Differing statements on the heavy metal content of natural stone relative to uncontaminated soil and the lithosphere	General discussion necessary as to whether additional requirements should be made for natural stone in terms of leaching of heavy metals
	Manufactured (artificial) aggregates: Possible to have increased heavy metal content. Batch tests to DIN 38414-S4 have shown that the insignificance thresholds ("no effect levels") of the DIBt Guideline are complied with. Not possible to make any statements about chromates and cadmium. No results from long-term static tests for concrete test specimens with the slags used.	When using mineral materials that are by-products of industrial processes, the content and leaching of heavy metals should be examined on the original material. The range of parameters should be based on the Z 2 values of the respective waste-specific regulations of LAGA. There is a need to examine whether concrete produced with manufactured aggregates also complies with the insignificance thresholds ("no effect levels") of the DIBt Guideline Soil/Groundwater. There is a need to examine whether it is sufficient to determine the content if the release can be inferred from the content.
	Heavyweight aggregates: Heavy metal content very high in comparison with normal and lightweight aggregates. No results available from leaching tests.	Necessary to continue examining the environmental compatibility through leaching tests.

Harmonised product standards	Content/Release of dangerous substances	Recommendations for the second standard generation
M 125: Aggregates		
DIN EN 12620 DIN EN 13055-1	<u>Lightweight aggregates:</u> With batch tests to DIN 38414-S4 for bricks and expanded clay, the insignificance thresholds ("no effect levels") according to the DIBt Guideline were exceed for a series of heavy metals. There have been no examinations of leaching using long-term static tests.	When using mineral waste such as furnace sand (processed coal bottom ash), the Z2 classification values of the respective waste-specific Technical Rules of the Working Group of the German Länder on Waste Issues (LAGA) should be complied with for the original material (content in solid materials and leachate). There is a need for further examination as only a few results exist from leaching tests. The test results should be assessed using the insignificance thresholds ("no effect levels") of the DIBt Guideline. When using waste glass, environmentally dubious waste glass, such as lead glass, should be excluded.
	<u>Recycled aggregates:</u>	Indicate the source of the recycled aggregates. The use of recycled aggregates from suspected contamination sites should be excluded. Recycled aggregates from sites not suspected of being contaminated should be examined in terms of the leaching of inorganic and organic parameters. The parameters being examined should be based on the Technical Rules of the LAGA for building rubble (Z 2 values), the DIN 4226-100 for recycled aggregates and the Dutch Building Materials Decree. The proportion of foreign matter in non-mineral material should be determined. Guidelines here can be found in the Technical Rules of the LAGA for building rubble and DIN 4226-100. There is still the need to examine whether recycled aggregates that comply with the leachate values according to DIN 4226-100 in the batch test also comply with the insignificance thresholds ("no effect levels") in the long-term static test with concrete test specimens made of recycled aggregates.

5.6 Mandate M 128 – Products related to concrete, mortar and grout

Mandate M 128 identifies the construction product families described in the table below and provides examples for the materials used.

Table 19: M 128: Product families and examples of materials used [74]

Construction product families	Materials used
Admixtures for concrete, mortar and grout	Chemicals
Additions for concrete, mortar and grout (including pigments)	Ground stone Silica fume Fly ash Ground granulated/vitrified/pelletised blast furnace slag Natural pozzolana (e.g. trass) Industrial pozzolana (e.g. metakaolin) Chemicals/ powders
Fibres for concrete, mortar and grout	Inorganic/organic fibres from, e.g.: Plastics Glass Steel Carbon Cellulose (incl. asbestos-substitute fibres)
Concrete protection and repair products	Chemicals Cement Aggregates Admixtures Additions Resins Polymers

For the product family "Additions", Mandate M 128 explicitly points out that the release of radioactivity needs to be considered in the standards to be elaborated. With each product family, however, the release of other dangerous substances also needs to be taken into consideration as soon as there are any indications of this. The general passage in the Mandate points out that all relevant provisions for dangerous substances must be complied with [74]. Only admixtures and additions will be considered in the rest of this section.

Harmonised European product standards in accordance with Mandate M 128

The table below lists the harmonised European product standards for additions and admixtures that are to supplemented with health and environmental criteria as part of the revision process.

Table 20: Harmonised European product standards for concrete additions and admixtures

No.	Title	Edition: As of 01/2004
DIN EN 12878 (Draft standard)	Pigments for the colouring of building materials based on cement and/or lime - Specifications and methods of test	December 2003
DIN EN 13263-1 (Draft standard)	Silica fume for concrete - Part 1: Definitions, requirements and conformity criteria	October 2002
DIN EN 450-1 (Draft standard)	Fly ash for concrete - Part 1: Definitions, specifications and conformity criteria	March 2002
DIN EN 934-2	Admixtures for concrete, mortar and grout - Part 2: Concrete admixtures; Definitions, requirements, conformity, marking and labelling	February 2002

In regard to the release of dangerous substances, the European product standards for pigments, silica fume and admixtures only contain the general comment in Annex Z that national regulations shall be complied with.

The current draft standard on fly ash, DIN EN 450-1 from July 2003, provides further specifications on the co-combustion of secondary fuels in power stations. It provides a list of secondary fuels (biomass, wood and refined biomass, animal meal, sewage and paper sludge, petroleum coke and ash-free liquid and gaseous fuels) that can be co-combusted in power stations. In addition, the draft standard states that at least 80 % of the fuel burnt must consist of coal and the maximum proportion of fly ash from co-combustion fuels shall not exceed 10 % by mass relative to the total ash [75].

The harmonised European standard for concrete admixtures, DIN EN 934-2, does not specify any requirements for the release of dangerous substances. Only Annex ZA notes that the requirements applicable at the place of use shall be complied with for dangerous substances in all concrete admixtures [76]. Before the harmonised standard for concrete admixtures was adopted, concrete admixtures in Germany required an *allgemeine bauaufsichtliche Zulassung* ('national technical approval') from the *Deutsches Institut für Bautechnik* – DIBt ('German Institute for Building Technology'). Since the end of the transitional period on 1 May 2003, it has been possible to place CE-marked concrete admixtures to DIN EN 934-2 on the market in Germany. However, the products may only be used if they comply with the requirements of the supplementary standard DIN V 18998 for assessing corrosion behaviour [77] and the application standard DIN V 20000-100 [78]. To assess the corrosion behaviour of admixtures, a pre-standard was published in November 2002, which, in the case of reinforced and pre-stressed concrete as well as concrete with embedded steel, applies only for admixtures whose constituents are included in a list in the Annex. The listed substances are constituents of concrete admixtures that have been previously permitted in Germany and for which experience has shown that no stress corrosion cracking is to be expected. Concrete admixtures that are not included in the European DIN EN 934-2 and/or the supplementary standard DIN V 18998, e.g. chromate reducers or recycling aids for wash water and foaming agents, still require for use in

Germany an *allgemeine bauaufsichtliche Zulassung* ('national technical approval') from the *Deutsches Institut für Bautechnik* – DIBt ('German Institute for Building Technology') or a European Technical Approval (ETA).

5.6.1 Additions - General

The European concrete standard DIN EN 206-1 defines concrete additions as finely divided materials used in concrete to improve specific properties or to achieve specific properties. With inorganic additions, it distinguishes between [22]:

- nearly inert type I additions (fillers to DIN EN 12620 [59], pigments to DIN EN 12878 (Draft) [59]) and
- pozzolanic or latent hydraulic type II additions (fly ash to DIN EN 450-1 (Draft) [75], silica fume to DIN EN 13263 (Draft) [80].

5.6.1.1 Fillers

DIN EN 12620 defines fillers as aggregates whose predominant part penetrates through a 0.063 mm sieve and is added to building materials to achieve specific properties [12620]. The fillers used in Germany consist of quartz or limestone. Fillers improve the workability and coherence of concretes produced from sand by increasing the fine particle content.

The heavy metal content of fillers is comparable with the content of sand and gravel and/or limestone. Due to the low overall content, it can be presumed that there is no risk to the environment. With limestone intercalated with ores, however, high contents of specific heavy metals have been measured in individual cases. According to the IBAC study, leaching tests should be conducted if there are corresponding indications [26].

Recommendations for the release of dangerous substances from fillers

It is presumed that there is no risk to the environment when using fillers from quartz or limestone. Leaching tests should be conducted, however, should there be indications that ores are intercalated in the limestone.

5.6.1.2 Pigments

The draft European Standard DIN EN 12878 defines pigments as material in the form of fine particles that are practically insoluble in the application medium and are exclusively used for colouring cement and/or building materials based on lime. The main constituents of pigments are usually [79]:

- Iron oxide and hydroxide
- Chromium, titanium and manganese oxide
- Complex, inorganic oxides and hydroxides, e.g. combinations of the above-mentioned oxides and hydroxides with cobalt, nickel oxides and hydroxides
- Ultramarine
- Phthalocyanine blue and green
- Carbon (inorganic)

In addition to the main constituents, up to 5 % of the pigments (relative to the solid material) can consist of dispersing agents, binders and/or grinding aids [79].

According to the IBAC research project, only inorganic pigments are suitable for use in concrete, although the European standard also permits the use of organic pigments. Although the pigments used often contain heavy metals, they occur in oxidic bonds or other stable compounds, so no mobilisation of these substances is to be expected. Furthermore, the stability in an alkaline environment must already be proved when testing the suitability of the pigments. For these reasons, the IBAC study classifies inorganic colour pigments as unobjectionable [26]. There are, however, no results from leaching tests.

Recommendations for the release of dangerous substances

When using inorganic pigments in accordance with DIN EN 12878 (Draft), the IBAC research report states that no hazardous effect to the environment is to be expected. This, however, still needs to be confirmed with leaching tests, in particular for organic pigments, which were not assessed as part of the research project.

5.6.1.3 Fly ash

The European draft of DIN EN 450-1 defines fly ash as a fine powder of mainly spherical, glassy particles derived from burning of pulverized coal with or without co-combustion materials. Fly ash is obtained by electrostatically or mechanically separating dust-like particles from flue gas produced in combustion plants. It essentially consists of silicon dioxide and aluminium oxide and has pozzolanic properties. It is possible to produce treated fly ash in suitable production plants by mixing, grinding, sieving or drying various fly ashes. When one or more fly ashes are obtained from combustion processes with secondary fuels, the treated fly ash is classified as fly ash from co-combustion processes. DIN EN 450-1 (Draft) does not apply to fly ashes from domestic or commercial waste incineration plants [75].

The European Waste Catalogue lists fly ash both as waste and as hazardous waste [67][16].

Table 21: EWC codes for fly ash according to the European Waste Catalogue [67]

	EWC Code	Waste type
Fly ash	10 01 02	Coal fly ash
	10 01 16*	Fly ash from co-incineration (from power stations) containing dangerous substances (classification as hazardous waste)
	10 01 17	Fly ash from co-incineration (from power stations) other than those mentioned in 10 01 16

In Germany, only coal fly ash has any significance as a cement or concrete addition. Due to its pozzolanic properties, it reacts with cement and forms hydraulic hardening products. Its utilization, which can amount to 20 % of the cement, reduces the water demand.

16 When classifying aggregates as waste, it needs to be ensured that the definition according to Art. 1 a) of the Waste Framework Directive 75/442/EEC is met, whereby wastes are defined as any substance or object which the holder discards or intends or is required to discard [70].

The use of fly ash in cement and concrete is regulated by the standards DIN EN 450-1 (Draft) [75], DIN EN 197 [43] and DIN EN 206-1 [22].

In Germany, around 3 million tons of fly ash are used each year as a concrete addition. That corresponds to around 50 % of the total amount used in Europe [81].

5.6.1.3.1 Content/Release of dangerous substances from fly ash

Content/Release of heavy metals from fly ash without co-combustion

The combustion process in power stations can cause the fly ash to become enriched with heavy metals from the fuel used. The content of heavy metals such as antimony, arsenic, barium lead, cadmium, chromium, cobalt, nickel, copper, selenium, vanadium and zinc is sometimes considerably higher than other concrete constituents and essentially depends on the fuel used. Annex A9 provides an overview of the average heavy metal content of coal fly ash. However, the content is not decisive for the amount released as the heavy metals are mainly bound in oxides or embedded in the glassy matrix of ash particles. Only surface compounds occurring in easily soluble form or compounds that are mobilizable in the alkaline environment of the hardened cement paste have the potential to be released. [26].

The IBAC project assessed existing studies on the release of heavy metals.

Batch tests conducted directly on fly ash according to DIN 38414-S4 [29] showed that a series of heavy metals (antimony, arsenic, lead, cadmium, chromium, selenium, zinc) sometimes clearly exceeded the insignificance thresholds ("no effect levels") laid down by the DIBt Guideline Soil/Groundwater [26]. A comparison with the Z2 classification values (leachate) of *LAGA-Mitteilung 20* for fly ash [27] showed that some of the coal fly ashes examined exceed the values for arsenic and chromium. It is not permissible for values to be exceeded here as the original material must comply with the Z2 values in the *LAGA-Mitteilung 20* for fly ash.

In addition, batch tests according to DIN 38414-S4 were assessed that were conducted for mortar with and without the addition of fly ash. Here it was shown that the leaching of heavy metals from mortar with fly ash is only slightly greater than for mortar without fly ash. However, both mortars (with and without fly ash) exceed individual insignificance thresholds ("no effect levels") given in the DIBt Guideline Soil/Groundwater (for lead, chromate and copper). For cadmium and mercury the detection limits were too high, so that it was not possible to make any assessment.

Long-term static tests conducted on mortar and concrete (with and without the addition of fly ash) have confirmed this result. For mortar and concrete with fly ash, the leaching of heavy metals was not substantially greater than for mortar and concrete without fly ash. For copper and zinc, it was even possible to observe less leaching from concrete with added fly ash compared to concrete without fly ash. This can be attributed to the densifying property of fly ash. With the long-term static tests, the individual insignificance thresholds ("no effect levels") given in the DIBt Guideline were complied with for concrete constituents.

<u>Recommendations for the content/release of heavy metals from fly ash without co-combustion</u>

Fly ash from coal combustion is listed as waste in the European Waste Catalogue [67]. According to the German *Kreislaufwirtschafts- und Abfallgesetz* – KrW-/AbfG ('Closed Substance Cycle Waste Management Act'), the use of fly ash from coal combustion for manufacturing concrete and mortar is regarded as waste recycling and thus is subject to specific requirements. For instance, Section 5 Paragraph 3 of the German Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal states that the recycling of wastes should not impair the well being of the general public, and in particular there should be no enrichment of pollutants in the cycle of

reusable materials [19]. The well being of the public is not impaired if the wastes are properly recycled without causing harm. The recycling is properly conducted if it complies with the provisions of public law (e.g. water and soil protection laws). Harmless recycling is defined by the subsidiary regulations of the German Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (KrW-/AbfG) and must also comply with the requirements for recycling from other legal fields.

The Working Group of the German Länder on Waste Issues (LAGA) [27] lays down requirements for recycling mineral residues and wastes that also include fly ash from coal combustion. Individual Länder in Germany have introduced these Technical Rules where they are therefore legally binding. To ensure harmless recycling, the coal fly ash in the leachate must comply with at least the Z2 classification values laid down by these technical guidelines for fly ash. In conjunction with the currently discussed revision of the LAGA rules, values for the heavy metal content in solid material should also be specified for the use of waste in construction products. Such values would be necessary for future technical specifications.

Likewise, technical specifications for construction products need to comply with the precautionary principle according to Section 1a of the German *Wasserhaushaltsgesetz – WHG* ('Federal Water Act') [18]. This principle is elaborated in more concrete terms in the so called GAP paper "*Grundsätze des vorsorgenden Grundwasserschutzes bei Abfallverwertung und Produkteinsatz*" ("Principles of precautionary groundwater protection for waste recycling and the use of products") [39] that has been adopted by the Working Group of the German Länder on Water Issues (LAWA). The LAWA has elaborated new insignificance thresholds ("no effect levels") which, have recently been adopted by the *Umweltministerkonferenz* – UMK ('Conference of the Länder Environmental Ministers'), and will soon be incorporated into the Guideline Soil/Groundwater.

Within the field of technical approvals, the DIBt Guideline Soil/Groundwater is based on the specifications of the Working Group of the German Länder on Waste Issues. In the batch test, the fly ash to be approved must comply with the Z2 leachate classification values stipulated by *LAGA-Mitteilung 20* for fly ash. Furthermore, in the long-term static test the concrete test specimens (manufactured with the fly ash being tested) must comply with the threshold values ("no effect levels") of the DIBt Guideline Soil/Groundwater.

To ensure that the German level of protection is maintained when using coal fly ash as a cement or concrete addition, the original substance should comply with the Z2 classification values (leachate) of *LAGA-Mitteilung 20* [27].

Content/Release of dangerous substances from fly ash from co-combustion of secondary fuels

Substitute fuels are also used in power stations in addition to coal. As part of a research project commissioned by CEN/TC 104 "Concrete", a study was conducted on the European situation for fly ash produced when using secondary fuels [82]. The study provides an overview of the secondary fuels used and presents the experiences of the Member Sates with fly ash produced from co-combustion. For the individual secondary fuels, data on heavy metal leaching from original fly ash produced from co-combustion is also compared with data on heavy metal leaching from concrete test specimens.

According to the study, European power stations use the following secondary fuels [82]:

- Biomass (wood chips, straw, olive shells, cacao shells and other plant fibres)
- Wood and treated biomass (demolition wood, coffee grounds, poultry dung)
- Animal meal
- Sewage sludge
- Paper sludge
- Petroleum coke
- Ash-free, liquid and gaseous fuels

In the Netherlands, extensive studies have been conducted on the use of secondary fuels such as sewage sludge, paper sludge, demolition wood and petroleum coke in the production of fly ash. Based on the results, a method has been developed to attest the conformity of fly ash produced from co-combustion according to EN 450. This method is an integral part of the Dutch standards (CUR Recommendation 94, 2003). If a type of fly ash meets the provisions of the conformity method, it can be sold as regular fly ash.

In Germany, co-combustion of municipal sewage sludge (max. 5 % by mass) is allowed in power stations for standardised fly ash to DIN EN 450. Studies have shown that no significant changes in the technological properties and leaching behaviour of the fly ash are to be expected. This fly ash was incorporated into the German *Bauregelliste* ('Building Regulations Lists'), Part A in 1996. When using a maximum of 5 % (by mass) sewage sludge, this fly ash can be certified to DIN EN 450 if it meets the requirements of DIN EN 450 and complies with the heavy metal[17] limit values prescribed for sewage sludge [13]. Fly ash that deviates from the standard requires an *allgemeine bauaufsichtliche Zulassung* ('national technical approval'). With approved fly ashes, it is possible to co-combust up to 10 % by mass petroleum coke; the restriction takes into account the co-combustion of other secondary fuels. For fly ash, the content of nickel and vanadium is restricted to 600 and 1500 mg/kg respectively. In addition, approved fly ashes must comply with requirements of the DIBt Guideline Soil/Groundwater.

In Denmark, studies have been conducted on the co-combustion of straw. It has not yet been possible to transpose the test results into national regulations.

In Great Britain, studies have been conducted on the co-combustion of petroleum coke. The results did not show any negative impact on the environment. In Great Britain, the Environment Agency and the Health & Safety Executive must approve the use of secondary fuels. The authorities decide as they see fit, as no limit values are prescribed.

In Finland, studies have been conducted on wood as a secondary fuel. The test results have not yet been transposed into national regulations.

Belgium has a standard for recycling waste for use as building material that includes requirements for solid materials and the leaching of heavy metals.

No other data on co-combustion has been provided by other countries.

The individual Member States' studies on co-combustion when generating fly ash came to the following conclusions [82]:

- Biomass, sewage sludge
  There were no significant increases in the heavy metal content of fly ash when using biomass and sewage sludge.
- Petroleum coke
  In individual cases the content of nickel and vanadium increased relative to fly ash without co-combustion when using petroleum coke (10-20 % by mass). Even burning 10 % by mass petroleum coke led to vanadium contents of up to 2,320 mg/kg in the overall ash
- Paper sludge, straw, wood, bone meal, cacao shells and poultry dung. The use of paper sludge (10 % by mass), straw (14 % by mass), bone meal (2.7 % by mass) and poultry dung (3 % by mass) did not lead to any increase in the heavy metal content of the fly ash.

17 Lead: 900 mg/kg TS, cadmium: 10 mg/kg TS, chromium: 900 mg/kg TS, copper: 800 mg/kg TS, nickel: 200 mg/kg TS, mercury: 8 mg/kg TS, zinc: 2,500 mg/kg TS, [83]

Recommendations for the release of dangerous substances from fly ashes produced with secondary fuels

The use of secondary fuels when producing fly ash should be declared. As has already been described in regard to release of heavy metals from fly ashes produced through pure coal combustion, the leaching of heavy metals should be tested on the original material with a leaching test to ensure that the level of protection in Germany is maintained. This means that the coal fly ash used as cement or concrete addition is tested as such. Here the original material should comply with the Z2 classification values (leachate) of the *LAGA-Mitteilung 20* for fly ash [27].

Due to the high content of nickel and vanadium that occurred with the co-combustion of petroleum coke, with this fly ash the nickel content should be limited to 600 mg/kg and the vanadium content to 1,500 mg/kg.

Release of organic substances from fly ashes

The IBAC research project states that there have only been a few studies on the leaching of organic substances. The data from the batch tests with coal fly ash indicate that there is little leaching. With these batch tests, the insignificance thresholds ("no effect levels") of the DIBt Guideline were only exceeded once with phenol [26].

Recommendations for the release of organic substances from fly ash

These results suggest that there is no significant leaching of organic substances. However, there have been only a few studies. To create a broader data basis, the organic parameters of the DIBt Guideline Soil/Groundwater should be examined.

5.6.1.4 Silica fume

Silica fume according to DIN EN 13263-1 (Draft) is a finely divided, amorphous silicon dioxide that is collected as a co-product during the melting process for manufacturing silicon metal and ferrosilicon alloys [80]. Silica fume is used almost exclusively for high-performance concrete and replaces 4 - 8 % of the concrete (relative to the cement). It has been used as a concrete addition in Scandinavian countries since the beginning of the 1970s. Silica fume has also been used in Germany since the 1980s [84].

The total content of heavy metals in silica fume is on average much less than for Portland cement. Annex A9 provides an overview of the average heavy metal content of silica fume. Owing to its pozzolan properties, the mobilizable portion of silica fume is firmly incorporated in the reaction products of the concrete or remains in the pore solution. Therefore, according to the IBAC research report, the use of silica fume tends to reduce the heavy metal content of concrete [26].

Recommendations for the release of dangerous substances

It can be assumed that dangerous substances are not released through the use of silica fume as a concrete addition.

5.6.2 Concrete admixtures

5.6.2.1 General

Admixtures are defined by the European concrete standard DIN EN 206-1 as material added during the mixing process of concrete to modify the properties in the fresh or hardened state [22]. The European standard for concrete admixtures, DIN EN 934-2, defines admixtures that are suitable for this. The total amount of admixtures added to the concrete may not exceed 5 % by mass (relative to the cement) [76].

Admixtures are used in 60-80 % of the concrete manufactured in ready-mixed concrete plants and on the building site and in 100 % of precast concrete components [84]. Mostly used are concrete plasticisers and liquifiers [26].

The table below provides an overview of concrete admixtures to DIN EN 934-2 [76], their main constituents and their areas of application.

Table 22: Classification of concrete admixtures [according to 23]

Admixture	Main constituent	Application
Plasticisers	Lignosulphonates Melamine sulphonate Naphthalene sulfonate Polycarboxylates	Improving workability and reducing water-cement ratio through improving flowability (lowering the internal friction in the concrete)
Liquifiers, Superplasticisers	Lignosulphonates Melamine sulphonate Naphthalene sulphonate Polycarboxylates	Obtaining flowable consistency (two-three times stronger than concrete plasticiser)
Retarders	Saccharose Gluconate Phosphate Ligninsulphonate	Retarding the hydratation of the cement (setting) during the transport of a ready mixed concrete due to influence on the chemical reaction of the cement with water. Prolonging the workability by several hours by delaying the hardening
Accelerators	Silicates (sodium/potassium water glass) Sodium/potassium aluminate Sodium/potassium carbonate Formates Amorphous aluminium hydroxide Aluminium sulphate	Accelerating the development of early strength and hardening of fresh concrete (needed for shotcrete and cold weather applications)
Air-entraining agents	Soap from natural resins (saponified tall oil, balsam and wood rosin) Synthetic non-ionic and ionic tensides	Achieving high freeze/thaw durability through forming tiny, uniformly spaced, air bubbles
Waterproofing agents	Calcium stearate	Manufacture of concretes impervious to water (reducing the permeability of concrete through increasing the hydrophobicity of the capillary pore system or closing the pores)
Stabilisers	Polysaccharides Nanosilica and colloidal silicic acid Natural rubber modifications Polyacrylates Polyethylenoxides	For shotcrete and underwater concrete (prevents segregation of the added water from fresh concrete)

Concrete admixtures do not contain any heavy metal compounds that are actively used, so that the content is very low. The next section shall only consider the release of organic substances by leaching to soil and groundwater.

5.6.2.2 Release of organic substances to soil and groundwater

The information on the concrete admixtures described here was mainly taken from the progress report "*Betonzusatzmittel und Umwelt*" ("Concrete admixtures and the environment") from the *Deutsche Bauchemie* e.V., the German industry association for construction chemicals [84]. Other sources are given. The classification as toxicologically unobjectionable is not an assessment according to the DIBt Guideline Soil/Groundwater [20].

Plasticisers and liquifiers

With the exception of polycarboxylates, the admixtures used are considered to be toxicologically unobjectionable. The German *Gefahrstoffverordnung* – GefStoffV ('Dangerous Substances Ordinance') classifies some of the polycarboxylate compounds as irritants. Although naphthalene sulphonate is considered to be toxicologically unobjectionable, environmental harm cannot be excluded because the leached compounds are very stable.[18]

The dosage of liquefying admixtures ranges from 0.2 to 2 % by mass (relative to the cement). An admixture concentration of 40 % produces a concentration of 0.12 % in concrete (cement content 350 kg/m³).

As part of the IBAC study, the leaching behaviour of plasticisers and liquefiers was assessed on cement particles by using batch and short-term static tests, analysing pore water in concrete and examining the sorption behaviour of liquefiers [26]. Until now there have been no results from long-term static tests. The examination on the sorption of liquefiers by cement particles showed that 90 % of the liquefier was already sorbed by the cement particles after 7 days so that only 10 % can be leached out. Analysis of the pore water in concrete showed that after 28 days the concentration of the liquefier had also sunk to 10 % of the initial value. The batch and static tests that were carried out also showed only very slight elution. Under real conditions, it is predicted that there would be less than 1% elution.

On the basis of these results, the IBAC research project classifies plasticisers and liquifiers released in this order of magnitude as not harmful to the environment. There is very little data available on the degradation products of liquefying additives, so it is not possible to draw any conclusions here [26].

Retarders

The agents used for retarders are considered to be toxicologically unobjectionable. According to the progress report from the *Deutsche Bauchemie* e.V. (*Sachstandsbericht der Deutschen Bauchemie*), the German industry association for construction chemicals, the substances are firmly combined in the hardened cement paste matrix so that no leaching is to be expected [8]. However, there were no test results that could have been drawn upon for assessing the leaching [26].

[18] For a thorough assessment of sulfonated naphthalenes applied as concrete superplasticisers see: http://e-collection.ethbib.ethz.ch/ecol-pool/diss/fulltext/eth14477.pdf.

Accelerators

Silicates (silicic acid, sodium or potassium salt), aluminates (sodium or potassium aluminate) and carbonates (sodium or potassium carbonate) react alkaline and are classified by the German *Gefahrstoffverordnung* ('Dangerous Substances Ordinance') [85] as irritating or caustic. The aforementioned substances form poorly soluble calcium salts in the concrete, which are bonded in the hardened cement paste matrix. However, the alkalis are partly leached.

Amorphous aluminium hydroxide and aluminium sulphate are classified as toxicologically unobjectionable. The compounds are alkali-free. They are bonded as calcium aluminate phases in the hardened cement paste so that leaching is not to be expected [26].

Air-entraining agents

Air-entraining agents are manufactured without the addition of additives and auxiliary agents. Depending on the alkalinity, the German *Gefahrstoffverordnung* ('Dangerous Substances Ordinance') [85] classifies the agents used as irritating or caustic.

The progress report of the *Deutschen Bauchemie* states that tenside substances accumulate on the edge of the air voids, whereby the hydrophilic part is embedded in the hardened cement paste matrix [84]. There were no test results for leaching tests [26].

Sealants

Calcium stearate is classified as toxicologically unobjectionable. Since it dissolves with difficulty and reacts hydrophobically, no leaching is to be expected [84]. However, there are no test results available to be able to assess the leaching [26].

Injection aids

Aluminium powder is classified as toxicologically unobjectionable. The hydration products are bonded in the hardened cement paste so that no leaching is to be expected [84, 26].

Stabilisers

The progress report of the *Deutsche Bauchemie* only provides information on the cellulose ether and starch ether constituents. These are bonded in the hardened cement paste. Leaching is not to be expected [84].

Recommendations for the release of organic substances from concrete admixtures

With the exception of plasticisers and liquifiers, there is hardly any research data available on the release of dangerous substances from concrete admixtures. The only degradation products considered are for plasticisers and liquifiers, and here only to a limited extent. The IBAC research project comes to the conclusion that the existing data and the properties of the substances used indicate that concrete admixtures have little environmental impact, partly because of the low dosages.

It is not possible to make a conclusive assessment due to insufficient data. Here it would be necessary to conduct leaching tests with concrete test specimens manufactured with the corresponding admixtures. The leaching of organic substances from concrete admixtures is also confirmed by the two following studies. A study by the trade association for Swiss manufacturers of concrete admixtures determined that up to 60 mg/l DOC (dissolved organic carbon) is leached from concrete debris in batch tests [86]. The study conducted by the *Institut für Bauforschung der RWTH Aachen* – IBAC (Institute for Building Materials

Research at the Technical University of Aachen) reports TOC values (total organic carbon) of up to 12.5 mg/l for a batch test to DIN 38414-S4 with mortar [87].

A basis for more comprehensive studies is also provided by a research project from the *Forschungs- und Materialprüfanstalt* (FMPA), a research and testing establishment for building materials and structures in Stuttgart, which provides an overview of which concrete admixtures can be released on principle and in quantifiable amounts [88].

5.6.3 Overview of the recommendations for the second standard generation for concrete additions and admixtures

The table below provides a summary of the studies on the environmental compatibility of concrete additions and admixtures described in the previous section and summarises the recommendations for revising the technical specifications.

Table 23: Overview of the recommendations for revising the technical specifications for concrete additions and admixtures

Harmonised product standards	Content/Release of dangerous substances	Recommendations for second standard generation
M 128: Products related to concrete, mortar and grout		
DIN EN 12878 (Draft) DIN EN 13263-1 (Draft)	**Release of heavy metals:**	
	Fillers Heavy metal content comparable with those for sand and gravel and limestone. With limestone intercalated with ores, higher contents of individual heavy metals have been measured in individual cases.	Presumably no release of dangerous substances when using fillers from quartz or limestone. Leaching tests should be conducted if there are indications that ores are intercalated in the limestone.
	Pigments Use of inorganic heavy metals that occur in oxidic bonds or other stable compounds. The stability of pigments in the alkaline environment shall be proved when testing the suitability of the pigments. No results from leaching tests.	Need for further examination using leaching tests, particularly for organic pigments.

Harmonised product standards	Content/Release of dangerous substances	Recommendations for second standard generation
M 128: Products related to concrete, mortar and grout		
DIN EN 450-1 (Draft) DIN EN 934-2	<u>Fly ash</u> Heavy metal content of fly ash clearly higher (considerably dependent on fuel used). With batch tests to DIN 38414-S4 with fly ash, the insignificance thresholds ("no effect levels") were exceeded for antimony, arsenic, lead, cadmium, chromium, selenium and zinc. The Z2 values (leachate) of the *LAGA-Mitteilung 20* for fly ash were exceeded for arsenic and chromium. With the long-term static tests, the insignificance thresholds ("no effect levels") were complied with for concrete and mortar.	When using coal fly ash as a concrete addition, the parameters of the *LAGA-Mitteilung 20* for fly ash should be tested for. The use of secondary fuels when producing fly ash should be declared, the compliance with the insignificance thresholds of the DIBt Guideline should be examined with a leaching test. When using petroleum coke, the nickel and vanadium content should be determined and declared.
	<u>Silica fume</u> Content of heavy metals is less than for Portland cement.	A release of heavy metals is not to be expected.
	Release of organic substances to soil and groundwater:	
	<u>Fly ash</u> There is very little data available. Results of batch tests have shown that there is very little leaching of organic substances. Values only exceeded in single case with phenol.	There is a need for further investigation as only a few results exist.
	<u>Concrete admixtures</u> *Plasticisers and liquifiers:* The leaching behaviour of plasticisers and liquefiers assessed on cement particles using batch and short-term static tests. Results from analysing the pore water in concrete show only slight release of organic substances. No results exist yet from long-term static tests. There is no information on degradation products. *Retarders:* Substances toxicologically unobjectionable. These should be firmly bonded in the hardened cement paste. No results from leaching tests. *Accelerators:* Bonded in the hardened cement paste. Leaching of alkalis. No results from leaching tests. *Air-entraining agents:* No results from leaching tests. *Sealants:* Toxicologically unobjectionable. No results from leaching tests. *Injection aids:* Toxicologically unobjectionable. Bonded in hardened cement paste. No results from leaching tests. *Stabilisers: No results from leaching tests.*	Because there have only been a few leaching tests, there is a need for further investigation. Here the results of the leaching tests should be assessed using the DIBt Guideline Soil/Groundwater.

5.7 Proposals for implementing the Essential Requirement No. 3 for concrete constituents

Cement

Cement is a mandated construction product for which there has been many years of experience in terms of its composition and the use of concrete constituents. Here, however, it needs to be differentiated between cement that is manufactured without using wastes[19] and cement that is manufactured with the use of wastes.

Cement that is manufactured without wastes is suitable for inclusion in the list of WFT products (WFT – Without Further Testing), as existing studies on the content and leaching give no cause for concern that there might be an environmentally relevant release of dangerous substances. However, this still needs to be verified for all types of cement and for the release of organic substances. If cement is included in the WFT list, the composition of the cement needs to be precisely specified in the product standard and the standard should state that no wastes may be used.

Cement that is manufactured with the use of wastes requires far more extensive regulations in the product standard. If wastes are used as secondary raw material or secondary fuel, and if there is also sufficient practical experience in the form of existing test parameters, then these wastes should be listed in the product standard with the corresponding test parameters to be determined. It should be indicated in the standard that the scope only refers to the wastes listed.

If wastes are used for which there is no experience in the form of test parameters, the manufacture of this cement shall be classified as being subject to approval, as the scope of the testing for the product to be approved can be specified by an expert committee.

Aggregates

The term "aggregates" encompasses a construction product group that can consist of very different materials.

Natural aggregates of mineral origin are suitable for inclusion in the list of WFT products. However, the radioactivity of natural stone such as granite must still be taken into account, which was not taken into consideration by this research project. The fact that the heavy metal content of natural stone sometimes lies above the limit values for soil, which define a no risk level, needs to be discussed.

It can be considered whether the manufactured aggregate crystalline blast furnace slag is a WFT product as existing studies on content and leaching provide no indication that there is a significant release of dangerous substances. Test parameters should be specified in the product standards for the aggregates melting chamber granulates and non-ferrous slag. The scope of the product standard should indicate that the standard is only to be used for the named aggregate.

If slags from waste incineration plants are used as aggregate, these should be classified as requiring approval due to their significantly varying composition. This classification as requiring approval also applies to all other wastes for which there is no experience and, correspondingly, no test parameters.

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19 Wastes describes substances that are listed in the European Waste Catalogue [67] as waste or hazardous waste. It must be decided for each individual case whether this waste also fulfils the definition according to Art. 1 a) of the Waste Framework Directive 75/442/EEC [70], whereby wastes are defined as any substance or object which the holder discards or intends or is required to discard.

No classification can be currently made for heavyweight aggregates, as there are no results from leaching tests.

Lightweight aggregates from natural materials and products which were manufactured without the use of wastes can be discussed in terms of being WFT products. The same restrictions apply as with the aforementioned natural aggregates.

If wastes are used for which experience and test parameters already exist, such as, for example, furnace sand, then these wastes and the specification of the parameters should be listed in the product standard. Wastes for which no test parameters are available should be made subject to approval.

Various specifications are required in the product standard for using recycled aggregates. Recycled aggregates from suspected contamination sites should be excluded from the scope of the product standard. Due to the considerably varying contamination of such aggregates, these should be made subject to approval, as here the scope of the testing can be specified by an expert committee for the specific product. For all other recycled aggregates, the scope of the parameters to be determined should be listed in the product standard. In order to avoid contamination by organic substances, the foreign matter content of the non-mineral material should be specified in the product standard.

Concrete additions

Fillers, pigments and fly ash were examined as concrete additions.

Fillers are suitable for inclusion in a list of WFT products, since, with the exception of limestone intercalated with ores, there was no indication of any risk to the environment. Exceptional cases should be listed in the product standard and the respective procedure indicated, such as the carrying out of leaching tests.

Inorganic pigments should be discussed in terms of inclusion in the WFT list as there was no indication of there being any risk to the environment. However, this does not apply to organic pigments since, because of the lack of leaching tests, no statements can be made. One possibility here would be to specify the product standard only for inorganic pigments and make organic pigments subject to approval until enough experience has been gained on the leaching behaviour of these substances.

When using coal fly ash without the co-combustion of wastes, test parameters must be specified in the product standards. If wastes (secondary fuels) are co-combusted during the production of fly ash, this fly ash should be classified as being subject to approval. If there has already been many years of experience in co-combusting wastes such as, for example, sewage sludge and petroleum coke, it should be discussed whether a positive list of wastes can be included in the product standard as has happened with the current draft version of the European fly ash standard DIN EN 450-1. Owing to the highly differing composition, fly ash from waste incineration plants domestic or commercial waste should be made subject to approval.

Concrete admixtures

Because of the lack of leaching tests, it is not yet possible to classify concrete admixtures.

6 Floorings as example of the release of dangerous substances in indoor spaces

Floorings are mandated construction products, which, owing to their large surface areas, are potentially one of the most important pollution sources in indoor spaces. Here it is not just the emission of volatile organic substances into the indoor air that is relevant but also the emission of semi-volatile organic substances – which are mostly attached to house dust – and the absorption of substances through skin contact. For example, small infants come into considerable contact with floorings as they crawl about during the first years of their lives. They can even absorb chemical compounds, such as plasticisers, pigments and biocides, via house dust and through their skin coming into contact with the flooring[20].

Floorings form a construction product group that uses numerous different materials and substances. The following table provides an overview of floorings and classifies them according to their composition and surface.

Table 24: Classification of floorings

Organic			Inorganic
Textile	**Resilient**	**Rigid**	
• Pile carpets • Needled floor coverings made of natural and artificial fibres	• PVC floorings • Polyolefin floorings • Linoleum floorings • Rubber floorings • Cork floorings	• Laminate floorings • Wood floorings	• Ceramic tiles • Natural stone floorings • Artificial stone floorings

Because of the enormous diversity of materials, the following section will only consider organic materials (textile, resilient and rigid floorings from wood and wood-based panels including laminates).

In order to assess the dangerous substances released from floorings, a comprehensive concept shall be presented that describes procedures for assessing the health effect of construction products in indoor spaces. The composition of various types of floorings will also be explained in detail. The section "Content/Release of dangerous substances" presents test results from emission measurements in test chambers and indoor air, and provides information on substances that are likely to be released due to their chemical properties. The resulting recommendations should be taken into account when revising the technical specifications for floorings in order to eliminate any danger to users of construction works. In addition to the recommendations, the proposals for the implementation of the Essential Requirement No. 3 "Hygiene, Health and the Environment" also indicate how this implementation can be conducted for standardised and approved floorings. A detailed description of the testing methods for determining the emission in indoor spaces shall be dispensed with because, in contrast to the diverse testing methods for leaching in soil and groundwater, European testing methods already exist that only require harmonisation.

[20] For the association between children's asthma and allergies and exposure to softening agents from PVC flooring and other plastic products in the indoor climate see:
http://ehp.niehs.nih.gov/members/2004/7187/7187.html

6.1 Concepts for assessing the health effects of construction products in indoor spaces

There are only a few European and national regulations for assessing the effects of construction products in indoor spaces, and these normally consist of either prohibitions and restrictions for individual substances (e.g. formaldehyde) or total parameters. A more detailed concept for assessing the health effect of construction products in indoor spaces is the German VOC/SVOC evaluation concept from the AgBB, described in Section 6.1.1, and the Approval Guidelines of the *Deutsches Institut für Bautechnik* (German Institute for Building Technology – DIBt) for indoor construction products (Section 6.1.2), which, based on the AgBB's VOC/SVOC evaluation concept, make even greater demands on construction products that require an *allgemeine bauaufsichtliche Zulassung* ('national technical approval'). Both concepts, which are described below, represent the German level of protection in terms of the release and evaluation of dangerous substances from construction products in indoor spaces.

6.1.1 Health-related evaluation procedure for volatile organic compounds emissions (VOC and SVOC) from building products (VOC/SVOC evaluation scheme from the AgBB)

In order to be able to assess the pollution of indoor air through the emission of volatile and semi-volatile organic substances from construction products, the *Ausschuss zur gesundheitlichen Bewertung von Bauprodukten* ('Committee for Health-Related Evaluation of Building Products' – AgBB)[21] has developed an evaluation scheme [21] which is based on the European ECA Report No. 18 "Evaluation of VOC emissions from building products" [89]. The AgBB's VOC/SVOC evaluation scheme was published for the first time in 2000 and will be assessed and, if need be, adapted following the two-year introductory phase from 2002 to 2004. An English version of the AgBB's evaluation scheme can be downloaded from the Internet at http://www.umweltbundesamt.de/uba-info-daten-e/daten-e/voc.htm.

The VOC/SVOC evaluation scheme provides a procedure for the evaluation of the health effect of VOC and SVOC emissions from construction products that are used in the interiors of buildings. The scheme defines volatile organic compounds (VOC) as compounds with a gas chromatographically determined retention range of C_6 to C_{16}, which can be determined as individual substances or as total parameters (TVOC = Total Volatile Organic Compounds). It defines semi-volatile organic compounds (SVOC) as compounds with a gas chromatographically determined retention area > C_{16} to C_{22}. In deviation from these definitions, the WHO (World Health Organisation) classifies organic compounds according to their boiling point, as a result of which the different groups are not defined in a very clear way [90]:

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21 The AgBB was founded in 1997 by the *Länderarbeitsgruppe "Umweltbezogener Gesundheitsschutz"* ('Federal States Working Group on Environment-related Health Protection' – LAUG) of the *Arbeitsgemeinschaft der Obersten Landesgesundheitsbehörden* (Permanent Working Group of the Highest State Health Authorities – AOLG). In addition to the health authorities of the *Länder*, the AgBB includes the *Umweltbundesamt* ('Federal Environmental Agency' – UBA), the *Bundesinstitut für gesundheitlichen Verbraucherschutz und Veterinärmedizin* (Federal Institute for Health-related Consumer Protection and Veterinary Medicine – BgVV), the *Deutsches Institut für Bautechnik* (German Institute for Building Technology – DIBt), the *Konferenz der für Städtebau, Bau- und Wohnungswesen zuständigen Minister und Senatoren der Länder* (Conference of the State Ministers and Senators for Town Building, Building and Housing Affairs – ARGEBAU), the *Bundesanstalt für Materialforschung und –prüfung* (Federal Institute for Materials Research and Testing – BAM) and the *Koordinierungsausschuss 03 für Hygiene, Gesundheit und Umweltschutz des Normenausschusses Bauwesen im DIN* (Co-ordinating Committee 03 for Hygiene, Health and the Environment' of the Building and Civil Engineering Standards Committee within DIN – DIN-KOA 03).

- Very volatile organic compounds (VVOC) with boiling points between 0 to 50 - 100 °C
- Volatile organic compounds (VOC) with boiling points between 50 - 100 to 240 - 260 °C and
- semi-volatile organic compounds (SVOC) with boiling points between 240 - 260 to 380 - 400 °C.

The release of volatile and semi-volatile organic compounds is determined using test chamber measurements. Here the scheme makes use of the European test standards DIN EN 13419 Part 1 - 3 (Draft) for determining the emission of VOC from construction products [91, 92, 93]. Parts 1 and 2 of the standard respectively describe the procedure when using a test chamber (Part 1) and a test cell (Part 2). Part 3 specifies the procedures for sampling, storing samples and preparing the test specimens. By specifying the test chamber conditions such as the air change, temperature and surface area of the test specimen, the intention is to achieve test chamber results that largely correspond with an actual room situation. The volatile organic compounds are analysed using standard ISO 16000-6, which, after final approval, is intended to be adopted as ENV 13419, Part 4 [94].

The evaluation of the emitted VOC and SVOC is carried out either with the help of LCI values (Lowest Concentration of Interest) for individual substances or by limiting the total parameters for TVOC, SVOC and the sum of the so-called "non-assessable compounds". The LCI values are derived from workplace limit values, the so-called maximum workplace concentrations (*Maximale Arbeitsplatzkonzentrationen* – MAK values). The different conditions in general indoor spaces and workplaces such as, for example, continuous exposure, existence of risk groups and the undefined total exposure in indoor spaces are taken into account when establishing the LCI values by dividing the MAK values as a general rule by 100. Greater value is given to possible carcinogenic substances according to Category 3 of Council Directive 67/548/EEC [3] by dividing the MAK value as a general rule by 1000. LCI values determined in this manner should be understood as calculated values and not as guideline values for indoor air that are sufficiently well-founded in toxicological terms. Carcinogenic substances and those with a suspected carcinogenic potential (Category 1 and 2 of Council Directive 67/548/EEC) [3] are evaluated separately. Mutagenic and reprotoxic substances are subject to individual examination[22].

The LCI list is revised and published roughly once a year according to need and currently comprises 138 compounds (as of June 2003). These are divided into the following substance groups:

- Aromatic hydrocarbons (31 compounds)
- Saturated aliphatic hydrocarbons (n, iso and cyclo-) (7 compounds)
- Terpenes (5 compounds)
- Aliphatic alcohols and ethanols (13 compounds)
- Aromatic alcohols (phenols) (2 compounds)
- Glycols, Glycolethanols, Glycolesters (12 compounds)
- Aldehydes (18 compounds)
- Ketones (9 compounds)
- Acids (9 compounds)

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22 CMR substance, Category 1 according to Council Directive 67/548/EEC: substance that is known to have a carcinogenic, mutagenic or reprotoxic effect on humans.
CMR substance, Category 2 according to Council Directive 67/548/EEC: substance that should be viewed as having a carcinogenic, mutagenic or reprotoxic effect on humans.
Approximately 850 substances are currently classified as CMR substances according to Category 1 and 2 (Council Directive 67/548/EEG) [95].

- Esters and Lactones (22 compounds)
- Chlorinated hydrocarbons (1 compound)
- Others (9 compounds)

The current list of the LCI values can be found in Annex A10.

In addition to the health-related evaluation of the VOC and SVOC emissions from construction products, the VOC/SVOC evaluation scheme is also intended to be used for recording sensory aspects, as odour emissions often have an adverse effect on the building users. Due to the lack of uniform testing methods and evaluation criteria, however, it has not yet been possible to integrate this aspect into the evaluation scheme, although it is currently being worked upon.

The procedure used by the AgBB evaluation scheme

The start of the test for measuring emissions (t_0) is defined as the time at which the product to be tested is unwrapped from the airtight packaging and placed in the test chamber or cell. The test specimen remains in the emission test chamber or cell over the entire duration of the test.

The $TVOC_3$ value is determined after testing for 3 days. In order to fulfil the demands of the scheme, the $TVOC_3$ value must be $\leq$ 10 mg/m³. In addition, the sum of the detected carcinogenic substances according to Category 1 and 2 of Council Directive 67/548/EEC [3] must be $\leq$ 0.01 mg/m³.

In order to assess the long-term emission behaviour, the $TVOC_{28}$ value is determined again after 28 days. This must not exceed 1 mg/m³. Furthermore, the sum of all SVOC must not be greater than 0.1 mg/m³. After 28 days, the sum of all carcinogenic substances (Category 1 and 2 of Council Directive 67/548/EEC) may not exceed a value of $\leq$ 0.001 mg/m³. In addition to assessing the total sum of all volatile organic compounds using the TVOC, the individual substances are also assessed after 28 days. Here, all volatile organic compounds are identified and quantified whose concentration is $\geq$ 2 µg/m³. However, LCI-based evaluations only consider substances whose concentration is $\geq$ 5 µg/m³. To assess individual substances, the ratio (R_i) of the chamber concentration of i (C_i) to the LCI value is established for each compound (i).

$$R_i = C_i/NIK_i$$

If the sum of the quotients for the individual compounds does not exceed 1, it is assumed that these substances have no adverse effect on health.

$$R = \text{sum of all } R_i = \text{sum of all quotients } (C_i/NIK_i) \leq 1$$

For all volatile organic compounds which cannot be identified or do not have an LCI value, it has been determined that the sum of these compounds may not exceed 0.1 mg/m³. The reason behind this criterion is the substitution problem; the intention is to avoid new substances that are not toxicologically assessed being increasingly used as soon as a substance has to be labelled as dangerous.

The following flow chart clarifies the procedure described for assessing VOC and SVOC emissions from construction products:

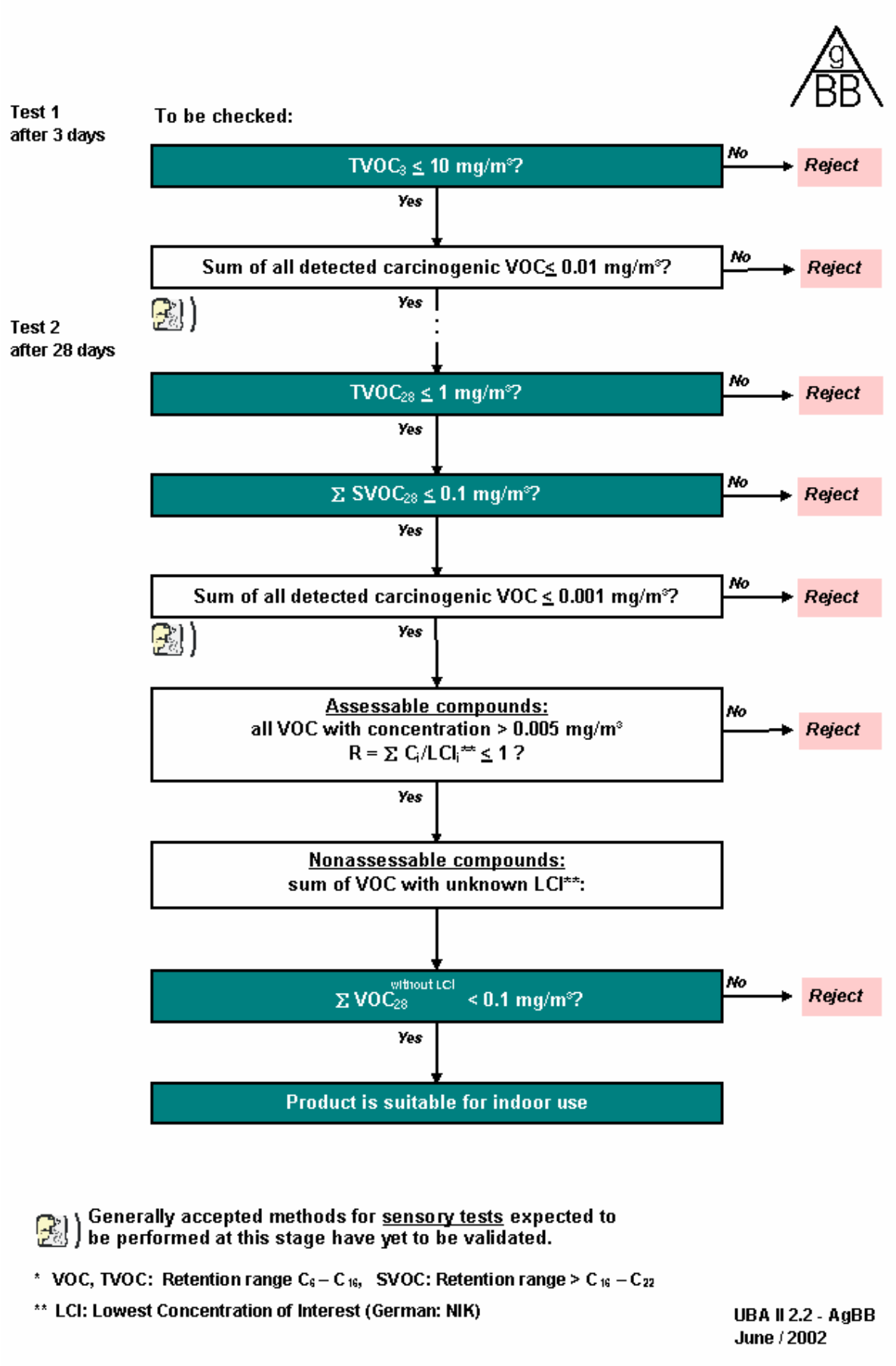

Fig. 4: Flow chart showing the health-related evaluation of VOC and SVOC emissions from construction products from the AgBB (valid for the introductory phase 2002-2004) [21]

6.1.2 DIBt approval guidelines for the health-related evaluation of indoor construction products (DIBt Approval Guidelines: Indoor Construction Products)

Based on the AgBB's VOC/SVOC evaluation scheme, the *Deutsches Institut für Bautechnik* (German Institute for Building Technology – DIBt) has further developed this procedure to achieve an evaluation basis for issuing *allgemeine bauaufsichtliche Zulassungen* ('national technical approvals') for indoor construction products [96]. The DIBt Approval Guidelines for indoor construction products are divided into two parts. Part I "General evaluation concept" specifies the procedure for the health-related evaluation of indoor construction products, which is to be applied to all construction products under examination. In Part II, "Evaluation concept for special construction products", the general concept is fine tuned for groups of special construction products and put into concrete terms regarding the testing procedures to be used. The product-specific Part II is so far available for the construction product group "Floorings and adhesives". For further products relevant to indoor spaces, corresponding product-specific requirements are being successively developed.

Part I "General evaluation concept" [96]

The evaluation concept of the DIBt approval guidelines is divided into two stages. The first stage deals with the substances used in the construction product. Information on this is provided by the chemical composition of the product, which the applicant discloses to the DIBt. The substances are assessed using the following criteria for exclusion:

- Legal prohibitions and restrictions for specific substances (e.g. *Chemikalienverbotsverordnung* ('Prohibition of Chemicals Ordinance')
- Prohibitions and restrictions stipulated by the DIBt for potentially dangerous substances in construction products.
- Substances which are labelled "Very toxic" (T+) or "Toxic" (T) in accordance with EU Directive 67/548/EEC [3] should be avoided. Should it not be possible to avoid using a substance for technical reasons, a special evaluation shall be carried out.
- Carcinogenic (T, R45, T, R49) and mutagenic (T, R46) substances may not be actively used.
- If waste (for reuse) is utilized when manufacturing construction products, the pure and undiluted waste shall be examined and evaluated separately. If necessary, suitable tests shall be carried out.
- When using waste wood, the provisions of the *Altholzverordnung* ('Waste Wood Ordinance') [97] shall be complied with.
- Mineral wastes used must meet the requirements of *LAGA-Mitteilung 20 "Anforderungen an die stoffliche Verwertung von mineralischen Abfällen"* (LAGA Rules "Requirements for re-use/utilization of mineral residues/wastes") [27].

Even if only one exclusion criterion applies, the construction product does not conform with the DIBt Approval Guidelines and an approval cannot be issued. However, a construction product already fulfills the requirements after the first stage if, due to the chemical composition, it can be assumed with sufficient certainty that the construction product does not represent a hazard to the indoor air or if construction products with a similar composition have already been tested after the second stage and complied with the requirements of the DIBt Approval Guidelines.

The second stage of the evaluation concept considers the substances that can be released. This stage corresponds to the AgBB's VOC/SVOC evaluation scheme (c.f. Section 6.1.1).

The following flow diagram illustrates the procedure of the DIBt Approval Guidelines:

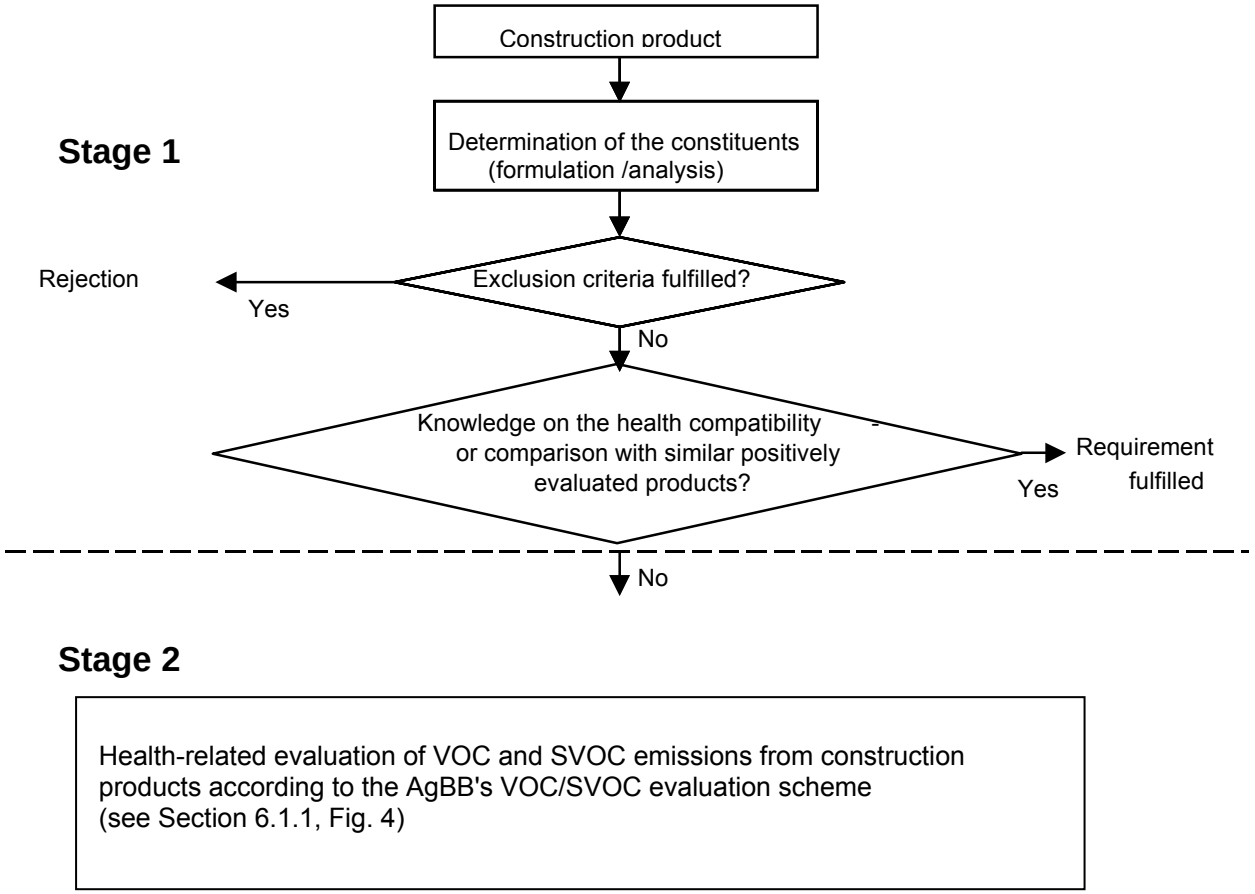

Fig. 5: Flow diagram showing the health-related evaluation of construction products according to the DIBt approval guidelines for the health-related evaluation of indoor construction products [96]

Part II "Evaluation concept for special construction products": Floorings and adhesives [96]

Part II "Floorings and Adhesives" applies to the approval of flame resistant floorings that are used glued or unglued in lounges.

The substances used in the respective construction products are determined and evaluated in line with stage 1 of the general evaluation concept in Part I. There are no particular requirements that only concern floorings and adhesives.

When determining and evaluating the emission of volatile and semi-volatile organic compounds according to stage 2, formaldehyde is also determined and evaluated in addition to VOC and SVOC provided that free formaldehyde or formaldehyde resin is actively used for the manufacture of the product. The emission of formaldehyde can also be determined according to DIN EN 13419-1 or –2 (Draft) [91, 92]; the analysis is conducted according to DIN ISO 16000-3 [98]. If the formaldehyde testing is carried out with wood-based panels, the emission testing shall be carried out in accordance with the provisions of the German *Chemikalienverbotsverordnung* ('Prohibition of Chemicals Ordinance') [99].

The sampling, packaging and storage of the samples shall be conducted according to DIN EN 13419-3 (Draft) [93]. With all flooring types, it is essential that the products tested are as fresh off the production line as possible.

The fabrication and preparation of the test sample shall also be conducted according to DIN EN 13419-3 (Draft) [93]. However, specifications for that are given where the start of the emission test t_0 is defined. Here the emission testing for textile, resilient and rigid floorings that have been sealed in the factory begins immediately on completion of the test specimen. Floor covering systems, adhesives and rigid floorings that are sealed on site shall be applied in liquid form on a suitable substrate and preconditioned for 72 hours in the test chamber. It is only then that the actual emission measurement according to DIN EN 13419-1 or -2 (Draft) begins in another emission chamber [91, 92].

The emission testing shall be conducted with an area-specific airflow rate of q = 1.25. The first measurement shall be conducted after 72 hours, the second measurement after 28 days.

The analytical determination of VOC and SVOC is based on ISO 16000-6 [94]. In deviation from the standard, which defines VVOC, VOC and SVOC by means of their boiling points, as does the WHO, the DIBt Approval Guidelines define the three substance groups analogous to the AgBB's VOC/SVOC evaluation scheme on the basis of the carbon structure and the retention times. Furthermore, the DIBt Approval Guidelines provide specific information on identification and quantification.

The evaluation of the VOC and SVOC emissions corresponds to the general evaluation concept procedure from Part I.

6.2 Mandate 119 - Floorings

The CEN Mandate 119 for developing harmonised European standards for floorings provides provisions for floorings that are used for the following purposes [100]:

- Floor beds (including suspended ground floors), roads and other traffic areas. This area is not being considered in the research project.
- Prefabricated systems floors and galleries, stairs, ramps, raised access floors, balustrades and hand rails, including external works.
- Floor and stair finishes.

According to the mandate, the following materials are usually used for floorings [100]:

Table 25: Mandate 119: Examples of materials used [100]

Construction product family	Materials used
Rigid floorings for external use and road finishes	Stone, artificial stone Concrete, fibre-reinforced concrete, asphalt concrete Clay, Glass, Ceramic, Metal, Timber (fibre boards, particle boards, cement particle boards, plywood), Plastic, Rubber, Organic fibres, Natural asphalt, Cork
Rigid floorings for internal uses including enclosed public transport premises	
Resilient and textile floorings for internal uses	Organic fibres, Cork Inorganic fibres and particles Rubber Plastics including linoleum
Resilient and textile floorings for external uses	
Floor screed materials	Cement, Calcium sulphate, Caustic magnesia, magnesium chloride, Bitumen, Bitumen emulsion, Synthetic resin, Aggregates, Admixtures, Additives

Specific requirements for health and environmental protection are mentioned in Mandate 119 only to the effect that with rigid, resilient and textile floorings, the content of asbestos and pentachlorophenol and the release of formaldehyde shall be taken into account when relevant [100].

6.2.1 Composition of floorings

In 2002, around 500 million m² of floorings were sold. The proportion of different flooring types sold is shown in the following table [101]:

Table 26: Sales of floorings in Germany in 2002 [101]

Flooring type	Sales in million m²	Proportion of total sales %
Textile floorings (tufted, needled, woven carpet)	273	53.6
PVC floorings	50	9.8
Linoleum floorings	16	3.1
Rubber floorings	7	1.4
Cork floorings	6	1.2
Laminate floorings	49	9.6
Wood floorings	27	5.3
Ceramic	74	14.5
Others	7	1.4
Total	**509**	**100**

Because of the enormous diversity of materials, the following section will only consider organic materials (textile, resilient and rigid floorings from wood and wood-based products including laminates).

6.2.1.1 Textile floorings

Almost 55 % of the floorings sold in Germany in 2002 were textile floorings. The total quantity of textile floorings consists of [101]:

- 175 million m² tufted carpet (pile carpet)
- 70 million m² needled carpet (non-pile carpet) and
- 28 million m² woven carpet (pile carpet)

DIN ISO 2424 classifies textile floorings into floorings with and without pile [102]. Pile carpets can be manufactured by means of knitting, tufting, weaving or flocking processes [103].

Textile floorings according to DIN ISO 2424 consist of a wear layer and a backing. The wear layer is the part that is directly used. With pile carpets this layer consists of textile yarns of fibres that rise up from the backing. With textile floorings without pile, the wear layer can be identical to the backing [102].

The backing consists of one or more layers that are bonded with the wear layer. It provides the supporting base for the wear layer, stabilises it and acts as a cushion. The primary backing fabric, which directly supports the wear layer, is often itself backed with other materials. This secondary backing can also be of fabric that can be woven, knitted or consist of fleece material. Non-textile secondary backings are also used, however, which are made of, for example, plastic or latex [102].

Needled pile floorings to DIN EN 13297 are manufactured by needling textile fibres together. The pile fibres can be bonded physically or chemically. Needled pile floorings can be partly impregnated with a bonding agent on the backing or, if the bonding agent penetrates the entire flooring, completely impregnated [103]. Synthetic latex or acrylates are used as binding agents, as well as bitumen [104].

An example of a non-pile, textile flooring is needled flooring to DIN EN 1470. This is a non-woven fabric that is compacted by intertwining the fibres using barbed needles. Just as with needled pile floorings, needled floorings can be partly or entirely impregnated with a bonding agent.

The following diagram illustrates the classification of textile floorings.

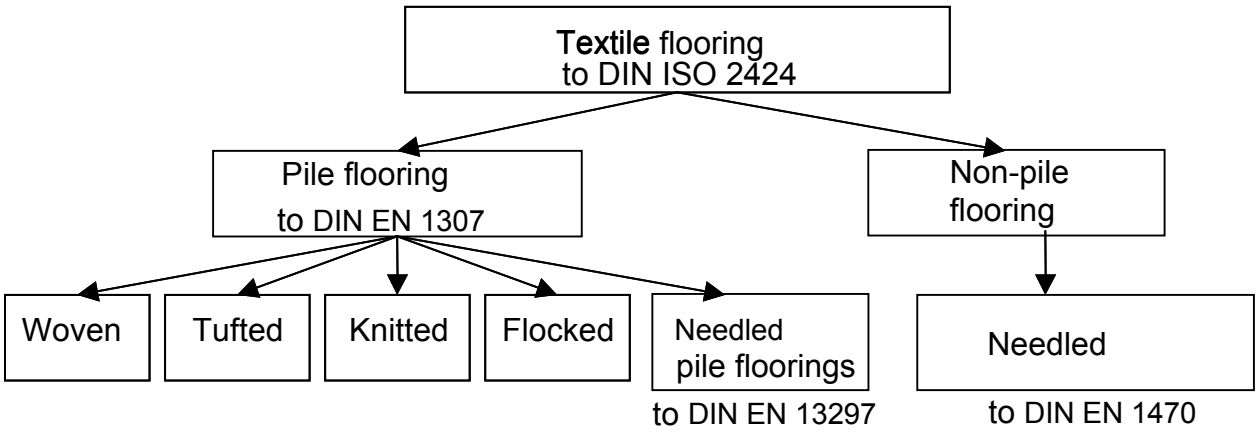

Fig. 6: Classification of textile floorings according to DIN ISO 2424 [102]

The different textile floorings used (pile and non-pile) usually have wear layers made of artificial fibres. As mainly tufted (65 %) and needled (25 %) floorings are used in Germany [101], the composition will be described using these two types.

Composition of tufted textile floorings

With tufted floorings, the wear layer, which is visible from above, consists of:

- synthetic fibres (generally polyamide) in the case of wall-to-wall carpeting
- animal fibres (new wool) or vegetable fibres (coconut, sisal, jute, cotton) in the case of natural fibre carpets.

The first layer of the backing is the primary backing in which the fibres of the wear layer are inserted with needles. Polypropylene and polyester are generally used as the primary backing, either as woven or spun-bonded fabric. Jute fabric is also occasionally used.

To bond the fibres to the primary backing, a layer of fixative or adhesive is applied, which usually consists of synthetic latex (styrene-butadiene rubber (SBR)). Natural latex is also used. To improve the coating process, the adhesive can contain diverse adjuvants [106].

A secondary backing is applied to the adhesive layer, which for wall-to-wall carpeting consists of the following materials [107]:

- approx. 80 % textile backing which is either woven or felt
- approx. 10 % foam backing from synthetic latex (styrene-butadiene rubber (SBR))
- approx. 10 % heavyweight backing made of bitumen, PVC or polyurethane foam.

Secondary backing layers from synthetic or natural latex can contain up to 75 % mineral fillers (e.g. chalk, aluminium trihydrate), whereby aluminium trihydrate is also used as a flame retardant.

Synthetic or natural latex secondary backing contains diverse chemicals. Accelerators and retarders are used for the vulcanisation reaction. Synthetic latex secondary backing can also contain other additives such as antioxidants to reduce external stress such as heat, oxygen, and ozone on rubber, emulsifying agents, sulphur, wetting agents, acrylate thickeners as well as chalk as a filler and covering agent. Depending on the manufacturing process, synthetic latex can also sometimes contain small amounts of the residual monomers styrene and butadiene [106].

According to a study by the *Umweltbundesamt* ('Federal Environmental Agency' – UBA), approximately 80 % of the carpet floorings in Germany and Europe that are impregnated with flame retardants for use in buildings or vehicles use aluminium trihydroxide (ATH). However, long chain chlorinated paraffins plus antimony trioxide (ATO) and ammonium polyphosphate (APP) are also used. In addition, the halogen-based flame retardants decabromodiphenyl ether (DecaBDPE), hexabromocyclododecane (HBCD) and tris(chloropropyl)phosphate (TCPP) are still used in Germany and Europe in textile backings [108]. Carpet floorings that carry the voluntary GUT label from the *Gemeinschaft Umweltfreundlicher Teppichboden* (Environmentally Friendly Carpet Association) are prohibited from using the halogen and phosphor-containing flame retardants polybrominated biphenyl (PBB), tris(2,3-dibromopropyl)phosphate (TRIS), tris(aziridinyl)phosphine oxide (TEPA), short chain chlorinated paraffins (SCCPs) and PeBDE [109].

In order to achieve particular properties, textile floorings generally receive a chemical finish. Artificial fibre carpets for residential use are generally impregnated with teflon-like fluorine compounds to make them less sensitive to soiling. Carpets for commercial use, however, generally do not have such protection because they undergo professional cleaning [107]. Antistatic sprays can be used to protect against electrostatic charging [84].

Wool carpets are generally treated with pesticides to guard against infestation from moths and beetles. Pyrethroid and permethrin are mainly used here. To protect wool carpets from beetle and moth infestations, the carpet quality label from the *Gemeinschaft Umweltfreundlicher Teppichboden e.V.* (GUT) requires that carpets are treated with permethrin with a maximum quantity of 210 mg/kg wool [109]. Carpets bearing the international labels "International Wools Secretariat" and "Wools of New Zealand" are also required to have moth and beetle protection. With carpets made from natural fibres such as cotton and sheep's wool, pesticides are sometimes already used during the manufacturing process, and can be detected as residue.

In order to colour tufted carpets, the fibre wear layer needled to the primary backing fabric is either dyed or printed. Inorganic and organic pigments as well as organic dyestuffs can be used for colouring that partly contain heavy metals. In addition to dyes, dyeing auxiliaries and antistatic protection are also required [106].

To dye polyester fibres, which, however, are hardly used in carpet floorings as pile material, organochlorine carriers are also used as adjuvants to achieve quicker diffusion of the dyes into the fibre and increased dyestuff absorption [109].

With printed carpets, print pastes are used that likewise contain inorganic and organic pigments or organic dyes, as well as thickening agents and chemicals for fixing the dyestuff to the fibres. Defoaming and wetting agents are used as printing additives [106].

Table 27: Overview of substance classes that can be used in tufted textile floorings [according to 106]

Component	Function	Substance classes used
Wear layer	Fibres	Artificial fibre carpets: Polypropylene, polyamide, polyacrylnitrile (mainly with pile rugs), polyester Natural fibre carpets: New wool, coconut, sisal, jute, cotton
Backing	Primary backing fabric for fibres	Polypropylene, polyethylene, cotton, jute or cloth
	Bonding of the fibres to the primary backing fabric	Synthetic latex or natural latex
	Secondary backing:	Textiles, synthetic or natural latex, jute, polyurethane foam, bitumen, PVC
	Manufacture of synthetic latex: Vulcanisation accelerator Vulcanisation retarder	Xanthates, dithiocarbamates, thiurams, benzothiazoles, guanidines, thiourea derivatives, amine derivatives Organic acids (benzoic or salicyclic acids), phthalic anhydrides
	Additives (synthetic latex)	Antioxidants (antiflex cracking agents), emulsifying agents, sulphur, wetting agents, acrylic thickeners and chalk (filler and covering agent)
	Flame retardants	Aluminium trihydrate (ATH), ammomiumpolyphosphate (APP), chlorinated paraffins plus antimony trioxide (ATO), decabromodiphenyl ethers (DecaBDPE), hexabromocyclododecane (HBCD), tris(chloropropyl)phosphate (TCPP)
Chemical protection	Reducing sensitivity to soiling	Teflon-like fluorine compounds
	Reducing electrostatic charging with artificial fibre carpets	Potassium formate, ammonium compounds
	Protection against moth and beetle infestations with wool carpets	Permethrin
Colouring	Dye for dyed carpets [110]	Inorganic pigments (e.g. titanium dioxide, iron oxide, chromium oxide as well as iron blue, ultramarine and soot pigments) Organic pigments (e.g. azo pigments, polycyclic pigments such as anthraquinone and metal complex pigments such as copper phthalocyanine) Organic dyes such as azoic dyes and metal complex dyes

Component	Function	Substance classes used
Colouring	Dyeing auxiliaries	Dye solvents, lubricants as well as dispersing, fixing, reducing, wetting, levelling and antistatic agents Organochlorine carriers, used only with polyester fibres
	Print pastes for printed carpets	Inorganic pigments (e.g. titanium dioxide, iron oxide, chromium oxide as well as iron blue, ultramarine and soot pigments) Organic pigments (e.g. azo pigments, polycyclic pigments such as anthraquinone and metal complex pigments such as copper phthalocyanine) Organic dyes such as azoic dyes and metal complex dyes Thickening agents, chemicals for fixing the dye to the fibres and chelating agents
	Printing additives	Defoaming and wetting agents (anionic tensides)

Composition of needled floorings

Needled floorings often consist of synthetic fibres such as polypropylene, polyamide or a combination of the two. If required, the non-woven fabric is reinforced with a backing or dipped in a synthetic latex or acrylate-based adhesive [84]. It is possible for just the wear layer or backing to be impregnated (part impregnation) or the entire needled flooring (full impregnation). Needled floorings in tile form are often given a heavyweight backing of bitumen, PVC or amorphous poly(alpha)olefins (APO). Normally they are not protected with flame retardants [108].

6.2.1.2 Resilient floorings

Resilient floorings describe 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 [111]. Resilient floorings include PVC, polyolefins, linoleum, rubber and cork.

6.2.1.2.1 PVC floorings

PVC floorings can be divided into floorings with underlay and floorings without underlay. Glass fibre mat, polyester, cork or jute felt are mainly used as underlay. Floorings are further classified according to whether they are manufactured as compact or expanded floorings (cushioned vinyls – CV-floorings). The material used for compact floorings consists of a single homogeneous layer or several layers with differing properties. Expanded PVC floorings contain an embedded fibreglass fleece on which a PVC foam layer is applied [112].

The basis polymer polyvinyl chloride (PVC) only makes up around half the material of PVC flooring. The other half is made up of additives added to achieve desired properties such as elasticity and protection against the influences of light and temperature [113]. The substance classes shown in Table 28 are used as additives. Approximately 10 % of the PVCs sold in

Western Europe are used for floorings. Because of their relevance for human health, two groups of additives, plasticisers and stabilisers, will be described in detail.

Plasticisers

Plasticisers are organic compounds integrated into the plastic matrix of PVC in order to increase its elasticity. The proportion of plasticisers used in PVC floorings varies between 10 and 20 % [113]. Phthalate esters are mainly used as plasticisers. The most important plasticiser is di(2-ethylhexyl)phthalate (DEHP, also called DOP). In recent years, however, di-isononyl phthalate (DINP) has also been increasing used [112]. Among the manufactured phthalates, DEHP, DINP and diisodecyl phthalate (DIDP) reach a market share of over 80 % [115]. In Western Europe, about one million tons of phthalates are produced each year, of which approximately 90 % are used to plasticise PVC [116].

Esters of adipic and citric acid and alkylsulphonic acid esters are used much less as plasticisers. Other plasticisers used include dipropylene glycol dibenzoate (DGD), trimethyl pentanediol diisobutyrate (TXIB), sebacates and azelates [112, 117].

Chlorinated paraffins are also used as so-called secondary plasticisers and at the same time serve as flame retardants [118]. Medium chain chlorinated paraffins (from C_{14} to C_{17}) are mainly used with a degree of chlorination ranging from 40 – 60 % [117].

Stabilisers

Stabilisers are added to PVC to prevent it from decomposing under the influence of temperature, oxygen and daylight [117]. Stabilisers comprising lead, calcium/zinc and organic tin compounds are mainly used [112]. Cadmium stabilisers are hardly used anymore in the European Union (forbidden under the Directive 76/769/EEC). Stabilisers containing lead, however, are still used very frequently [117]. Calcium/zinc compounds are most commonly used as stabilisers for PVC floorings [112].

Dibutyltin (DBT) is mainly used as an organic tin compound, but tributyltin (TBT) is also sometimes used. Thus 12 out of 15 PVC floorings examined within the framework of *Ökotest* contained organic tin compounds [119].

The table below provides an overview of additives used in PVC, as well as their function and the substance classes used.

Table 28: Examples of additives and their function in PVC

Additive	Function	Substance classes used
Plasticisers	Protection of the elasticity	Phthalate esters: Di(2-ethylhexyl)phthalate (DEHP) Di-isononyl phthalate (DINP) Dibutyl phthalate (DBP) Benzylbutyl phthalate (BBP) Di-isodecyl phthalate (DIDP) Di-n-octyl phthalate (DNOP) Di-isopentyl phthalate (DIPP) Other plasticisers [112, 117]: Adipic acid esters, e.g. di(2-ethylhexyl)adipate Citric acid esters, e.g. acetyl tributyl citrate Cyclohexanedicarboxylate esters Alkylsulphonic acid esters Dipropylene glycol dibenzoate (DGD) Trimethyl pentanediol diisobutyrate (TXIB) Sebacates Azelates Chlorinated paraffins
Stabilisers	Stabilisation against the influence of light and temperature	Cadmium stabilisers (forbidden in the EU) Lead stabilisers Organotin stabilisers Calcium/zinc stabilisers
Pigments [110]	Colouring of plastic products	Inorganic pigments (e.g. titanium dioxide, iron oxide, chromium oxide and iron blue, ultramarine and soot pigments), lead chromate [41] Organic pigments (e.g. azo pigments, polycyclic pigments such as anthraquinone and metal complex pigments such as copper phthalocyanine)
Fillers	Improving the workability and wear performance (comprise up to 50 % of the PVC material) [56]	Calcium carbonate (chalk) Magnesium silicate hydroxide (talc) Barytes
Flame retardant [43, 56]	Increasing fire resistance	Aluminium trihydrate (ATH) Phosphoric acid esters Antimony trioxide (ATO) Chlorinated paraffin
Lubricants	Improving the flow during the thermoplastic processing (comprise up to 3 % of the PVC material) [56]	e.g. waxes
Antistatic agents	Reducing electrostatic charging	e.g. perchlorates
Surface active agent	Reducing surface tension	e.g. esters of long chain alcohols
Reinforcement	Reinforcement for expanded PVC floorings	e.g. glass fibres

6.2.1.2.2 Polyolefin floorings

Until now there have been no product standards for polyolefin floorings. According to the manufacturers, the requirements are based on the existing standards for resilient floorings [120].

The floorings consist of polyolefins, whereby polyethylene and polypropylene are mainly used. The elasticity of the flooring is achieved by adding a copolymer, e.g. ethylene vinyl acetate (EVA), to an internal plasticiser. Up to 70 % dried mineral powder such as chalk or kaolin can be added as fillers. Further additives include colour pigments such as titanium dioxide and iron oxide. Usually a layer of acrylic dispersion or polyurethane is used to protect the surface [84]. As polyolefins are easily inflammable, flame retardants are also used. The most relevant flame retardant in terms of quantity when manufacturing polyolefin is aluminium trihydrate (ATH) [121].

6.2.1.2.3 Linoleum floorings

Linoleum floorings are manufactured by rolling out a homogenous mixture of [84, 122, 123, 124]:

- linoleum-cement
- ground cork and/or wood flour (29 - 35 %)
- coloured pigments based on calcium, iron or manganese
- inorganic fillers (e.g. limestone) (23 - 28 %)

on fibre, foam or cork backings. The flooring is ready for use after an oxidative cross-linking process at 90 °C.

The linoleum-cement used as a binder consists of a mixture of

- linseed oil (75 - 80 %) or other drying vegetable oils
- resin (rosin, pine resin) (20 - 25 %)
- drying accelerator (siccative)

Linoleum floorings generally have a thin surface layer made of polyacrylate or PVC [125].

6.2.1.2.4 Rubber floorings

Rubber floorings to DIN EN 1816, 1817, 12199 and 14521 (draft) are made of natural or synthetic rubber [126, 127, 128, 129]. They can be manufactured homogeneously (single layer) or heterogeneously (multiple layers) according to DIN EN 1817 and DIN EN 12199 respectively, or with a decorative layer according to DIN EN 14521. Floorings according to DIN EN 1816 have a foam backing.

The rubbers mainly used are styrene-butadiene rubber (SBR) and natural rubber (NR). Other rubbers such as butyl rubber (IIR), ethylene-propylene rubber (EPM) or ethylene-propylene terpolymer (EPDM) are used less frequently.

In addition to the rubbers used, floorings consist of fillers, pigments and processing agents. Conventionally they are cross-linked with elementary sulphur while adding vulcanisation accelerators. Rubber floorings are protected against the influence of light and oxygen by adding antioxidants. Because of the elastic properties of cross-linked polymers, the use of plasticisers is not necessary [130].

Rubber floorings are composed of approximately 35 % rubber, 50 - 60 % inorganic fillers such as clay and kaolin, 5 % pigments, 1.5 % sulphur and processing agents [130].

6.2.1.2.5 Cork floorings

Cork floorings mainly consist of cork floor tiles or cork parquet. Cork floor tiles to DIN EN 12104 are manufactured by agglomerating granulated cork while adding binders. The floorings can be additionally coated with layers of decorative material such as decorative cork or wood veneers. Cork floorings are either already surface coated at the manufacturing stage (coating generally thinner than 0.05 mm) or after the laying [131].

Formaldehyde resins (phenol formaldehyde, urea formaldehyde and melamine formaldehyde resins), polyurethane resins or natural oils such as cashew-nut oil are used as binders for cork floor tiles [132].

Cork granules and the binders used usually do not contain any significant amount of heavy metals. It is not usual to use pesticides during the extraction and production of cork, as cork is not vulnerable to infestation by insects and moulds [132].

6.2.1.3 Laminate floorings

European standard DIN EN 13329 defines laminate floorings as a surface layer comprising one or more thin sheets of a fibrous material (usually paper) impregnated with aminoplastic thermosetting resins. These sheets are either pressed onto the substrate with the simultaneous use of heat and pressure (high pressure laminate – HPL or continually pressed laminate – CPL), or pressed directly on the substrate (DPL) [133]. Melamine resin is mainly used as the aminoplastic resin for the upper wear level (overlay). Depending on the type of laminate, the subsequent paper sheets (underlays) use the cheaper phenol resin [84]. Melamine and phenol resin are created by polymerizing formaldehyde with melamine and phenol.

The substrate is usually chipboard to DIN EN 309, or medium density fibreboard (MDF) or high-density fibreboard (HDF) to DIN EN 316 [134, 135]. The substrates can contain chemicals as source protection (edge hydrophobing) [84].

As defined by DIN EN 309, *particle boards* are manufactured under pressure and heat from small particles of wood and/or other lignocellulosic material (e.g. flax shives, hemp shives, bagasse) with the addition of an adhesive [134]. Particle boards are manufactured with an adhesive content of 5-10 % (relative to the wood weight). Approximately 90 % of the particle boards for indoor use are bonded with urea formaldehyde resin (UFR). The chemical reaction between urea and formaldehyde leaves a small proportion of unbound formaldehyde which can be emitted [84].

As defined by DIN EN 316, *fibre boards* are manufactured from lignocellulosic fibres with application of heat and/or pressure [135]. The bond is derived either from the felting of the fibres and their inherent adhesive properties or from a synthetic adhesive added to the fibres. More than 90 % of the MDF boards are glued together with urea formaldehyde resin, of which 2-8 % is melamine (MUF resin) [84].

With laminate flooring, a backer is applied to the lower side of the substrate in order to balance and stabilise the product. The backer usually consists of high pressure or continually pressed laminate, impregnated paper or veneer [133].

6.2.1.4 Floorings from solid wood and wood-based panels

Wooden floorings can consist of solid wood (single layer structure) or several sheets of wood and wood-based panels (multi-layer structure).

With **wooden floorings made of solid wood**, it is possible to distinguish between sold wood parquet and solid wood floorboards. Solid wood parquet is manufactured as single-layer parquet that is usually fabricated out of strip parquet, mosaic parquet, lamparquet and vertical finger parquet.

Solid wood floorboards are made of hard or softwood. Softwood floorboards are tongue and grooved planks. Hardwood floorboards made of solid wood consist of several pieces (strips) that are dovetailed or glued together along the ends or narrow sides [136].

Multi-layer parquet to DIN EN 13489 is manufactured from multi-layer parquet elements. These elements consist of a wear layer of solid wood and one or more additional wood layers or layers of wood-based panels that are glued together. The thickness of the wear layer must be greater than 2.5 mm [137].

The composition of wood-based panels (particle boards, fibre boards) has already been described for laminate floorings (Section 6.2.1.3).

All the types of wood floorings described can already be provided with a surface treatment in the factory or sealed on site. Floorings manufactured according to the product standards for wood floorings can be treated with biocides. The CE marking should indicate the preservative treatment used against biological attack in accordance with EN 351-1 [138].

6.2.2 Content/Release of dangerous substances from floorings

At room temperature, floorings can release volatile organic compounds that are constituents of diverse materials used in them. Organic compounds can be released into indoor air by emission or by abrasion and bonding to house dust. Users can absorb compounds by inhaling air, orally via the house dust or dermally through body contact with the flooring.

Owing to the enormous diversity of substances used in floorings, it is difficult to assess the released organic compounds in health terms. In the past, the total concentration of all volatile organic compounds (total volatile organic compounds – TVOC) was generally assessed. The *Innenraumlufthygiene-Kommission* ('Indoor Air Hygiene Commission' – IRK) of the *Umweltbundesamt* ('Federal Environmental Agency' – UBA) has specified guideline values for individual substances (toluene, styrene) and for TVOC. For TVOC, concentration ranges have been specified since it has proved very difficult to derive specific numerical values. According to the IRK, it can only be reasonably expected for short periods to stay every day in rooms with TVOC concentrations between 10 and 25 mg/m³ (such concentrations can occur when carrying out renovation work). In rooms that are intended to be used for longer periods, the TVOC value should not exceed a range of 1-3 mg/m³. For rooms used on average for longer periods, the aim should be to have TVOC concentrations of 0.2-0.3 mg/m³ and, if possible, even less. [139]. The AgBB's VOC/SVOC evaluation scheme described in Section 6.1.1 provides a more detailed procedure for assessing the emission of volatile organic compounds [21].

When making a health-related evaluation, particular attention should be paid to semi-volatile organic compounds (SVOC) as these do not only occur temporarily after completion of the works or after renovation but can pollute the indoor air in the long term.

With the release of volatile organic compounds, it should be taken into consideration that floorings are often used in combination with adhesives and that the substrate may be treated with a primer and filling compound. The combined materials influence one another and can

show different emission behaviour as individual components. For instance, individual studies have shown that indoor air pollution associated with health or odour impairment is not always due to the flooring but can also be partly attributed to the adhesives used [141].

This research project only considers "floorings" as the "Floorings" mandate only refers to these products.

Until now, very little data has been published on the emission of VOC and SVOC from floorings. Frequent changes in the products also means that hardly any information on new materials can be derived form the older studies [142].

The results from emission measurements described below are intended to provide an indication as to which VOC and SVOC may be emitted in increased amounts from various floorings. Due to the different testing methods and TVOC definitions, it is not possible to assess the measurement results with the AgBB's VOC/SVOC evaluation scheme (cf. Section. 6.1.1).

Because there has been insufficient evaluation of indoor air pollution at European level, in autumn 2003 the European Commission's Joint Research Centre (JRC) in Ispra, Italy, initiated the new "INDEX" project concerned with the 'critical appraisal of the setting and implementation of EU indoor exposure limits'. The project aims to set up a priority list of substances whose occurrence must be regulated in indoor spaces as well as provide proposals and recommendations for possible exposure limits for these substances [140].

Release of VOC and SVOC

Test chamber measurements of carpets as part of a study by the *Institut für Umwelt und Gesundheit* in Fulda (Institute for the Environment and Health – IUG) determined the presence of aromatic hydrocarbons such as benzene, styrene, toluene, m/p-xylene and 2-ethyltoluene, which are contained in the synthetic latex backing. These volatile substances are generally released within short periods of time. With the release of benzene, particular attention needs to be paid to the storage and transport of the samples since the widespread occurrence of benzene can cause contamination of the sample specimens. It was possible to verify the release of volatile n- and cycloalkanes (e.g. n-hexane, n-heptane to n-hexadecane, cyclohexane) from carpet floorings. Small amounts of formaldehyde (methanal) were also measured. Also established were higher aldehydes and ketones (e.g. acetaldehyde, propionaldehyde, butyraldehyde, acetone, cyclohexanone), which are released into indoor spaces as the oils dry off that are contained in the adhesives used in the floorings [106].

In a study on VOC and SVOC emissions from floor constructions and the materials used for them, test chamber measurements verified the release of the aliphatic hydrocarbons pentadecane, tetradecane and heptadecane from all the textile floorings examined. The release of acetic acid was established with carpet floorings made of natural fibres [143]. Acetic acid is used as a pH regulator in colouring carpet floorings.

The plasticisers used in PVC floorings are only loosely bound to the PVC matrix without chemical bonding. Semi-volatile plasticiser molecules are released by molecules migrating to the floor surface and then being emitted [144]. Plasticisers are semi-volatile and, after exiting the material, attach themselves to larger particles such as, for example, house dust. Every year, around 1 % of the total amount of plasticisers is emitted from the PVC flooring [117].

In 1991, phthalates were measured in indoor air when examining 40 indoor air samples taken from Berlin households. Here, the average concentration of the plasticisers mainly used was found to be 480 ng/m³ for di(2-ethylhexyl)phthalate (DEHP) and 3,000 ng/m³ for dibutylphthalate (DBP). The highest values that were measured were 2,200 ng/m³ DEHP and 33,000 ng/m³ DBP [145].

In addition to plasticisers, phenoles and 2-ethylhexanal can also be emitted from PVC floorings. A Swiss case study has identified these compounds as the main cause of odour contamination and health problems [146].

With linoleum floorings, it is possible for oxidation products such as aldheydes to be released as a result of the oxidative decomposition of linseed oil, which consists mainly of oleic, linoleic and linolenic acid. These are generally also responsible for the odour pollution from new floors. The emission behaviour of linoleum floorings varies considerably from product to product and substantially depends on the drying process of the flooring. It is generally possible to identify aliphatic aldehydes (particularly hexanal and higher aldehydes). Poor quality floorings often emit acetaldehyde and aliphatic and aromatic hydrocarbons [125].

Floorings from wood-based panels can emit VOC and SVOC, e.g. phenols, from the adhesives used. A further emission source for the release of VOC and SVOC is factory-applied surface finishing. With multi-layer parquet, UV curing varnish systems are used that can release odour-intensive substances. With wooden floorings made of solid wood, polyurethane, acid-cured and water varnish are used, which particularly emit VOC and SVOC during the first few weeks [147]. With laminate floorings it has also been proved that floor heating can substantially increase the emission of VOC.

In order to be able to establish the long-term behaviour with the emission of VOC and SVOC from floorings, it is important to know the course of the emission over time. Emission tests in the test chamber have shown that although SVOC emit more slowly than VOC due to there being less vapour pressure, they emit over a longer period. The emission of volatile organic compounds shows a clear decay characteristic over the 24-hour, 3-day and 28-day values. Volatile compounds such as toluene reach the maximum concentration in the test chamber within an hour and then decay within 24 hours to a concentration less than 10 % of the maximum value. Semi-volatile compounds, however, can be identified for weeks [Vankann, 2003, Wilke, 2003].

Release of odour-intensive substances

Many of the volatile organic compounds listed above are also relevant in terms of odour emissions, as sustained odour from floorings is a repeated cause of complaints and can also cause health problems such as headaches and nausea.

In particular, cyclohexene derivatives used in synthetic latex backings are among the odour-intensive substances from textile floorings that can be released over longer periods of time. The substances 4-phenylcyclohexene (4-PCH), 4-vinylcyclohexene (4-VCH) and 2-ethyl-1-hexanol are sometimes created as by-products when manufacturing synthetic latex from the monomers styrene and butadiene. Here, 4-PCH and 4-VCH smell very unpleasant and have a low odour threshold of approx. 2 µg/m³ [106]. Cyclohexene derivatives are only slowly released and can often still be perceived after years. A research project by the *Bundesanstalt für Materialforschung und Prüfung* (German Federal Institute for Materials Research and Testing – BAM) to examine and determine low-emission adhesives and floorings has also confirmed the release of cyclohexene derivatives. With 14 tested textile floorings, 10 floorings still emitted after 28 days between 1 and 18 µg/m³ 4-PCH [143].

Further odour-intensive substances include dodecenes ($C_{12}H_{24}$), which are created from dodecylmercaptane, a chain-transfer agent for the reaction between styrene and butadiene. Ethylacetate and n-butylacetate from the group of acetates also have a characteristic odour, whereby n-butylacetate also has a low odour threshold [106].

Release of formaldehyde

When using melamine and phenol formaldehyde resin in laminated, multi-layer parquet and cork floorings, formaldehyde can be released from the wood-based panels, the bonding and from the surface sealing.

Test chamber measurements from the *Wilhelm-Klauditz-Instituts für Holzforschung* (Wilhelm-Klauditz Institute for Timber Research – WKI) resulted in laminated floor values of 0.005-0.03 ppm formaldehyde from the laminate floorings examined, which can be deemed to be

low [149]. Another study has shown, however, that floor heating can considerably increase formaldehyde emissions from laminate floorings [148].

Content/Release of pesticides

The insecticide permethrine, which is often used in wool carpets, is mainly transported by particles in indoor air due to the very low vapour pressure. Through the abrasion of carpet fibres this enters house dust, which can then be inhaled by humans when it is whirled up. The potential health risk for people through inhaling permethrine is a matter of considerable debate [150, 151].

Content/Release of heavy metals

Heavy metal compounds that occur in preserving agents, such as organotin compounds, can be released from PVC floorings into the indoor air by abrasion of the PVC flooring [119].

6.2.3 Recommendations

The Essential Requirement No. 3 "Hygiene, Health and the Environment" has not yet been transposed into the harmonised European flooring standards. Until now, three so-called 'umbrella' standards have existed that are intended to cover the health and environmental protection requirements for the individual flooring standards. These umbrella standards only mention, however, the individual substances formaldehyde and pentachlorophenol, which are also mentioned in Mandate 119 for floorings,

The following section lists the umbrella standards with the respective product standards and provides recommendations for the release of dangerous substances. These should be taken into consideration when revising the harmonised technical specifications for floorings as the existing umbrella standards are insufficient for ensuring that users are not placed at risk from construction works as demanded by the Construction Product Directive. The listed requirements for health and environmental protection should be supplemented when revising the umbrella standards or be listed as specific requirements in the product standards for the individual types of flooring.

6.2.3.1 Previous requirements for health and environmental protection in the first standard generation

DIN EN 14041 (Draft): Resilient, textile and laminate floor coverings - Essential characteristics

The current health protection requirements for textile, resilient and laminate floorings are laid down by the umbrella standard DIN EN 14041 (Draft). In terms of health protection, however, this draft version only mentions the release of formaldehyde and the content of pentachlorophenol [152].

According to the draft standard, when using materials containing formaldehyde the release of formaldehyde shall be determined in accordance with DIN EN 717-1 [153] or DIN EN 717-2 [154] and the formaldehyde class E1 or E2 shall be stated in the CE-marking. It is not necessary to label products that do not use materials containing formaldehyde; they can also be classified under Class E1 without testing. A point of criticism regarding the draft standard is that the regulation for formaldehyde contradicts German legislation. In Germany, it is already forbidden to market wood-based panels that are in formaldehyde class E2. This fact must be indicated in the European draft standard, for example by noting that no products in formaldehyde class E2 may be marketed in Germany.

In terms of the biocide pentachlorophenol (PCP), the standard demands that floorings may not contain pentachlorophenol or its derivatives. This requirement is considered fulfilled if the content of PCP is less than 0.1 % by mass. This corresponds to 1 g PCP per kg flooring. The German *Chemikalienverbotsverordnung* ('Chemicals Interdiction Regulation') forbids the marketing of products containing more than 5 mg PCP per kg in the parts that are treated (0.0005 % by mass) [99]. Council Directive 76/769/EEC relating to restrictions on the marketing and use of certain dangerous substances forbids the marketing of substances and preparations that contain more than 0.1 % by mass PCP [10]. The Directive does not refer, however, to products. It is therefore not expedient to adopt this limit value for flooring as a product. In addition to Germany's deviating regulation for PCP, the European Commission has also agreed to the stricter requirements for PCP stipulated by the Dutch and Danish[23]. These national protection levels must be transposed into a harmonised European standard by specifying levels or classes.

Another point of criticism is that the standard does not contain any regulations for using wastes, e.g. used wood in wood-based panels.

{The umbrella standard DIN EN 14041 (Draft) refers to the product standards described in the following table.

Table 29: Product standards for textile, resilient and laminated floorings that are listed in DIN EN 14041, Annex A (Draft) [152]

Standard	Title	Status
DIN EN 14041 (Draft)	Resilient, textile and laminate floor coverings - Essential characteristics	Formal Vote
Textile floorings		
EN 1307 (Draft)	Textile floor coverings - Classification of pile carpet	Under approval
EN 1470 (Draft)	Textile floor coverings - Classification of needled floor coverings except for needled pile floor coverings	Under development
EN 13297 (Draft)	Textile floor coverings - Classification of needled pile floor coverings	Under development
DIN EN 14215	Textile floor coverings - Classification of machine-made pile rugs and runners	September 2003
Resilient floorings		
PVC floorings		
EN 649/prA1 (Draft)	Resilient floor coverings - Homogeneous and heterogeneous polyvinyl chloride floor coverings - Specification	Under Approval
DIN EN 650	Resilient floor coverings - Polyvinyl chloride floor coverings on jute backing or on polyester felt backing or on polyester felt with polyvinyl chloride backing - Specification	January 1997

23 94/783/EC: Decision of the Commission from 14 September 1994 concerning the prohibition of pentachlorophenol notified by the Federal Republic of Germany, Official Journal No. L 316 of 09.12.1994, p. 0043 – 0048

96/211/EC: Commission Decision of 26 February 1996 concerning the prohibition of pentachlorophenol (PCP) notified by Denmark, Official Journal No. L 068 of 19.03.1996, p. 0032 – 0040

1999/831/EC: Commission decision of 26 October 1999 concerning thenational provisions notified by the kingdom of the Netherlands concerning the limitations of the marketing and use of pentachlorophenol (PCP), Official Journal No. L 329 of 22.12.1999, p. 0015 – 0024

Standard	Title	Status
Resilient floorings		
PVC floorings		
EN 651/prA1 (Draft)	Resilient floor coverings - Polyvinyl chloride floor coverings with foam layer - Specification	Under Approval
DIN EN 652	Resilient floor coverings - Polyvinyl chloride floor coverings with cork-based backing - Specification	January 1997
DIN EN 653	Resilient floor coverings - Expanded (cushioned) polyvinyl chloride floor coverings - Specification	January 1997
EN 654:1996/A1 (Draft)	Resilient floor coverings - Semi-flexible polyvinyl chloride tiles - Specification	Under Approval
DIN EN 655	Resilient floor coverings - Tiles of agglomerated composition cork with polyvinyl chloride wear layer - Specification	January 1997
DIN EN 13413	Resilient floor coverings - Polyvinyl chloride floor coverings on a filled fibrous backing - Specification	March 2002
DIN EN 13553	Resilient floor coverings - Polyvinyl chloride floor coverings for use in special wet areas - Specification	July 2002
DIN EN 13845 (Draft)	Resilient floor coverings - Polyvinyl chloride floor coverings with enhanced slip resistance - Specification	September 2003
Linoleum floorings		
EN 548 (Draft)	Resilient floor coverings - Specification for plain and decorative linoleum	Under development
DIN EN 686	Resilient floor coverings - Specification for plain and decorative linoleum on a foam backing	September 1997
DIN EN 687	Resilient floor coverings - Specification for plain and decorative linoleum on a corkment backing	September 1997
DIN EN 688	Resilient floor coverings - Specification for corklinoleum	September 1997
Rubber floorings		
DIN EN 1816	Resilient floor coverings - Specification for homogeneous and heterogeneous smooth rubber floor coverings with foam backing	May 1998
DIN EN 1817	Resilient floor coverings - Specification for homogeneous and heterogeneous smooth rubber floor coverings	May 1998
DIN EN 12199	Resilient floor coverings - Specifications for homogeneous and heterogeneous relief rubber floor coverings	May1998
DIN EN 14521 (Draft)	Resilient floor coverings - Specification for smooth rubber floor coverings with or without foam backing with a decorative layer	September 2002
Cork floorings		
DIN EN 12104	Resilient floor coverings - Cork floor tiles - Specification	October 2000
Laminate floorings		
DIN EN 13329	Laminate floor coverings - Specifications, requirements and test methods	September 2000

DIN EN 14342 (Draft): Wood flooring - Characteristics, evaluation of conformity and marking

The harmonised European umbrella standard DIN EN 14342 (Draft) has been elaborated for wood floorings from solid wood and wood-based panels. This specifies the characteristics of wood floorings for indoor use. In terms of health and environmental protection, it refers to the following characteristics [155]:

- Biological durability
- Release of formaldehyde
- Release of pentachlorophenol

In terms of the biological durability, reference is made to the European standards DIN EN 335-1 (general) [138] and EN 335-2, which defines the hazard classes for biological attack when using solid wood [156] and wood-based panels [157]. According to the aforementioned standards, the durability of solid wood and wood-based panels can be improved by using wood preservatives.

The German wood preservative standards DIN 68800 Part 3 and 5 also define hazard classes for biological attack [158, 159]. In contrast to the European standards, in Germany there is also a hazard class 0 that does not demand any wood protection. For the purposes of load-bearing and stiffening, only wood preservatives may be used for timber and wood-based panels that are approved by the *Deutsches Institut für Bautechnik* (German Institute for Building Technology – DIBt). Here legally binding restrictions are stipulated for specific active agents in terms of their indoor use. For the non-load-bearing area of floorings, preferably no wood preservatives at all or only such wood preservatives should be used that have been approved for indoor spaces.

The standard also points out that untreated solid wood which does not have any adhesives, coating or surface treatment, does not emit any notable amounts of formaldehyde. In case a restriction of the formaldehyde content be required, testing methods are indicated with which the emission shall be measured (DIN EN 717-1 or DIN EN 717-2). The test results shall be given in the form of formaldehyde classes E1 or E2. Wood-based panels in which no formaldehyde substances are used in their manufacture or processing may be classified as class E1 without any testing. A point of criticism of the draft standard is that – as with DIN EN 14041 (Draft) – this regulation contradicts German legislation.

According to standard DIN EN 1432, should pentachlorophenol be used for treating the wood, it is necessary to observe the Biocides Directive [160] and national legal restrictions. Should the PCP content exceed 5 ppm, the CE marking shall indicate "PCP > 5 ppm". Here it needs to be pointed out that in Germany it is forbidden to market products that contain more than 5 ppm PCP per kg in the treated parts of the product. This fact must be indicated in the European draft standard, for example by noting that no products with a content > 5 ppm PCP in their treated parts may be marketed in Germany.

The following table provides an overview of the product standards for wood floorings affected by the umbrella standard DIN EN 14342 (Draft):

Table 30: Product standards for wood floorings whose health aspects are regulated in standard DIN EN 14342 (Draft)

Standard	Title	Status
DIN EN 14342 (Draft)	Wood flooring – Characteristics, evaluation of conformity and marking	March 2002
Wood flooring		
DIN EN 13226	Wood flooring - Solid parquet elements with grooves and/or tongues	May 2003
DIN EN 13227	Wood flooring - Solid lamparquet products	June 2003
DIN EN 13228	Wood flooring - Solid wood overlay flooring elements including blocks with an interlocking system	June 2003
DIN EN 13488	Wood flooring – Mosaic parquet elements	May 2003
DIN EN 13489	Wood flooring - Multi-layer parquet elements	May 2003
DIN EN 13629	Wood flooring – Solid pre-assembled hardwood board	June 2003
DIN EN 13990 (Draft)	Wood flooring - Solid softwood floor boards	December 2000
DIN EN 14761 (Draft)	Wood flooring - Solid wood parquet - Vertical finger, wide finger and module brick	October 2003

DIN EN 13986: Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking

The harmonised European standard for wood-based panels, DIN EN 13986 [161] also applies for floorings consisting of wood-based panels such as cork parquet, laminate floorings and multi-layer parquet elements. For wood-based panels that are used indoors (solid wood panels, laminated veneer lumber, plywood, oriented strand boards, particle boards, fibre boards and MDF boards), the standard regulates the following properties that are relevant to health:

- Biological durability
- Formaldehyde emission
- Release of pentachlorophenol

For the mentioned points, the regulations in the wood-based panel standard DIN EN 13986 correspond to the regulations in the DIN EN 14342 draft standard for wood floorings.

6.2.3.1.1 Recommendations for the second generation of flooring standards

As the regulations included up to now in the umbrella standards are insufficient for transposing the Essential Requirement 3 for floorings, recommendations are be detailed below that should be taken into consideration when revising the technical specifications. Here, some individual recommendations apply to all types of flooring while other individual recommendations only apply to specific floor types, depending on the material used.

Content of CMR substances from Category 1 and 2 and substances labelled "Toxic" (T) and "Very toxic" (T+)

When manufacturing floorings, it is possible that carcinogenic, mutagenic and reprotoxic substances (CMR substances) are used from Category 1 and 2 [24] as well as substances that are classified or labelled as toxic (T) and very toxic (T+) according to the EU Dangerous Substances Directive (67/548/EEC). The following table lists examples of CMR substances as well as toxic and very toxic substances that are used in floorings.

Table 31: Examples of CMR substances from Category 1 and 2 as well as "toxic" and "very toxic" substances in floorings

Substance	CAS No.	Classification	Function
Chromium trioxide	1333-82-0	Carcinogenic, Cat. 1 (R 49) Toxic (T)	Pigment
Di(2-ethylhexyl)phthalate (DEHP)	117-81-7	Reprotoxic, Cat. 2 (R 60-61) Toxic (T)	Plasticiser
Dibutylphthalate (DBP)	84-74-2	Reprotoxic, Cat. 2 (R 61) Toxic (T)	Plasticiser
Lead compounds		Reprotoxic, Cat. 1 (R 60) Toxic (T)	Stabilisers

Due to the potential hazard, floorings should avoid using CMR substances (Category 1 and 2) and substances that are classified as "Toxic" (T) and "Very toxic" (T+) to Council Directive 67/548/EEC [3].

At European level, CMR substances classified in Category 1 and 2 are only regulated in the EU's Marketing and Use Directive (76/769/EEC) to the extent that these substances and preparations may not be sold to the general public if specific concentrations are exceeded [10]. The requirement does not apply, however, to products.

At national level, the DIBt Approval Guidelines: Indoor Construction Products require, for approvals in Germany, that no carcinogenic and mutagenic substances of Category 1 and 2 be actively used and that substances classified as T und T+ should not be used [96].

Various European countries have voluntary regulations that prohibit the use of CMR substances. For example, both the Austrian environmental label for textile floorings (UZ 35), resilient floorings (UZ 42) and wood-based panels (UZ 07) and the Scandinavian environmental label for textiles, wood and wood-based panels demand that, in addition to prohibiting the use of CMR, T and T+ substances, no substances may be used that are classified as "environmentally hazardous" (N). The German *Blauer Engel* eco-label for low-

24 CMR substance, Category 1 of Council Directive 67/548/EEC: substance that is known to have a carcinogenic, mutagenic or reprotoxic effect on humans.
CMR substance, Category 2 of Council Directive 67/548/EEC: substance that should be viewed as having a carcinogenic, mutagenic or reprotoxic effect on humans.
Approximately 850 substances are currently classified as CMR substances according to Category 1 and 2 (Council Directive 67/548/EEG) [95].

emission products from wood and wood-based panels (RAL-UZ 38) excludes the use of coating systems that contain CMR, T and T+ substances as constituent components. The voluntary regulations for CMR substances in floorings are listed in Annex A11.

Content of pentachlorophenol (PCP)

Owing to deviating national regulations, the content of PCP in floorings needs to be determined and the corresponding levels/classes or declared values included in the CE marking. In Germany, for example, it is already forbidden to market products containing PCP where the treated parts of the product contain more than 5 mg PCP per kg (this corresponds with a limit of 3 mg/kg for the whole product). This must be taken into account in the standards.

Release of formaldehyde

If materials containing formaldehyde are used in manufacturing floorings, then, because of existing national legal requirements, the release of formaldehyde must be determined by conducting an emission test in a test chamber or cell.

Regulations for the emission of formaldehyde exist in several European countries (e.g., Denmark, Finland, Norway, Italy and Poland). In Germany, an emission limit of 0.1 ppm formaldehyde applies for the use of wood-based panels, which has also been adopted by the DIBt Approval Guidelines: Indoor Construction Products [96].

Various national voluntary regulations for floorings restrict the emission or at least the content of formaldehyde, and generally go further than the legal requirements. The voluntary regulations for formaldehyde in floorings are listed in Annex A11.

Release of volatile and semi-volatile organic compounds (VOC and SVOC)

Because of the health relevance of VOC and SVOC, the total emission of these compounds should be determined in the form of the sum of the VOC (TVOC value) and the sum of the SVOC. To enable an evaluation of the individual substances, all VOC with a concentration $\geq$ 2 µg/m³ should be identified and quantified. The precise procedures should be based on the AgBB's VOC/SVOC evaluation scheme (c.f. Section 6.1.1).

In Germany, the DIBt Approval Guidelines: Indoor Construction Products restrict the emission of VOC and SVOC from floorings. Several countries have voluntary regulations for VOC and SVOC. They are limited, however, to determining the TVOC and SVOC values and individual VOC (e.g. styrene, toluene, 4-PCH, 4-VCH) and the VOC total parameter (e.g sum of saturated n-aldehydes, sum of aromatic aldehydes). The AgBB's VOC/SVOC evaluation scheme goes further here as approximately 140 individual substances are assessed in addition. The voluntary regulations for VOC and SVOC in floorings are listed in Annex A11.

Release of odour-intensive substances

The odour emission from floorings should be determined because this could have an adverse effect on the users of buildings.

At the national level in Germany, the determination of odour emissions is not yet taken into account within the framework of the DIBt Approval Guidelines: Indoor Construction Products as there are no uniform testing methods and evaluation measures.

At a voluntary level, numerous labels for floorings restrict odour emissions, which are determined using different testing methods. The voluntary regulations for odours from floorings are listed in Annex A11.

Use of waste materials

The use of waste materials in floorings should be declared.

In individual members states, regulations exist for the use of used wood. For example, in Norway and Poland the use of used wood in wood-based panels is either not permitted or is restricted in terms of the substances used. In Germany, the values stipulated by the *Altholzverordnung* ('Waste Wood Ordinance') must be complied with when using used wood [97]. The values stipulated by the German *Altholzverordnung* are listed in Annex A12.

Recommendations that should also be taken into account with textile and resilient floorings

Content of azoic dyes that release carcinogenic amines

Azoic dyes that release carcinogenic amines should not be used in floorings

According to the EU's Marketing and Use Directive (76/769/EEC), azoic dyes that release carcinogenic amines may not be used in textiles and leather products that come into contact with human skin [10]. Due to possible skin contact with floorings, their use should also be avoided in other application areas such as PVC floorings.

The voluntary regulations for floorings also prohibit the use of azoic dyes that release carcinogenic amines. The regulations are listed in Annex A11.

Content of flame retardants

No polybrominated diphenyl ethers should be used in textile and resilient floorings.

As part of the EU's Existing Substances Regulation, a draft risk assessment report has been produced for decabromodiphenyl ether (DecaBDPE), the most relevant representative of the polybrominated diphenyl ethers in terms of quantity [DeBDPE]. The study suggests that further tests and monitoring of data are required, but at the same time advises that measures should already be taken to reduce emissions or diffuse releases because of the persistent properties [162].

A study by the *Umweltbundesamt* ('Federal Environmental Agency' – UBA) for establishing a basis for assessing the substitution of environmentally relevant flame retardants also comes to the conclusion that, because of the occurrence of DecaBDPE in sediments and in indoor and ambient air, these flame retardants should also be substituted [108].

In addition to decabromodiphenyl ethers, a risk assessment is also being conducted for the flame retardants hexabromocyclododecane (HBCD) and tris(chloropropyl)-phosphate (TCPP) as part of the EU's Existing Substances Regulation, for which, however, there are still no results. The restriction of other flame retardants should be discussed according to the state of technology and knowledge.

At national level in Germany, the DIBt Approval Guidelines: Indoor Construction Products prohibit the use of polybrominated diphenyl ethers in floorings, as polybrominated dioxins and furans can be released in case of fire. This prohibition has been applied by the DIBt since 1986 for all approved construction products.

In Germany, the TEGEWA (trade association for manufacturers of textile auxiliaries and tanning and washing agents) and the *Verband der kunststofferzeugenden Industrie* ('Association of the Plastics Producing Industry' – VKE) have also voluntarily agreed in 1986 to discontinue using polybrominated diphenyl ethers [108].

The voluntary regulations for textile and resilient floorings are more stringent and prohibit the use of organophosphorus and organochlorine flame retardants, flame retardants that contain antimony, arsenic or boron as well as brominated flame retardants and chlorinated paraffin. The regulations for flame retardants in textiles and resilient floorings are listed in Annex A11.

Recommendations that only apply to textile floorings

Content of pesticides

Because of the potential health risks under discussion, the permissible content should be defined when using permethrin as a moth and beetle proofing agent in wool carpets. The voluntary regulation of the G*emeinschaft umweltfreundlicher Teppichboden e.V.* (GUT) provides orientation here and stipulates a maximum concentration of 210 mg/kg permethrin for wool carpets [109]. The pesticides used as moth and beetle proofing should be approved and correspondingly declared in accordance with the Biocides Directive [160].

The voluntary regulations for textile floorings have already prohibited or restricted the use of specific biocides used in cultivating or manufacturing natural fibres. The content of organochlorine pesticides, organophosphorus pesticides, pyrethroids, chlorophenols (PCP, TeCP), herbicides and organotin compounds in the floorings should be tested. The voluntary regulations for pesticides in textile floorings are listed in Annex A11.

No information was available on the health risks from pesticide residues in natural fibre carpets. Further research is required here.

Content of benz(a)pyrene when using bitumen

In order to ensure that no tar oils are used, the content of benzo(a)pyrene (BaP) as an indicator substance for polycyclic aromatic hydrocarbons (PAH) should be determined when using bitumen products in textile floorings. According to Council Directive 67/548/ EEC [3], benzo(a)pyrene is classified as carcinogenic and therefore may not be actively used in indoor spaces in accordance with the DIBt Approval Guidelines: Indoor Construction Products. As bitumen contains BaP, in the DIBt Approval Guidelines the content is restricted to 5 mg BaP per kg bitumen. This value can be easily complied with for pure bitumens and ensures that no blended bitumens containing tar oils are used.

Recommendations that only apply to PVC floorings

Content of plasticisers

In PVC floorings, phthalates are mainly used as primary plasticizers, and medium chain chlorinated paraffins (from C_{14} to C_{17}) are used as secondary plasticisers. Because of their potential health and environmental risks, both groups of substances are currently under discussion.

The use of the plasticisers

- di(2-ethylhexyl)phthalate (DEHP)
- dibutyl phthalate (DBP)

in PVC floorings should be avoided if technically possible as these substances are classified as reprotoxic Category 2 and as toxic (T) according to Council Directive 67/548/EEC [3]. It is still being discussed whether to classify benzylbutyl phthalate (BBP) as reprotoxic.

Within the framework of the EU's Existing Substances Regulation [163], risk assessment studies for five phthalates (DEHP, DBP, BBP, DINP and DIDP) and for medium chain chlorinated paraffins have been or are being drawn up. The DEHP draft sees the need for measures to reduce the risk of consumers (particularly children) being directly or indirectly exposed via products (toys), children and infant food and indoor air [164]. The study on DBP also establishes a need for further information and research [165]. The studies on di-isononyl phthalate (DINP) and diisodecyl phthalate (DIDP) do not consider any additional measures for reducing risks to be necessary [166, 167].

According to the *Leitfaden zur Anwendung umweltverträglicher Stoffe* ('Guidance for the use of environmentally sound substances') from the *Umweltbundesamt* ('Federal Environmental

Agency' – UBA), alternatives for plasticisers are available on the market, e.g. long chain phthalates such as DINP and DIDP, adipates, citrates, phosphoric acid esters, alkylsulphonic acid esters and cyclohexanedicarboxylic esters. However, it is emphasised in the Guideline that the alternatives for DEHP and chlorinated paraffins should be sufficiently evaluated, as not all alternatives represent an improvement in terms of health or the environment [117].

Content of heavy metals from stabilisers

The use of lead or cadmium stabilisers in PVC floorings should be discontinued should this not already have been done so.

According to the EU Dangerous Substances Directive 67/548/ EEC [3], many cadmium compounds (oxides, chlorides, fluorides, sulphates and sulphides) are classified as toxic (T) or very toxic (T+), while individual compounds (cadmium chloride, cadmium fluoride) are classified as carcinogenic, mutagenic and reprotoxic Category 2. With the exception of lead compounds assessed separately, all lead compounds are classified as reprotoxic Category 2.

Discontinuing the use of lead and cadmium stabilisers forms part of the voluntary agreement 'Voluntary commitment of the PVC industry', which, under the name 'Vinyl 2010', has been adopted in March 2000 by the four principal associations of the PVC industry (ECVM, ECPI, ESPA und EuPC). This agreement of the PVC industry includes the following measurements [112]:

- Discontinuation of the use of cadmium stabilisers (by March 2001)
- Risk assessments of lead stabilisers (by 2004)
- Gradual phasing out of lead (by 2015)

According to the guidelines of the *Umweltbundesamt* ('Federal Environmental Agency' – UBA), various alternatives for lead or cadmium stabilisers are available on the market that have been safely used [117].

Recommendations that only apply to rubber floorings

The release of carcinogenic N-nitrosamines

In order to prevent the release of carcinogenic N-nitrosamines, no nitrosatable substances should be used in rubber floorings.

The German *Richtlinie für Gefahrstoffe 552* ('Technical Rules for Hazardous Substances' – TRGS 552) identifies 12 N-nitrosamines that are classified as carcinogenic by the *Gefahrstoffverordnung* ('Dangerous Substances Ordinance') [85]. These substances can form during the vulcanisation of rubber floorings in cases where vulcanisation accelerators are used that release nitrosable secondary amines, which in turn react with nitrous oxides to form N-nitrosamines. The forming of N-nitrosamines classified as carcinogenic can be avoided through the specific use of other chemical accelerators. According to TRGS 552, substitution substances for vulcanisation systems that do not release any secondary amines include thiophosphates (e.g. ZDBP), xanthogenates (e.g. ZIX), thiazoles (e.g. MBT), guanidines (e.g. DPG) or caprolactam disulphide [168].

The Austrian voluntary regulation for resilient floorings, the *Österreichisches Umweltzeichen* ('Austrian environment label') UZ 42, restricts the use of N-nitrosamines in rubber floorings [169].

Recommendations that only apply to floorings from wood-based panels

The use of used wood

The use of used wood should be declared or, alternatively, the parameters should be determined that are given by the German *Altholzverordnung* ('Waste Wood Ordinance') [97] or by the voluntary agreement of the European Wood Employers Association [170].

6.2.3.2 Overview of the recommendations for the second standard generation of floorings

The table below provides an overview of the recommendations that should be taken into account for the second generation of products.

Table 32: Overview of the recommendations for the second standard generation of floorings

Content/Release of dangerous substances	Recommendations
All floorings (textile, resilient, laminates, floorings from solid wood and wood-based panels)	
Content of CMR substances (Category 1 and 2) and of substances classified as "Toxic" (T) or "Very toxic" (T+)	Category 1 and 2 CMR substances and substances classified as T or T+ according to Council Directive 67/548/ EEC [3] should not be actively used.
Content of pentachlorophenol	The content of pentachlorophenol should be determined and declared in the form of levels and classes or as a value in the CE marking.
Release of formaldehyde	When using materials containing formaldehyde, the release of formaldehyde should be determined.
Release of VOC and SVOC	Determination of VOC and SVOC emissions after 3 days and 28 days, calculation of TVOC values and the sum of the SVOC (exact determination according to the AgBB's VOC/SVOC evaluation scheme, Section 6.1.1)
Release of substances with intensive odour	The odour emission should be determined.
Use of wastes	The use of wastes should be declared (with the exception of production waste such as blends).
In addition for textile and resilient floorings	
Content of azo dyes that release carcinogenic amines	The azo dyes that release carcinogenic amines (Council Directive 76/769/ EEC [10]) should not be used.
Content of flame retardants	Polybrominated diphenyl ethers should not be used. Prohibition or restriction of further flame retardants such as HBCD, TCPP should be scrutinised.

Content/Release of dangerous substances	Recommendations
For textile floorings only	
Content of pesticides in textile floorings made of natural fibres	When using permethrin as moth and beetle proofing, the content should be limited. The use of pesticides as moth and beetle proofing for wool carpets should be declared. There was no information on health risks from pesticide residues in natural fibre carpets. Further research is required here.
Content of benz(a)pyrene when using bitumen	When using bitumen in textile floorings, the content of BaP in bitumen should be determined.
For PVC floorings only	
Content of plasticisers	The use of the plasticisers DEHP, DBP and BBP should be avoided. The necessity of the use of medium chain chlorinated paraffins should be scrutinised.
Content of heavy metals from stabilisers	The use of stabilisers based on lead should be avoided. The use of stabilisers based on cadmium in floor coverings manufactured from polymers and copolymers of vinylchloride is already forbidden in the EU according to the Dangerous Substances Directive (76/769 EEC).
For rubber floorings only	
Release of N-nitrosamines	The use of nitrosatable substances should be avoided.
For floorings made of wood-based panels only	
The use of used wood	The use of used wood should be declared. The parameters given by the *Altholzverordnung* ('Waste Wood Ordinance') [97] should be determined.

6.3 Proposals for implementing the Essential Requirement No. 3 for floorings

Floorings form a construction product group that, as described in Section 6.2.1 (Composition of floorings), can consist of a variety of different materials and substances. Due to this diversity and the few test results available for release behaviour, it is not considered sensible to include this product group in the WFT product list (Without Further Testing).

For floorings that are manufactured according to harmonised European standards, the description of the composition should be as detailed as possible. Substances that are already prohibited nationally or are currently under discussion, such as CMR substances, azoic dyes that release carcinogenic amines and polybrominated diphenyl ethers, should be listed in the product standards. Substances that are already restricted or are under discussion, such as formaldehyde, PCP, VOC and SVOC, should be listed in the product standards and harmonised European testing methods for determining these substances should be indicated. The dangerous substances that can be released from the respective floorings, and which should therefore be specified in the product standards, are described in detail in the recommendations in Section 6.2.3 above.

Floorings for which there is insufficient knowledge about their release behaviour, and/or for which wastes are used in their manufacture, should be classified as requiring approval as here the scope of the testing can be specified by an expert committee for the specific product.

7 Summary and prospects

According to the Council of European Producers of Materials for Construction (CEPMC), more than 20,000 different products and materials are used in Europe for constructing buildings and infrastructure. This large group of construction products, which represents an essential economic factor within the European economic area, is mostly unknown in terms of the release of dangerous substances and their effect on human health and the environment. Retrospectively it can be established that preventive measures must be taken if harm is to be avoided, such as that caused by the known dangerous substances asbestos, formaldehyde and pentachlorophenol (PCP). However, already during the manufacturing stage of the construction products, more knowledge is needed on the products, their manufacturing processes, constituents and emission potential than previously existed.

The background to this research project is the fact that, due to a lack of boundary conditions in the first generation of European technical specifications, no health and environmental requirements for construction products are included, i.e. the Essential Requirement No. 3 "Hygiene, Health and the Environment" required by the Construction Products Directive (CPD) has not yet been implemented. It is envisaged that the implementation should occur in the second generation of the technical specifications. For this purpose an implementation concept was developed as part of the research project, which incorporates the current European developments. Recommendations have been devised for selected construction products, which should be taken into account in revising the technical specifications.

The range of construction products used has been restricted to products for which a mandate for the development of harmonised European standards has been issued by the European Commission to CEN, the European Committee for Standardisation.

The research project also provides a review of concepts for assessing the release of dangerous substances from construction products in soil, groundwater and indoor spaces. Based on the German protection level and the procedures established here, recommendations were devised for observing health and environmental requirements, which should be taken into account when revising the technical specifications.

This research project provides standardisation and approval committees with detailed information on the possibilities for transposing the Essential Requirement No. 3 into the technical specifications. For the exemplary construction products "concrete constituents" and "floorings", the study provides detailed information on the composition of products and the release behaviour of dangerous substances. Furthermore, recommendations have been drawn up that show where there is need for further action and more extensive studies to exclude risks to users of the works and their immediate environment. The description of more extensive concepts for assessing the effects of construction products on soil, ground water and indoor spaces and the description of various national and European testing methods for determining the leaching into soil and groundwater provide a comprehensive overview of the subject area. No detailed descriptions were made of the testing methods for emissions in indoor spaces as there are already European testing methods that only require harmonisation.

As an example for the release of dangerous substances in soil and groundwater, the mandated concrete constituents cement, aggregates, concrete additions and admixtures were selected as these mass-produced construction materials are used on a significantly large scale. With regard to the release of dangerous substance in indoor spaces, the

floorings mandate was chosen (textile, resilient, laminate, solid wood/wood-based panel floorings), as floorings can represent a substantial emission source as a result of their large surface area in indoor spaces.

In terms of this selection of construction products it should be noted that it was necessary to restrict their number due to the diversity of construction products. However, it should not be inferred that the selected construction products are particularly potentially hazardous to health or the environment. For all other mandated construction products, information on potentially releasable dangerous substances has been collected and systemised. These are described in Annex A4 in the form of a list of mandated construction products. Against this background, this report should also be understood as a reference work for selected construction products.

The following can be determined on the current state of the implementation of the Construction Products Directive (CPD):

Until now, the European Commission has issued around 30 mandates to the European Committee for Standardisation (CEN) and around 20 mandates to the European Organisation for Technical Approvals (EOTA) for the purpose of respectively developing harmonised European standards and technical approval guidelines for construction products. With the implementation of the Essential Requirement No. 3 required by the mandates, the lack of harmonised testing methods for determining the release of dangerous substances has proved to be a considerable problem. The work of the European Commission in drawing up mandates for harmonised testing methods for dangerous substances needs to be seen in this context.

In addition to drawing up mandates for harmonised testing methods for dangerous substances, the European Commission has developed a database for regulated substances that provides information on European and national regulations for dangerous substances.

In order to ensure that the Essential Requirement No. 3 is rigorously observed in the technical specifications, the research project proposes a tiered concept. For the purpose of assessing the potential release behaviour of dangerous substances, information is required on both the chemical composition as well as on the planned use of products in building structures.

The research project proposes dividing the vast majority of mandated construction products into three groups: WFT products (WFT – **W**ithout **F**urther **T**esting), standardised products for further testing and approved products for further testing.

With products that are suitable for inclusion in a WFT product list, detailed descriptions of the composition would ensure that no dangerous substances are released. This mostly concerns proven products for which there has been long-term experience in their use. For these products, no additional tests are necessary to fulfil the health and environmental requirements. The corresponding technical specifications should indicate that the respective product is a WFT product.

Construction products that are not suitable for inclusion in the list of WFT products should remain as standardised products if they fulfil specific prerequisites. This concerns products whose composition can be sufficiently described, which are composed of a limited number of substances, and where the dangerous substances to be determined can be specified. With these products, the dangerous substances that can be released must be tested. The levels, classes or declared values for the pollution parameters should be stated in the CE labelling. However, a complete evaluation of all constituents will for the most part be very difficult. Therefore, for standardised products, more extensive testing and evaluation concepts should also be drawn upon.

Products that are composed of diverse substances should be manufactured in accordance with a European technical approval. This generally concerns innovative products where there is no knowledge about the release behaviour. Individual tests should also normally be conducted when using wastes. The testing of emittable dangerous substances should be

based on existing specific knowledge about the chemical composition, thus combining a descriptive and a performance-related approach. Whether products are to be subject to standards or approvals should be determined by the European Commission at the mandate level.

This approach is illustrated in more specific terms by using selected concrete constituents and floorings as examples.

Thus the research project mainly presents a methodical approach for taking account of the Essential Requirement No.3 in technical specifications that, in principle, would be applied analogously to all construction products within the scope of the Construction Product Directive.

Synopsis

In terms of the release behaviour and/or content of dangerous substances from/in construction products, this research project was only able to consider the mandates issued to CEN for developing harmonised European product standards since it would have gone beyond the scope of this study to consider the mandates issued to EOTA as well.

By stating the materials used and the intended use of the construction products, the evaluation of the CEN mandates provides information on both the possible release of dangerous substances in the environmental media of soil, groundwater and indoor spaces and on the content of dangerous substances. However, it is generally only possible to make a concrete evaluation of the leaching and emission behaviour of dangerous substances from construction products by evaluating tests that have been carried out.

By using specific examples of selected construction products, this research project has made the first steps in systematically examining the health and environmental protection in European technical specifications. The study has shown that a detailed examination is required for all construction products. Here it needs to be born in mind that the individual construction products were selected as examples because there is a comparatively significant amount of knowledge on their release behaviour. It can generally be established that far too little significance has been attached to the release of dangerous substances. This also needs to be seen in view of the fact that many substances do not have any test procedures. At the same time, within the European Union there are many different national test procedures for individual substances. If the health and environmental requirements are to be adequately formulated, it is necessary that all Member States define harmonised European test methods.

There must be greater research on the often unknown release behaviour of dangerous substances from construction products and on the lack of test methods. Mandates for harmonised test methods are currently being drawn up. However, the test methods are unlikely to be adopted before 2008. Therefore, it is urgent that interim solutions are developed for the intermediate period.

Finally, it needs to be pointed out that only the phase of use of the construction products has been considered until now within the scope of the Construction Product Directive. For health and ecological reasons, however, the entire life of a product should be considered in the evaluation. In addition to the phase of use, the manufacture and disposal of the respective construction products should be equally considered as part of the entire life cycle.

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9 Annexes

Annex A1: **Recommendations of the Workshop 'Implementation of ER 3 in European Technical Specifications for Construction Products' (3 April 2003 in Berlin)**

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Annex A1: Recommendations of the Workshop 'Implementation of ER 3 in European Technical Specifications for Construction Products' (3 April 2003 in Berlin)

Recommendations concerning the implementation of the Essential Requirement 'Hygiene, health and the environment' (ER 3) in European technical specifications under the Construction Products Directive (CPD)

1. The implementation of the Essential requirement No 3 should be given high priority by the European Commission and the Member States.

2. The principles of European environmental policy are to be integrated into the implementation process.

3. The Member States improve the support for the work of the Commission "Ad hoc group on regulated substances in construction products" and for standardisation by adequate allocation of regulatory and technical expertise.

4. An European expert group with clear terms of reference on the basis of the existing "Ad hoc group on regulated substances for construction products' should be established. This group should attain the status of a permanent expert group of the Standing Committee on Construction. In this way it could be ensured that any new development based on scientific facts and the respective changes in the national and EU level requirements will be taken into account when updating the existing mandates and drafting new mandates. Another aim of the expert group should be to assist the technical specification writers in implementing ER 3 under the CPD.

5. CEN should establish the most effective way of helping construction product TCs to define scenarios relevant to the additional characteristics to be mandated to meet the requirements of ER3 and, with the help of environmental TCs, the minimum number of test methods required to meet the identified objectives. A horizontal technical committee consisting of experts of both construction and environmental fields in CEN should be considered in order to integrate environmental expertise efficiently into standardisation in the construction sector.

6. “Positive lists” should be drafted for materials, which can be used without concern and thus without compulsory testing. Materials, from which harmful emissions do not occur, would qualify for the positive list.

7. The “ad hoc group” should draft the first horizontal mandates, which enable the inclusion of health and environmental aspects into technical specifications for construction products. Priority release paths to be considered are indoor air, soil, groundwater and surface water. The mandates should cover all relevant regulatory requirements. These include requirements on the release of dangerous substances into the environment, requirements limiting the content of certain substances in products, as well as requirements limiting the synergistic effects of all harmful substances present in a product.

8. In order to achieve legal security for the manufacturers of construction products it is important that the Member States intensify their efforts to notify to the Commission all the regulations concerning construction products.

Annex A2: Mandates issued by the European Commission to CEN for elaborating harmonised construction product standards

M/100 Precast concrete products

M/101 Doors, windows and related products

M/102 Membranes

M/103 Thermal insulating products

M/104 Structural bearings

M/105 Chimneys, flues and specific products

M/106 Gypsum products

M/107 Geotextiles

M/108 Curtain walling

M/109 Fire alarm/detection, fixed firefighting, fire and smoke control and explosion suppression products

M/110 Sanitary appliances

M/111 Circulation fixtures

M/112 Structural timber products and ancillaries

M/113 Wood-based panels

M/114 Cement, building limes and other hydraulic binders

M/115 Reinforcing and prestressing steel (for concrete)

M/116 Masonry and related products

M/118 Waste water engineering products

M/119 Floorings

M/120 Structural metallic products and ancillaries

M/121 Internal and external wall and ceiling finishes

M/122 Roof coverings, rooflights, roof windows and ancillary products

M/124 Road construction products

M/125 Aggregates

M/126 Amendments to mandates M/100, M/101, M/102 and M/103

M/127 Construction adhesives

M/128 Products related to concrete, mortar and grout

M/129 Space heating appliances

M/130 Amendments to mandates M/100, M/101, M/102, M/103, M/105, M/106 and M/109.

M/131 Pipes, tanks and ancillaries not in contact with water intended for human consumption

M/132 Amendments to M/104, M/111 and M/119

M/135 Flat glass, profiled glass and glass block products

Annex A3: Mandates issued by the European Commission to EOTA for elaborating harmonised Technical Approval Guidelines (ETAGs) for construction products

ME/93-01	Structural sealant glazing systems
ME/93-02	Metal anchors for concrete (heavy duty uses)
ME/95-01	External thermal insulation composite systems (ETICS)
ME/95-02	Metal anchors for use in concrete for fixing lightweight systems
ME/95-03	Plastic anchors for use in concrete and masonry
ME/95-04	Metal injection anchors for use in masonry
ME/96-01	Mechanically fastened flexible waterproofing membranes
ME/96-02	Internal partition kits
ME/96-03	Liquid applied roof waterproofing kits
ME/96-04	Systems of shuttering hollow blocks or plates made of insulation materials
ME/96-05	Self supporting translucent roof kits
ME/96-06	Prefabricated stair kits
ME/97-01	Post tensioning kits for prestressing of structures
ME/97-02	Light composite woodbased beams and columns
ME/98-01	Timber frame & log prefabricated building kits
ME/98-02	Fire stopping, fire sealing and fire protective products – Part 1
ME/98-03	Fire stopping, fire sealing and fire protective products – Part 2

Annex A4: Construction products with a CEN mandate: Potentially releasable dangerous substances

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 100 Precast concrete products					
Products used for storage fixtures	Silos	Precast normal, lightweight, autoclaved aerated concrete		CMR substances Cat. I/II Radioactivity Heavy metals VOC Use of wastes	
Circulation fixtures	Boundary fences		EN 12839:2001		
Products used for telecommunication masts and towers	Junction boxes for telecommunications				
Products used for supplying electricity	Masts and posts				
Frames (including chimneys and shafts)	Linear structural elements Bridge deck elements	Precast normal concrete			
Products used for roofs	Roof elements	Precast normal, lightweight, autoclaved aerated concrete			
Products used for prefabricated systems for floors and galleries, stairs, ramps, raised access floors, balustrades and hand rails, including external works	Stairs				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 100 Precast concrete products					
Products used for floors, galleries and ceilings	Precast prestressed hollow core elements for floors Shuttering slabs lattice girder elements for floors Beam/block floor units and elements Floor slabs with webs	Precast normal, lightweight, autoclaved aerated concrete		CMR substances Cat. I/II Radioactivity Heavy metals VOC Use of wastes	
Products used for external walls (including cladding), internal walls and partitions	Loadbearing wall elements Cladding elements				
Products used for pile foundations	Foundation piles	Precast normal concrete			
Products used for foundations and retainings walls	Retaining wall elements	Precast normal, lightweight, autoclaved aerated concrete			
Products used for floor beds (including suspended ground floors), roads and other trafficked areas	Box culverts				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 101 Doors, windows and related products					
External and internal doors and windows, roof openings and roof lights (including fire doors and shutters)	Windows with or without incorporated shutters	Metal, wood, plastics, glass		Arsenic (wood) Benzene (adhesives, dyes, coatings) Benzo(a)pyrene (wood) Biocides (wood, plastics) Lead (stabilisers, plastic windows) Cadmium and its compounds (stabilisers, plastic windows) Chlorinated paraffins (plastic windows) Chromium (wood, metal) CMR substances Cat. I/II Formaldehyde Flame retardants (polybrominated diphenyl ether, plastic windows) Mercury (wood) PCB/PCT Pentachlorophenol Phenols Phthalates (plasticisers, PVC windows) Tar oils VOC Organotin compounds (plastic windows)	Nordic Ecolabelling [171]: Ecolabelling of windows Green Seal (USA) [172]: Windows
	Doors with or without incorporated shutters		EN 13241-1:2003		
	Gates				
	Building hardware	Metal, plastics		Cadmium and its compounds (plastics, coatings) Chromium (metal)	

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 102 Membranes					
Products used for floor beds	Damp proofing sheets	Plastics, bitumen, composites		Benzo(a)pyrene (use of cut back bitumen) Biocides (plastics, composites, bitumen, herbicides) Lead (stabilisers, PVC sheeting) Cadmium and its compounds (plastics) CMR substances Cat. I/II Phthalates (plasticisers, PVC sheeting)	
Products used for external walls, internal walls and partitions	Damp proof curses Water vapour control layers	Plastics, bitumen			
Products used for roofs	Roof underlays Water vapour control layers				
Products used for roof finishes	Roof sheeting				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 103 Thermal insulating products					
Products used for floor beds	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed), glass (foamed)	EN 13162:2001 EN 13163:2001 EN 13164:2001/ A1/2004 EN 13165:2001/ A1:2004 EN 13166:2001/ A1:2004 EN 13167:2001/ A1:2004 EN 13168:2001/ A1:2004 EN 13169:2001/ A1:2004 EN 13170:2001 EN 13171:2001/ A1:2004 prEN 14063-1 prEN 14316-1 prEN 14317-1	Benzo(a)pyrene (cut 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	Österreichisches Umweltzeichen UZ 43 [173]: *Wärmedämmstoffe aus fossilen Rohstoffen mit hydrophoben Eigenschaften* (’Thermal insulating materials from raw materials with hydrophobe properties’) Österreichisches Umweltzeichen UZ 44 [174]: *Wärmedämmstoffe aus nachwachsenden Rohstoffen* (’Thermal insulating materials from regrowing raw materials’) Österreichisches Umweltzeichen UZ 45 [175]: *Wärmedämmstoffe aus mineralischen Rohstoffen* (’Thermal insulating materials from mineral raw materials’) Natureplus, RL 0103 [176]: *Dämmstoffe aus Schafwolle* (’Insulation materials from sheep wool’) Environmental Choice (Kanada) [177]: Thermal insulation Greenguard (USA) [178]: Insulation
Products used for floor beds	Products intended to be formed in-situ	Organic fibres, inorganic fibres and particles, plastics (foamed)			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 103 Thermal insulating products					
Products used for foundations and retaining walls	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed), glass (foamed)	EN 13162:2001 EN 13163:2001 EN 13164:2001/ A1/2004 EN 13165:2001/ A1:2004 EN 13166:2001/ A1:2004 EN 13167:2001/ A1:2004 EN 13168:2001/ A1:2004 EN 13169:2001/ A1:2004 EN 13170:2001 EN 13171:2001/ A1:2004 prEN 14063-1 prEN 14316-1 prEN 14317-1	Benzo(a)pyrene (cut 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	Österreichisches Umweltzeichen UZ 43 [173]: *Wärmedämmstoffe aus fossilen Rohstoffen mit hydrophoben Eigenschaften* (’Thermal insulating materials from raw materials with hydrophobe properties’) Österreichisches Umweltzeichen UZ 44 [174]: *Wärmedämmstoffe aus nachwachsenden Rohstoffen* (’Thermal insulating materials from regrowing raw materials’) Österreichisches Umweltzeichen UZ 45 [175]: *Wärmedämmstoffe aus mineralischen Rohstoffen* (’Thermal insulating materials from mineral raw materials’) Natureplus, RL 0103 [176]: *Dämmstoffe aus Schafwolle* (’Insulation materials from sheep wool’) Environmental Choice (Kanada) [177]: Thermal insulation Greenguard (USA) [178]: Insulation
Products used for external walls, internal walls and partitions	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed), glass (foamed)			
Products used for external walls, internal walls and partitions	Products intended to be formed in-situ	Organic fibres, inorganic fibres and particles, plastics (foamed)			
Products used for floors, galleries and ceilings	Factory-made products	Inorganic fibres and particles, plastics (foamed), glass (foamed)			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 103 Thermal insulating products					
Products used for floors, galleries and ceilings	Products intended to be formed in-situ	Organic fibres, inorganic fibres and particles, plastics (foamed)	EN 13162:2001 EN 13163:2001 EN 13164:2001/ A1/2004 EN 13165:2001/ A1:2004 EN 13166:2001/ A1:2004 EN 13167:2001/ A1:2004 EN 13168:2001/ A1:2004 EN 13169:2001/ A1:2004 EN 13170:2001 EN 13171:2001/ A1:2004 prEN 14063-1 prEN 14316-1 prEN 14317-	Benzo(a)pyrene (cut 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	Österreichisches Umweltzeichen UZ 43 [173]: *Wärmedämmstoffe aus fossilen Rohstoffen mit hydrophoben Eigenschaften* (’Thermal insulating materials from raw materials with hydrophobe properties’) Österreichisches Umweltzeichen UZ 44 [174]: *Wärmedämmstoffe aus nachwachsenden Rohstoffen* (’Thermal insulating materials from regrowing raw materials’) Österreichisches Umweltzeichen UZ 45 [175]: *Wärmedämmstoffe aus mineralischen Rohstoffen* (’Thermal insulating materials from mineral raw materials’) Natureplus, RL 0103 [176]: *Dämmstoffe aus Schafwolle* (’Insulation materials from sheep wool’) Environmental Choice (Kanada) [177]: Thermal insulation Greenguard (USA) [178]: Insulation
Products used for roofs	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed), glass (foamed)			
Products used for roofs	Products intended to be formed in-situ	Organic fibres, inorganic fibres and particles, plastics (foamed)			
Products used for suspended ceilings	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed), glass (foamed)			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 103 Thermal insulating products					
Products used for external wall and partition finishes	Factory-made products	Inorganic fibres and particles, plastics (foamed)	EN 13162:2001 EN 13163:2001 EN 13164:2001/ A1/2004 EN 13165:2001/ A1:2004 EN 13166:2001/ A1:2004 EN 13167:2001/ A1:2004 EN 13168:2001/ A1:2004 EN 13169:2001/ A1:2004 EN 13170:2001 EN 13171:2001/ A1:2004 prEN 14063-1 prEN 14316-1 prEN 14317-	Benzo(a)pyrene (cut 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	Österreichisches Umweltzeichen UZ 43 [173]: *Wärmedämmstoffe aus fossilen Rohstoffen mit hydrophoben Eigenschaften* ('Thermal insulating materials from raw materials with hydrophobe properties') Österreichisches Umweltzeichen UZ 44 [174]: *Wärmedämmstoffe aus nachwachsenden Rohstoffen* ('Thermal insulating materials from regrowing raw materials') Österreichisches Umweltzeichen UZ 45 [175]: *Wärmedämmstoffe aus mineralischen Rohstoffen* ('Thermal insulating materials from mineral raw materials') Natureplus, RL 0103 [176]: *Dämmstoffe aus Schafwolle* ('Insulation materials from sheep wool') Environmental Choice (Kanada) [177]: Thermal insulation Greenguard (USA) [178]: Insulation
Products used for internal wall and partition finishes	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed)			
Products used for ceiling finishes	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed)			
Products used for supplying hot and cold water	Factory-made products	Inorganic fibres and particles, plastics (foamed)			
Products used for supplying hot and cold water	Products intended to be formed in-situ	Cement binders, organic fibres, inorganic fibres and particles, plastics (foamed)			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 103 Thermal insulating products					
Products used for supplying fuels, oil and other liquids	Factory-made products	Inorganic fibres and particles, plastics (foamed)	EN 13162:2001 EN 13163:2001 EN 13164:2001/ A1/2004 EN 13165:2001/ A1:2004 EN 13166:2001/ A1:2004 EN 13167:2001/ A1:2004 EN 13168:2001/ A1:2004 EN 13169:2001/ A1:2004 EN 13170:2001 EN 13171:2001/ A1:2004 prEN 14063-1 prEN 14316-1 prEN 14317-	Benzo(a)pyrene (cut 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	Österreichisches Umweltzeichen UZ 43 [173]: *Wärmedämmstoffe aus fossilen Rohstoffen mit hydrophoben Eigenschaften* (’Thermal insulating materials from raw materials with hydrophobe properties’) Österreichisches Umweltzeichen UZ 44 [174]: *Wärmedämmstoffe aus nachwachsenden Rohstoffen* (’Thermal insulating materials from regrowing raw materials’) Österreichisches Umweltzeichen UZ 45 [175]: *Wärmedämmstoffe aus mineralischen Rohstoffen* (’Thermal insulating materials from mineral raw materials’) Natureplus, RL 0103 [176]: *Dämmstoffe aus Schafwolle* (’Insulation materials from sheep wool’) Environmental Choice (Kanada) [177]: Thermal insulation Greenguard (USA) [178]: Insulation
Products used for supplying fuels, oil and other liquids	Products intended to be formed in-situ	Cement binders, inorganic fibres and particles, plastics (foamed)			
Products to be used for gases, pressure and vacuum systems	Factory-made products	Plastics (foamed)			
Products to be used for gases, pressure and vacuum systems	Products intended to be formed in-situ	Inorganic fibres and particles, plastics (foamed)			
Products used for space heating, cooling and air conditioning	Factory-made products	Organic fibres, inorganic fibres and particles, plastics (foamed), glass (foamed)			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 103 Thermal insulating products					
Products used for space heating, cooling and air conditioning	Products intended to be formed in-situ	Organic fibres, inorganic fibres and particles, plastics (foamed)	EN 13162:2001 EN 13163:2001 EN 13164:2001/ A1/2004 EN 13165:2001/ A1:2004 EN 13166:2001/ A1:2004 EN 13167:2001/ A1:2004 EN 13168:2001/ A1:2004 EN 13169:2001/ A1:2004 EN 13170:2001 EN 13171:2001/ A1:2004 prEN 14063-1 prEN 14316-1 prEN 14317-	Benzo(a)pyrene (cut 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	Österreichisches Umweltzeichen UZ 43 [173]: *Wärmedämmstoffe aus fossilen Rohstoffen mit hydrophoben Eigenschaften* (’Thermal insulating materials from raw materials with hydrophobe properties’) Österreichisches Umweltzeichen UZ 44 [174]: *Wärmedämmstoffe aus nachwachsenden Rohstoffen* (’Thermal insulating materials from regrowing raw materials’) Österreichisches Umweltzeichen UZ 45 [175]: *Wärmedämmstoffe aus mineralischen Rohstoffen* (’Thermal insulating materials from mineral raw materials’) Natureplus, RL 0103 [176]: *Dämmstoffe aus Schafwolle* (’Insulation materials from sheep wool’) Environmental Choice (Kanada) [177]: Thermal insulation Greenguard (USA) [178]: Insulation

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 104 Structural bearings					
Frames (including chimneys and shafts)	Elastomeric bearings, pot bearings, roller bearings, rocker bearings, spherical and cylindrical bearings, guide bearings and restraint bearings, sliding elements	Elastomer, steel, stainless steel, PTFE (polytetrafluorethylen), bronze, aluminium, cast iron, brass, POM	EN 1337-4:2004 EN 1337-6:2004 EN 1337-7:2004	Biocides Cadmium and its compounds Chromium PCB	

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 105 Chimneys					
Frames (including chimneys and shafts)	Prefabricated chimneys: storey height elements, flue liners: elements or blocks, multi-wall chimneys: elements or blocks, single wall chimney blocks	Clay / ceramic, concrete, metal, plastics, stone	EN 12446:2003 EN 13502:2002 EN 1457:1999/ A1:2002 EN 1856-1:2003 EN 1857:2003 EN 1858:2003 EN 1856 2:2004+F151	CMR substances Cat. I/II Heavy metals	
	Kits of free standing chimneys and attached chimneys				
	Chimney terminals				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 106 Gypsum products					
External walls, internal walls and partitions, internal wall and partition finishes	Gypsum plasterboards	Gypsum, metal, composites, plaster, gypsum compounds, gypsum+ reinforcement (organic, mineral or metallic)		Benzene (adhesives, components) Biocides (wood, cardboard containing fungicides) Biopersistent fibres (insulation materials) Cadmium and its compounds (plastics) CMR substances Cat. I/II Formaldehyde (wood, components, adhesives) Radioactivity (gypsum from phosphoric acid manufacture) Heavy metals (gypsum from phosphoric acid manufacture) VOC (adhesives, components)	Blauer Engel, RAL-UZ 60 [179]: *Recyclinggipsprodukte* ('Recycled Gypsum Products') Environmental Choice (Australien) [180]: Gypsum plasterboard Environmental Choice (Kanada) [181]: Gypsum Wallboard
	Gypsum blocks		EN 12859:2001 EN 12860:2001		
	Ancillary products for plasterboards				
	Gypsum plasters				
	Ancillary products for plastering				
Floors, galleries and ceilings, suspended ceilings, ceiling finishes	Gypsum plasterboards	Metal, plasterboards, plastering + organic fibres + inorganic fibres and particles, wood, plastics, plasterboard + plastics + foil + insulating materials, gypsum+			
	Gypsum ceiling elements				
	Ancillary products for plasterboards and gypsum ceiling elements		prEN 14195		
	Gypsum plasters				
	Ancillary products for plastering				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 107 Geotextiles				
Floor beds, foundations and retaining walls, disposal of solid waste, drainage and disposal of other liquids and gaseous waste	Products used as fluid or gas barriers	Organic fibres, plastics-metal, plastics/rubber, bitumen, metal, inorganic fibres and particles, composites	EN 13249:2000 EN 13250:2000 EN 13251:2000 EN 13252:2000 EN 13253:2000 EN 13254:2000 EN 13255:2000 EN 13256:2000 EN 13257:2000 EN 13265:2000	Biocides Cadmium and its compounds CMR substances Cat I/II Plasticisers (phthalates) Flame retardants (used in tunnels)
	Products used as protective layer			
	Products used for reinforcement			
	Products used for drainage and filtration			
	Products used as separating layer			
M 108 Curtain Walling				
External walls, internal walls and partitions	Curtain wall kits	Stone, precast concrete, glass reinforced concrete, glass reinforced gypsum, metal, timber, plastics, glass, insulating materials, organic fibres, glass (foamed), inorganic fibres and particles, plastics (foamed), bitumen		Arsenic (wood), Benzene (paint, adhesives, dyes) Biocides (wood, plastics), Benzo(a)pyrene (wood, bitumen) Biopersistent fibres (insulation materials), Cadmium and its compounds (plastics, dyes, coatings), Chromium (wood, metal), CMR substances Cat. I/II, Formaldehyde (wood), Copper (metal), Pentachlorophenol (wood), PCB/PCT, Phenol (wood), Mercury (wood) Radioactivity (concrete, stone), Tar oils (wood), VOC, Zinc (metal)
M 110 Sanitary appliances				
Sanitary appliances	Sanitary appliances (not including sanitary tapware nor waste outlet fittings)	Precast concrete components, ceramics, metals, plastics/rubber and resins, glass	EN 13310:2003 EN 997:2003 prEN 12764	Cadmium and its compounds (plastics) Formaldehyde (synthetic resin) Radioactivity (concrete) VOC (adhesives, plastics)

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 112 Structural timber products				
Floor beds, pile foundations, external walls, internal walls and partitions, floors, galleries, ceilings, roofs, frames	Solid structural timber products used in bridges, rail-tracks and buildings	Timber, glued laminated timber		Arsenic Benzene (adhesives, dyes, coatings) Benzo(a)pyrene Biocides Cadmium and its compounds (dyes) Chromium CMR substances Cat. I/II Flame retardants Mercury Organotin compounds (in water constructions) Pentachlorophenol Phenols Tar oils VOC (glues)
	Timber poles for overhead lines	Wood		Arsenic Benzene (adhesives) Benzo(a)pyrene Biocides Chromium CMR substances Cat. I/II Flame retardants Mercury Pentachlorophenol Phenols Tar oils
	Structural glued laminated products and other glued timber products	Wood-based panels Laminated veneer lumber Oriented strand board		Arsenic, Benzene (adhesives, dyes, coatings) Benzo(a)pyrene, Biocides, Cadmium and its compounds (dyes), Chromium, CMR substances Cat. I/II Flame retardants, Mercury, Organotin compounds (in water constructions), Pentachlorophenol, Phenols, Tar oils VOC (glues)
	Timber fasteners	Steel, cast iron, wood		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 113 Wood-based panels					
External walls, internal walls and partitions, floors, galleries, ceilings, frames, external and internal doors and windows, roof openings and roof lights, suspended ceilings, claddings, ceiling, floor and stair finishes	Wood-based panels unfaced, overlaid and veneered or coated - for structural internal use	Solid wood, chipped wood, wood veneers, wood fibers, impregnated paper, (melamine formaldehyde) metal, organic adhesives (resins), inorganic adhesives (cement), paints, coatings	EN 13986:2002	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) Pentachlorophenol (used wood) Phenols Heavy metals (used wood) Tar oils VOC	Blauer Engel, RAL-UZ 38 [182]: *Emissionsarme Produkte aus Holz- und Holzwerkstoffen* ('Low Emission Wood Products and Wood-Bases Products') Österreichisches Umweltzeichen UZ 07 [183]: *Holzwerkstoffe* ('Wood-based panels') Nordic Ecolabelling [184]: Panels for the building, decorating and furniture industry
	Wood-based panels unfaced, overlaid and veneered or coated - for **structural external uses**				
	Wood-based panels \ endash unfaced, overlaid and veneered or coated - for **non-structural internal use**				
	Wood-based panels \ endash unfaced, overlaid and veneered or coated - **for non-structural external use**				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 114 Cements, building limes and other hydraulic binders				
Preparation of concrete, mortar, grout and other mixes	Common cements	Portland cement clinker, granulated blastfurnace slag, natural pozzolana, fly ash, shale, limestone, silica fume, minor additional constituents, calcium sulphate, admixtures	EN 197-1:2000/ A1:2004	Chromate Heavy metals Use of wastes
	Special cements		EN 14216:2004	
	Masonry cement	Portland cement clinker, inorganic mineral materials, organic materials	EN 413-1:2004	
	Calcium aluminate cements	Calcium aluminate clinker, grinding aids		
	Building limes	Burnt limestone, burnt shell, burnt dolomitic limestone, hydraulic lime, pozzolanic or hydraulic materials, admixtures	EN 459-1:2001	
	Hydraulic base binders for road construction	Portland cement clinker, granulated blastfurnace slag, natural pozzolana, fly ash, shale limestone, lime, minor additional constituents, calcium sulphate, admixtures		
M 115 Reinforcing and prestressing steel for concrete				
Floor beds, foundations and retaining walls, pile foundations, external walls, internal walls and partitions, floors, galleries, ceilings, roofs, frames, floor and stair finishes, drainage and disposal of other liquids and gaseous waste, telecommunication masts and towers, storage fixtures	Reinforcing steel products	Non-alloyed or alloyed steel, stainless steel, zinc coated steel, epoxy coated steel		Cadmium and its compounds (plastics, coatings)
	Prestressing stell products	Galvanized steel, non-alloyed or alloyed steel		
	Tensioning ducts and sheaths	Plastics, steel		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 116 Masonry and related products					
Foundations, retaining walls, external walls, internal walls and partitions, cladding, ceiling finishes, drainage and disposal of other liquids and gaseous waste	Masonry units	Natural stone, aggregate concrete (dense and lightweight), autoclaved aerated concrete, calcium silicate, clay	EN 12859 EN 771-1:2003 EN 771-2:2003 EN 771-3:2003 EN 771-4:2003 EN 771-5:2003	Biopersistent fibres (insulation materials), formaldehyde, heavy metals, VOC, radioactivity	Österreichisches Umweltzeichen UZ 39 [185]: *Mauersteine, hydraulisch gebunden* (’Masonry Units, hydraulically bound’)
	Lintels				
	Factory-made masonry mortar	Mortar	EN 998-1:2003 EN 998:2:2003		
	Factory-made rendering/plastering mortar				
	Ancillary components	Metal, plastics	EN 845-1:2003 EN 845-2:2003 EN 845-3:2003	Cadmium and its compounds (plastics, coatings)	
	Bed joint reinforcement				
M 118 Waste water engineering products					
Drainage and disposal of other liquids and gaseous waste, sanitary and cleaning fixtures	Waste water engineering products inside buildings	Precast concrete components, fibre cement, metal (steel, cast iron), aluminium, copper, zinc, glass, plastics, glass fibre, vitrified clay, synthetic resin, composite materials, rubber	EN 12050-1:2000 EN 12050-2:2000 EN 12050-3:2000 EN 12050-4:2000 EN 13164:2001/ A1:2004	Cadmium and its compounds (plastics, coatings) Chromium (metal) CMR substances Cat. I/II Heavy metals Radioactivity (concrete)	Österreichisches Umweltzeichen UZ 41 [186]: *Kanalrohre aus Kunststoff* (’Plastic ducts’)
	Waste water engineering products outside buildings				

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 119 Floorings					
Floor beds, prefabricated systems floors and galleries, stairs, ramps, raised access floors, balustrades and hand rails, including external works, floor and stair finishes	Resilient and textile floorings for internal use		EN 14041:2004	Benzene (adhesives) Benzo(a)pyrene (asphalt) Biocides Cadmium and its compounds Chlorinated paraffins CMR substances Cat. I/II Formaldehyde (wood-based panels) Halogenated organic compounds Pentachlorophenol Phenol (wood-based panels) Radioactivity (natural stone, ceramic tiles) VOC/SVOC Phthalates (plasticisers, PVC) Organotin compounds Flame retardants Heavy metals Use of wastes	Natureplus, RL 1400 [190a]: *Textile Bodenbeläge* ('Textile floorings') Natureplus, RL 1201 [190b]: *Linoleum floorings* ('Linoleum floorings') Ökotex-Standard 100 [191]: *Textile Bodenbeläge* ('Textile floorings') Kork-Logo [132] : *Kork-Bodenbeläge* ('Cork floorings') Österreichisches Umweltzeichen [169, 192]: *Textile u. elastische Bodenbeläge* ('Textile floorings and resilient floorings') Nordic Ecolabelling [187b]: Textiles Environmental Choice (Australien) [193]: Woollen carpets Environmental Choice (Australien) [194]: Textile floorings
	Resilient and textile floorings for external uses			Benzene Biocides CMR substances Cat. I/II Heavy metals	
	Screed	Cement, calcium sulphate, caustic magnesium, magnesium chloride, bitumen, bitumen emulsion, synthetic resin, aggregates, admixtures, additions	EN 13813:2002 EN 14016-1:2004	Benzo(a)pyrene Formaldehyde Heavy metals VOC	

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 119 Floorings					
Floor beds, prefabricated systems floors and galleries, stairs, ramps, raised access floors, balustrades and hand rails, including external works, floor and stair finishes	Rigid floorings products for external use and road finishes	Stone, concrete, clay, glass, ceramic, fibre- reinforced concrete, cast stone, metal, wood-based panel, plastic, rubber, organic fibres, asphalt concrete, natural asphalt, cork, plastics, inorganic fibres and particles, linoleum	EN 13748-2:2004	Arsenic (wood) Benzene (adhesives, coatings, synthetic resin) Benzo(a)pyrene (wood) CMR substances Cat. I/II Chromium (wood) Mercury (wood) Phenols Heavy metals	
	Rigid floorings for internal uses including enclosed public transport premises		EN 13748-1:2004 EN 14411:2003	Benzene (adhesives) Benzo(a)pyrene (asphalt) Biocides Cadmium and its compounds Chlorinated paraffins CMR substances Cat. I/II Formaldehyde (wood-based panels) Halogenated organic compounds Pentachlorophenol Phenol (wood-based panels) Radioactivity (natural stone, ceramic tiles) VOC/SVOC Phthalates (plasticisers, PVC) Organotin compounds Flame retardants Heavy metals Use of wastes	Natureplus, RL 0209 [186b]: *Bodenbeläge aus Holz und Holzwerkstoffen* (’Floorings made of wood and of wood-based panels’) Nordic Ecolabelling [187a]: Rigid, textile, resilient floorings EU-Blume [188]: Rigid floorings Greenguard (USA) [189]: Hard surface flooring

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 120 Structural metallic products and ancillaries					
Floor beds, retaining walls, pile foundations, external walls, internal walls and partitions, floors, galleries, ceilings, roofs, frames, floor and stair finishes, electricity supply, lighting, telecommunication masts and towers, storage fixtures	Structural metallic sections	Steel, aluminium alloys, metallic (Zn, Al, Zn-Al) coated steel, organic coated steel, stainless steel, steel alloys, cast steel, cast iron		Cadmium and its compounds (coatings) Benzene (coatings) Chromium (metal)	
	Structural metallic construction members				
	Welding materials	Aluminium alloys, steel alloys, stainless steel, steel			
	Structural connectors	Aluminium alloys, metallic coated steel, coated steel, stainless steel, steel	EN 485-2:2004		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 121 Internal and external wall and ceiling finishes					
External walls, internal walls and partitions, suspended ceilings, external wall finishes, internal wall and partition finishes, ceiling finishes	**Internal finishes:**				
	Wall coverings in roll form, ceiling linings	Organic fibres, paper, inorganic fibres, rubber, plastics, composites, cork	EN13830:2003	Arsenic (wood) Benzene (adhesives) Benzo(a)pyrene (wood) Biocides Biopersistent fibres Lead carbonate, lead sulphate (dyes) Cadmium and its compounds (plastics, coatings) Chromium (wood) CMR substances Cat. I/II Decabromodiphenylether Formaldehyde PCB/PCT Pentachlorophenol (wood, paper, organic fibres) Phthalates (plasticisers, PVC wallpaper) Mercury (wood) Radioactivity (concrete, ceramic) Heavy metals (wallpapers) Tar oils (wood) VOC Organotin compounds (PVC wallpapers)	Blauer Engel, RAL-UZ 35a [195]: T*apeten und Rauhfaser, überwiegend aus Papierrecycling* ('Wallpapers and Woodchip Wall Coverings primerily made of Recycled Paper') Blauer Engel, RAL-UZ 35b [196]: *Tapeten mit anderem Werkstoff* ('Wallpapers containing another material') RAL-GZ 479 [197]: *Tapeten (außer Glasfasern)* ('Wallpapers (except for glass fibre') Nordic Ecolabelling [198]: Wall coverings
	Wall and ceiling tiles	Natural stone, concrete block, concrete, clay, ceramic, metal, timber, plastics (including, foamed), bitumen, surface treated mineral wool, wood wool, organic fibres, inorganic fibres, fibre reinforced calcium silicate, fibre cement, slates			Greenguard (USA) [199]: Wallcoverings and Ceiling systems

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 121 Internal and external wall and ceiling finishes				
External walls, internal walls and partitions, suspended ceilings, external wall finishes, internal wall and partition finishes, ceiling finishes	**Internal finishes:**			
	Wall and ceiling panels	Metal, reinforced concrete, fibre cement, timber, plastics, cork, inorganic-bonded boards, composites		Arsenic (wood) Benzene (adhesives) Benzo(a)pyrene (wood) Biocides Biopersistent fibres Lead carbonate, lead sulphate (dyes) Cadmium and its compounds (plastics, coatings) Chromium (wood) CMR substances Cat. I/II Decabromodiphenylether Formaldehyde PCB/PCT Pentachlorophenol (wood, paper, organic fibres) Phthalates (plasticisers, PVC wallpaper) Mercury (wood) Radioactivity (concrete, ceramic) Heavy metals (wallpapers) Tar oils (wood) VOC Organotin compounds (PVC wallpapers)
	External wall finishes	Timber, metal, plastics, composites, fibre cement, wood based materials		
	Suspended ceilings (kits)	See above	EN 13964:2004	
	Ancillary products for internal finishes in walls and ceilings	Metal, timber, plastics		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 121 Internal and external wall and ceiling finishes				
External walls, internal walls and partitions, suspended ceilings, external wall finishes, internal wall and partition finishes, ceiling finishes	**External finishes:**			
	Wall and ceiling tiles, wall cladding slabs, wall shingles, external wall finishes	Organic fibres, paper, inorganic fibres, rubber, plastics, composites, cork, natural stone, concrete block, concrete, clay, ceramic, metal, timber, plastics, (including, foamed), bitumen, surface treated mineral wool, wood wool, organic fibres, inorganic fibres, fibre reinforced calcium silicate, fibre cement, slates		Compounds (plastics, coatings) Chromium (wood) CMR substances Cat. I/II Decabromodiphenylether PCB/PCT Pentachlorophenol (wood, paper, organic fibres) Phenols (wood) Mercury (wood) Radioactivity (concrete, ceramic) Tar oils (wood)
	Wall and ceiling panels			
	Suspended ceilings (kits)			
	Ancillary products for external finishes in walls and ceilings	Metal, timber, plastics		Cadmium and its compounds (plastics, coatings) Chromium (metal)

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 122 Roof coverings, rooflights, roof windows and ancillary products				
Roofs, external and internal doors and windows, roof openings and rooflights, roof finishes	Roof coverings: Flat and profiled metal sheets, roofing tiles, roofing slates, roofing stones, roofing shingles, factory-bonded composite or sandwich panels (with / without insulation)	Plastics (e.g. GRP, PVC, PC, PMMA), metal, wood, concrete, fibre cement, glass, bituminous composites, organic fibres, inorganic fibres, stone (natural and manufactured), slate, concrete, fibre cement, clay	EN 12326-1:2004	Arsenic (wood) Benzo(a)pyrene (wood) Biocides (e.g. herbicides) Biopersistent fibres Lead (lead roof, lead stabilisers in PVC sheeting) Cadmium and its compounds (plastics, coatings) Chromium (wood) Copper (copper sheet) Mercury (wood) Phenols (wood) Phthalates (plasticisers, PVC sheeting) Zinc (tin-coated sheet)
	Roof coverings: Bituminous roof sheetings	Bitumen		Benzo(a)pyrene (cut back bitumen)
	Roof coverings: Roof pavings	Stone (natural and manufactured), slate, concrete, fibre cement, clay, metal, glass, wood, plastics, bitumen/ composites		Arsenic (wood) Asbestos (fibre cement) Benzo(a)pyrene (wood) Biocides Cadmium and its compounds (plastics, coatings) Chromium (wood) Mercury (wood) Phenols (wood) Plasticisers (phthalates, PVC windows)

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances
M 122 Roof coverings, rooflights, roof windows and ancillary products				
Roofs, external and internal doors and windows, roof openings and rooflights, roof finishes	Rooflights and roof windows	Metal, wood, plastics, rubber, glass, concrete, clay, fixing, jointing		Arsenic (wood) Benzene (adhesives) Biocides Cadmium and its compounds (plastics, coatings) CMR substances Cat. I/II Chromium (wood, metal) Formaldehyde PCB/PCT Pentachlorophenol (wood) Mercury (wood) VOC
	Ancillary products		prEN 12951	

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 125 Aggregates					
Floor beds, foundations and retaining walls, pile foundations, external walls, internal walls and partitions, floors, galleries and ceilings, roofs, frames, disposal of solid waste, drainage and disposal of other liquids and gaseous waste, gas supply systems, pressure and vacuum systems, electricity supply, telecommunication masts and towers, storage fixtures	Aggregates for concrete, mortar and grout	Natural: stone (round, crushed, ground), sand, gravel, lava and tuff Manufactured or by-products of industrial processes; e.g. ashes, clays, slags, vermiculite, perlite, brightening materials, incinerator residues Recycled: e.g. concrete, masonry, asphalt	EN 12620:2002 EN 13055-1:2002 EN 13139:2002	Natural: radioactivity heavy metals Manufactured or by-products of industrial processes or recycled aggregates: CMR substances Cat. I/II Cyanides Fluorides Naphthalene Phenols Polyaromatic hydrocarbons Heavy metals VOC/SVOC Use of wastes	Gütegemeinschaft Metallhüttenschlacken [200]: *Metallhüttenschlacken* ('Non-ferrous slag') Gütegemeinschaft Eisenhüttenschlacken [201]: *Eisenhüttenschlacken* ('Ferrous slag')
	Aggregates for bituminous mixtures and surface treatments		EN 13043:2002 EN 13055-2:2004		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 125 Aggregates					
Floor beds, foundations and retaining walls, pile foundations, external walls, internal walls and partitions, floors, galleries and ceilings, roofs, frames, disposal of solid waste, drainage and disposal of other liquids and gaseous waste, gas supply systems, pressure and vacuum systems, electricity supply, telecommunication masts and towers, storage fixtures	Aggregates for unbound and hydraulically bound mixtures	Natural: stone (round, crushed, ground), sand, gravel, lava and tuff Manufactured or by-products of industrial processes: e.g. ashes, clays, slags, vermiculite, perlite, brightening materials, incinerator residues Recycled: e.g. concrete, masonry, asphalt	EN 13242:2002	Natural: radioactivity heavy metals Manufactured or by-products of industrial processes or recycled aggregates : CMR substances Cat. I/II Cyanides Fluorides Naphthalene Phenols Polyaromatic hydrocarbons Heavy metals VOC/SVOC Use of wastes	Gütegemeinschaft Metallhüttenschlacken [200]: *Metallhüttenschlacken* ('Non-ferrous slag') Gütegemeinschaft Eisenhüttenschlacken [201]: *Eisenhüttenschlacken* ('Ferrous slag')
	Armourstones		EN 13383-1:2002		
	Railway ballast		EN 13450:2002		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 125 Aggregates					
Floor beds, foundations and retaining walls, pile foundations, external walls, internal walls and partitions, floors, galleries and ceilings, roofs, frames, disposal of solid waste, drainage and disposal of other liquids and gaseous waste, gas supply systems, pressure and vacuum systems, electricity supply, telecommunication masts and towers, storage fixtures	Fillers for bituminous mixtures and surface treatments Fillers for concrete, mortar and grout	Natural: stone (round, crushed, ground), sand, gravel, lava and tuff Manufactured or by-products of industrial processes: e.g. ashes, clays, slags, vermiculite, perlite, brightening materials, incinerator residues Recycled: e.g. concrete, masonry, asphalt		Manufactured or by-products of industrial processes or recycled aggregates : CMR substances Cat. I/II Cyanides Fluorides Naphthalene Phenols Polyaromatic hydrocarbons Heavy metals VOC/SVOC	
M 127 Construction adhesives					
Floor beds, external walls, internal walls, partitions, floors, galleries, ceilings, roofs, frames, external and internal doors and windows, roof openings and roof lights, external wall finishes, internal wall and partition finishes, floors and stair finishes, ceiling finishes, roof finishes	Construction adhesives	Organic and inorganic adhesives, e.g. epoxy resins, polyurethane resins, acrylic resins, aminoplastic resins, phenolic resins	EN 12004: 2001/ A1:2002	Biocides CMR substances Cat. I/II Ethylenglycole (tile adhesive) Formaldehyde Phenol VOC/SVOC	GEV Emicode [202]: Ahesives Environmental Choice (Australien) [203]: Adhesives Environmental Choice (Kanada) [204]: Adhesives Green Seal GS-36 (USA) [205]: Commercial Adhesives
	Adhesives for tiles	Organic and inorganic adhesives, e.g. hydraulic binders, mineral binders, dispersion polymers, reaction resins	EN 12860		

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 128 Products related to concrete, mortar and grout					
Floor beds, foundations and retaining walls, pile foundations, external walls, internal walls and partitions, floors, galleries and ceilings, roofs, frames, disposal of solid waste, drainage and disposal of other liquids and gaseous waste, gas supply systems, pressure and vacuum systems, electricity supply, telecommunication masts and towers, storage fixtures	Admixtures for concrete, mortar and grout	Chemicals		CMR substances Cat. I/II Formaldehyde VOC/SVOC	FSHBZ-Gütesiegel (Schweiz) [206]: *Beton- und Mörtelzusatzmittel* (’Concrete and mortar admixtures’)
	Admixtures for concrete, mortar and grout	Ground stone, silica fume, fly ash, ground granulated/ vitrified/ pelletised blastfurnace slag, natural pozzolana (e.g. trass), industrial pozzolana (e.g. metakoalin), chemicals / powders	EN 934-2:2001 EN 934-3:2003 EN 934-4	CMR substances Cat. I/II Cyanides Heavy metals Radioactivity	
	Fibres for concrete, mortar and grout	Inorganic / organic fibres: e.g.: plasics, glass, steel, carbon, cellulose, asbestos-substitute fibres		Biopersistent fibres	
	Surface protection systems and repair products for concrete	Chemicals, cement, aggregates, admixtures, additions, resins, polymers	EN 1504-4:2004	CMR substances Cat. I/II Formaldehyde Heavy metals VOC/SVOC	
M 129 Space heating appliances					
Waterheaters, supply of hot and cold water, space heating, cooling and air-conditioning	Space heating appliances without internal energy source	Metals (e.g. steel, aluminium, copper, cast-iron), plastics		Asbestos Ceramic fibres Biopersistent fibres Radioactivity	
	Space heating appliances burning solid and liquid fuels	E.g. metals, glass, natural stones, ceramics, thermal insulation, mortar, bricks, vermiculite, masonry, plastics, wood			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 131 Pipes tanks and ancillaries not in contact with water intended for human consumption					
Drainage and disposal of other liquids and gaseous waste, supply of fuels, oil and other liquids, supply of gases, pressure and vacuum systems, telecommunication masts and towers, fire detection and alarm, sanitary and cleaning fixtures, strorage fixtures	Piping kits	Cementitious materials : e.g. reinforced/fibred/ unreinforced/pre-stressed concrete, epoxide, fibre cement Metallic materials: e.g. steel, aluminium, copper,alloys, cast/ductile/grey/malleable cast iron Organic materials: e.g. plastics, polymers, elastomers, PVC, PE Glassy materials: e.g. glass, vitrified clay Composite: e.g. glass fibre reinforced polyester, carbon fibre reinforced epoxy resins		Benzene Cadmium and its compounds (plastics, coatings) Formaldehyde Heavy metals (cementitious materials) PCB Radioactivity (cementitious materials) VOC	
	Pipes		EN 588-2:2001		Österreichisches Umweltzeichen UZ 41 [186]: Kanalrohre aus Kunststoff (’Plastic ducts’)
	Tanks, leakage alarm systems and overfill prevention devices				
	Protective conduit				
	Fittings, adhesives, joints, joint sealings and gaskets	Metals, rubber, plastics, chemical compounds	EN 681-1:1996/ A2:2002 EN 681-2:2000 A1:2002 EN 681-3:2000 A1:2002 EN 681-4:2000 A1:2002 EN 682:2002		
	Duct supports	Plastics, metals, precast concrete			
	Valves and taps	Metals, rubber, plastics, compounds, cast iron			
	Safety ancillaries for gas piping kits/systems	Steel, cast iron, aluminium alloys, plastics			

Intended use	Family and/or subfamilies	Materials used	hEN 1)	Potential release of dangerous substances	Voluntary regulations 2)
M 135 Flat glass, profiled glass and glass block products					
External walls, internal walls and partitions, floors, galleries and ceilings, frames, external and internal doors, windows, roof openings and rooflights, suspended ceilings, external wall finishes, internal wall and partition finishes, ceiling finishes, roof finishes, transport lifts, hoists, escalators, conveyors	Flat or curved glass panels	Glass (can incorporate: organic materials, metal, silicate materials, silicone materials)	prEN 1096-4 prEN 12150-2 prEN 12337-2 prEN 13024-2 prEN 14178-2 prEN 1748-1-2 prEN 1748-2-2 prEN 1863-2 prEN 572-9	Heavy metals	
	Channel shaped glass	Glass			
	Insulating glass units				
	Glass blocks	Glass (can incorporate: metal)			
	Glass block wall panels				

1) Harmonised European Standards (hEN) published in the Official Journal of the European Communities or currently being formerly voted on.
(Published at www.cenorm.be/sectors/construction.htm). As of June 2004

2) As of July 2004. The list of voluntary regulations does not claim to be exhaustive.

Annex A5: Insignificance thresholds ("no effect levels") given by the DIBt Guideline Soil/Groundwater [20]

		Unit	Trivial threshold value
Inorganic Parameters	Antimony (Sb)	µg/l	10
	Arsenic (As)	µg/l	10
	Lead (Pb)	µg/l	25
	Cadmium (Cd)Cadmium (Cd)	µg/l	5
	Chromium, total (Cr)	µg/l	50
	Chromate (Cr)	µg/l	8
	Cobalt (Co)	µg/l	50
	Copper (Cu)	µg/l	50
	Molybdenum (Mo)	µg/l	50
	Nickel (Ni)	µg/l	50
	Mercury (Hg)	µg/l	1
	Selenium (Se)	µg/l	10
	Zinc (Zn)	µg/l	500
	Tin (Sn)	µg/l	40
	Cyanide, total (CN^-)	µg/l	50
	Cyanide, easily emitted (CN^-)	µg/l	10
	Fluoride (F^-)	µg/l	750
Organic Parameters	PAH, total [1)] – Naphthalene	µg/l	0.2 2
	VHH, total [2)]	µg/l	10
	Aldrin	µg/l	0.1
	9.1.1.1.1.1.1.1 DDTDDT	µg/l	0.1
	PCB, total [3)]	µg/l	0.05
	Petroleum hydrocarbons [4)]	µg/l	200
	BTEX [5)] - Benzene as single substance	µg/l	20 1
	Phenol	µg/l	20

1) PAH, total: Sum of the polycyclic aromatic hydrocarbons without naphthalene and methyl naphthalene, normally determined by adding together 15 single substances according to the list of the US Environmental Protection Agency (EPA) without naphthalene; if applicable, inclusion of other relevant PAHs (e.g. quinolines)
2) VHH, total: Volatile halogenated hydrocarbons, i.e. sum of the halogenated C_1- and C_2- hydrocarbons
3) PCB, total: Sum of the polychlorinated biphenyls; normally determined by using the 6 congeneres according to Ballschmiter in accordance with *AltölV* (DIN 51527) multiplied by 5; if applicable, for example in the case of a known substance spectrum, simple summation of all relevant individual substances (DIN 38407-3-2 and –3-3, respectively)
4) n-alkene (C10 ... C39), isoalkene, cycloalkene and aromatic hydrocarbons
5) BTEX aromatic substances, total: volatile hydrocarbons (benzene, toluene, xylenes, ethyl benzene, styrene, cumene)

Annex A6:Z2 classification values from *LAGA-Mitteilung 20* (LAGA Rules "Requirements for recycling mineral wastes") [27]

Parameter	Unit	Soil		Building rubble	HMV slag	Foundry sand	Slag from iron, steel and casting foundries	Coarse/furnace ash from coal-fired power stations (6	Fly ash from coal-fired power stations (7
Solid materials		Z O	Z 2	Z 2	Z 2	Z 2	Z 2	Z 2	Z 2
pH value (1		5.5 – 8	-						
EOX	mg/kg	1	15	10		3			
Hydrocarbons	mg/kg	100	1,000	1,000 (3					
MOH (H 18)						150			
Sum of BTEX	mg/kg	< 1	5						
Sum of VHH	mg/kg	< 1	5						
PAH (EPA)	mg/kg	1	20	75 (100) (4		20			
PCB (congeneres to DIN 51527)	mg/kg	0,02	1	1					
Arsenic	mg/kg	20	150						
Lead	mg/kg	100	1,000			100 (5			
Cadmium	mg/kg	0,6	10			5 (5			
Chromium (total)	mg/kg	50	600			600 (5			
Copper	mg/kg	40	600			300 (5			
Nickel	mg/kg	40	600			300 (5			
Mercury	mg/kg	0,3	10						
Thallium	mg/kg	0,5	10						
Zinc	mg/kg	120	1,500			500 (5			
Chromium (total)	mg/kg	1	100						
Leachate									
pH value (1		6.5 – 9	5.5 – 12	7.0 – 12.5	7 – 13	5.5 – 12	5 – 12	10 – 12	8 – 13

Parameter	Unit	Soil		Building rubble	HMV slag	Foundry sand	Slag from iron, steel and casting foundries	Coarse/furnace ash from coal-fired power stations (6	Fly ash from coal-fired power stations (7
Electric conductivity	µS/cm	500	1,500	3,000	6,000	1,000	1,000	1,000	5,000
Chloride	mg/l	10	30	150	250			50	50
Sulphate	mg/l	50	150	600	600			200	1,000
Fluoride	µg/l					1,000			
Cyanide (total)	µg/l	< 10	100 (2						
Cyanide, volatile	µg/l				0,02				
Phenol index	µg/l	< 10	100	100		100			
DOC	µg/l					20,000			
Ammonia nitrogen	µg/l					1.000			
Arsenic	µg/l	10	60	50		60		100	100
Lead	µg/l	20	200	100	50	200			
Cadmium	µg/l	2	10	5	5	10			10
Chromium (total)	µg/l	15	150	100	200	150	20		350
Copper	µg/l	50	300	200	300	300			
Nickel	µg/l	40	200	100	40	150	20		
Mercury	µg/l	0,2	2	2	1			2	
Thallium	µg/l	< 1	5						
Zinc	µg/l	100	600	400	300	600			

(1 Lower pH values do not in themselves represent an exclusion criterion. The cause shall be investigated if values are exceeded
(2 Reuse for Z 2 > 100 µg/l is permissible if Z 2 cyanide (easily emissible) < 50 µg/l
(3 Exceeded values that are attributable to asphalt constituents do not represent an exclusion criterion
(4 In individual cases it is possible to deviate to the extent of the value given in brackets.
(5 Not an exclusion criterion in itself. The cause shall be investigated if values are exceeded
(6 The Z 2 classification values are lower with bottom ash. There are no classification values for melting chamber granulates.
(7 Values apply for fly ash from pulverised coal combustion plants. There is no substantial difference between fly ash from fluidised-bed furnaces and from slag-tap furnaces

Annex A7: Content and emission values for category 1 construction products (Annex 2 of the Dutch Building Material Decree) [25]

APPENDIX 2

BELONGING TO SECTIONS 1, SUB-SECTIONS 1, J, K AND L, 7, 9 AND 22 OF THE BUILDING MATERIALS (SOIL AND SURFACE WATERS PROTECTION) DECREE

Composition and immission standards for building materials, not being clean earth

Substance	CAS number	Immission standards (mg/m^2 per 100 years)	Composition values for other building materials than earth (mg/kg dry matter)	Composition values for earth assuming 25% clay (grain size < 2 ìm) and 10% humus* (mg/kg dry matter)
INORGANIC COMPOUNDS				
1. Metals				
antimony (Sb)	[7440-36-0]	39	-	-
arsenic (As)	[7440-38-2]	435	-	55
barium (Ba)	[7440-39-3]	6300	-	625
cadmium (Cd)	[7440-43-9]	12	-	12
chromium (Cr)	[7440-47-3]	1500	-	380
cobalt (Co)	[7440-48-2]	300	-	240
copper (Cu)	[7440-50-8]	540	-	190
mercury (Hg)	[7439-97-6]	4.5	-	10
lead (Pb)	[7439-92-1]	1275	-	530
molybdenum (Mo)	[7439-98-7]	150	-	200
nickel (Ni)	[7440-02-0]	525	-	210
selenium (Se)	[7782-49-2]	15	-	-
tin (Sn)	[7440-31-5]	300	-	-
vanadium (V)	[7440-62-2]	2400	-	-
zinc (Zn)	[7440-66-5]	2100	-	720
2. Other inorganic compounds				
bromide	not applicable	300[1]	-	-
chloride	not applicable	30000[2]	-	-
cyanide (free)[3]	not applicable	15	-	20
cyanide (complex) (pH 5)[3]	not applicable	75	-	50
cyanide (complex) (pH<5)[3]	not applicable	75	-	650
fluoride	not applicable	14000[4]	-	-
thiocyanates (sum)	not applicable	-	-	20
sulphate	not applicable	45000[5]	-	-
ORGANIC COMPOUNDS				
3. Aromatic compounds				
benzene	[71-43-2]	-	1.25	1
ethylbenzene	[100-41-4]	-	1.25	1.25
toluene	[108-88-3]	-	1.25	1.25
xylenes (sum)[6]	[95-47-6], [108-38-3], [106-42-3]	-	1.25	1.25

styrene (Vinylbenzene)	[100-42-5]	-	-	100
phenol	[108-95-2]	-	1.25	1.25
cresols (sum)[7]	[108-39-4], [95-48-7], [106-44-5]	-	-	5
o-dihydroxybenzene (Catechol)	[120-80-9]	-	-	20
m-dihydroxybenzene (Resorcinol)	[108-46-3]	-	-	10
p-dihydroxybenzene (Hydrochinon)	[123-31-9]	-	-	10
4. Polycyclic aromatic hydrocarbons (PAHs)[8]				
naphthalene	[91-20-3]	-	5	5
phenanthrene	[85-01-8]	-	20	20
anthracene	[120-12-7]	-	10	10
fluoranthene	[206-44-0]	-	35	35
chrysene	[56-55-3]	-	10	10
benzo(a)anthracene	[218-01-9]	-	50	40
benzo(a)pyrene	[207-08-9]	-	10	10
benzo(k)fluoranthene	[50-32-8]	-	50	40
indeno (1,2,3cd) pyrene	[191-42-2]	-	50	40
benzo(ghi)perylene	[193-39-5]	-	50	40
PAHs sum (sum of 10)[9]	[91-20-3], [85-01-8], [120-12-7], [206-44-0], [56-55-3], [218-01-9], [207-08-9], [50-32-8], [191-42-2], [193-39-5]	-	75	40
5. Chlorinated hydrocarbons				
a. (volatile) chlorohydrocarbons				
monochloro ethene (Vinylchloride)	[75-01-4]	-	-	0.1
dichloromethane	[75-09-2]	-	-	4
1,2-dichloro ethane	[107-06-2]	-	-	4
trichloromethane	[67-66-3]	-	-	3
trichloro ethene (Tri)	[79-01-6]	-	-	4
tetrachloromethane (Tetra)	[56-23-5]	-	-	1
tetrachloro ethene (Per)	[127-18-4]	-	-	4
chloronaphthalene (sum á, â)	[90-13-1], [91-58-7]	-	-	10
b. chlorobenzenes				
chlorobenzenes (sum)[10]	[108-90-7],[95-50-1], [541-73-1], [106-46-7], [87-61-6], [120-82-1], [108-70-3], [634-66-2], [634-90-2],[95-94-3], 608-93-5], [188-74-1]	-	-	5
c. chlorophenols				
chlorophenols (sum)[11]	[95-57-8], [108-43-0], [106-48-9], [576-24-9], [120-83-2], [583-78-8], [87-65-0], [95-77-2], [591-35-5], [15950-66-0], [933-78-8], [933-75-5], [95-95-4], [88-06-2], [609-19-8], [4901-51-3], [935-95-5], [58-90-2], [87-86-5]	-	-	6
pentachlorophenol	[87-86-5]	-	-	5
d. polychloro-biphenyls (PCBs)				
PCBs (sum of 7)[12]	[7012-37-5], [35693-99-3], [37680-37-2], [35065-28-2], [35065-27-1], [35065-29-3], [31308-00-6]	-	0.5	0.5

e. remaining chlorinated hydrocarbons				
EOCl (sum)	not applicable	-	3 mg Cl/kg	3 mg Cl/kg

6. Pesticides				
a. organochloro pesticides				
DDT/DDE/DDD[13]	[72-54-9], [53-19-0], [784-02-6], [72-54-8], [3424-82-6], [50-29-3]	-	-	0.5
drins (sum)[14]	[390-00-2], [60-57-1], [72-20-8]	-	-	0.5
HCH-compounds[15]	[319-84-6], [319-85-7], [58-89-9], [319-86-8]	-	-	0.5
organochloro compounds (sum)[16]	not applicable	-	0.5	0.5
b. remaining pesticides				
Atrazine	[1912-24-9]	-	-	0.5
Carbaryl	[63-25-2]	-	-	0.5
Carbofuran	[1563-66-2]	-	-	0.5
Maneb	[1247-38-2]	-	-	0.5
non chlorine pesticides (sum)[17]	not applicable	-	0.5	0.5

7. Remaining organic compounds				
cyclohexanone	[108-94-1]	-	-	270
phthalates (sum)	not applicable	-	-	60
mineral oil[18]	not applicable	-	500[19]	500
pyridine	[110-86-1]	-	-	1
tetrahydrophuran	[109-99-9]	-	-	0.4
tetrahydrothiophene	[110-01-0]	-	-	90

Contrary to the table no immission standard applies to bromide, in the event of the use of a building material in locations where there is direct contact or direct is possible with brackish surface water or sea water with a natural chloride concentration of more than 5,000 mg/l.
The immission standard for chloride given in the table is expressed in mg/m^2 per annum. Contrary to the table the following immission standards apply to chloride:
a. an immission standard of 87000 mg/m^2 per 1 annum for the use on or in the soil of an unmoulded building material that is applied as category 1 building material.
b. an immission standard of 174000 mg/m^2 per 1 annum for the use in surface water of a unmoulded building material used as category 1 building material and
c. no immission standard for the use of a building material in locations where there is direct contact or direct contact is possible with brackish surface water or sea water with a natural chloride concentration of more than 5000 mg/l.
Acidity: pH (0.01 M $CaCl_2$). For determining a pH higher than or equal to 5 and a pH smaller than 5, the 90-percentile of the measured standards applies.
Contrary to the immission standard for fluoride given in the table, an immission standard of 56000 mg/m^2 per 100 years applies for the use of a building material in places where there is direct contact or direct contact is possible with brackish surface water or sea water with a natural chloride concentration of more than 5000 mg/l.
The immission standard for sulphate given in the table is expressed in mg/m^2 per annum. Contrary to the immission standard given in the table, the following applies to sulphate:
a. an immission standard of 100,000 mg/m^2 per annum for the use on or in the soil of an unmoulded building material that is applied as category 1 building material.
b. an immission standard of 124,000 mg/m^2 per annum for the use in surface water of a unmoulded building material used as category 1 building material and
c. an immission standard of 180,000 mg/m^2 per annum for the use of a building material in locations where there is direct contact or direct contact is possible with brackish surface water or sea water with a natural chloride concentration of more than 5000 mg/l.
Xylene (sum) is defined as the sum of m-xylene, p-xylene and o-xylene.
Cresols (sum) is defined as the sum of m-cresol, p-cresol and o-cresol.

Contrary to the table the following applies to construction and demolition waste and products made from this including cement aggregate, mix aggregate, crusher sand and sieve sand:

a. no composition value for individual PAHs and

b. a composition value for sum PAHs (10 PAHs) of 50 mg/kg.

This deviation from the table is **not** applicable to the tarry asphalt aggregate referred to in footnote 19.

PAH (sum of 10) is defined as: the sum of anthracene, benzo(a)anthracene, benzofluoranthene, benzopyrene, chrysene, phenantrene, fluorantene, indeno (1,2,3-cd) pyrene, naphthalene and benzo(ghi)perylene.

0 Chlorobenzene (sum) is defined as the sum of all isomers of all chlorobenzenes (mono, di, tri, tetra, penta, hexachlorobenzene).

1 Chlorophenol is defined as: the sum of all isomers of chlorophenols (mono, di, tri, tetra and pentachlorophenol).

2 PCBs (sum of 7) is defined as: the sum of PCB 28, 52, 101, 118, 138, 153, 180.

3 DDT, DDD, DDE is defined as: the sum of DDT, DDD and DDE.

4 Drins is defined as: the sum of aldrin, dieldrin and andrin.

5 HCH compounds are defined as: the sum of á-HCH, â-HCH, ã-HCH and Ã-HCH.

6 Organochloro pesticides (sum) is defined as: the sum of all pesticides containing chlorine.

7 Non-chlorine-containing pesticides (sum) is defined as: the sum of all pesticides with the exception of pesticides containing chlorine.

8 Mineral oils relates to the sum of all the alkanes. If any form of mineral oil contamination is demonstrated in the soil, the concentration of aromatic and/or polycyclical aromatic hydrocarbons has to be determined alongside the mineral oil concentration.

9 Contrary to the table, no composition value applies to mineral oil for the building materials listed below:

- Asphalt or asphalt concrete, including possible surface treatments, interim layers and top layers, being a building material that comprises a binder on the basis of bitumen, stonelike materials, sand and filler, and which as such is used regularly in road and hydraulic engineering or for constructions for floors, leak-proof or otherwise;
- Stabilized asphalt aggregate being a building material that comprises sand, cement and/or bitumen emulsion, water and at least 70% mm asphalt aggregate, which as such is regularly used in road building or hydraulic engineering and in which the content of asphalt concrete in the asphalt aggregate is at least 40%.
- Asphalt aggregate being a building material that as such is regularly used in road building foundations and which comprises at least 80% broken or cut asphalt or asphalt concrete.
- Mineralized bitumen roofing materials which are regularly used in civil engineering and non-residential construction.

Annex A8: 27 products in the family of common cements according to DIN EN 197-1 [43]

Main cement types	Description of the 27 products (types of common cement)		Composition: (percentage by mass) [a]										
			Main constituents										Minor additional constituents
			Portland cement clinker	Granulated blastfurnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						Natural	Natural calcined	Siliceous	Calcareous				
			K	S	D [b]	P	Q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95-100	-	-	-	-	-	-	-	-	-	0-5
CEM II	Portland-slag cement	CEM II/A-S	80-94	6-20	-	-	-	-	-	-	-	-	0-5
		CEM II/B-S	65-79	21-35	-	-	-	-	-	-	-	-	0-5
	Portland-silica fume cement	CEM II/A-D	90-94	-	6-10	-	-	-	-	-	-	-	0-5
	Portland-pozzolana cement	CEM II/A-P	80-94	-	-	6-20	-	-	-	-	-	-	0-5
		CEM II/B-S	65-79	-	-	21-35	-	-	-	-	-	-	0-5
		CEM II/A-Q	80-94	-	-	-	6-20	-	-	-	-	-	0-5
		CEM II/B-Q	65-79	-	-	-	21-35	-	-	-	-	-	0-5
	Portland-fly ash cement	CEM II/A-V	80-94	-	-	-	-	6-20	-	-	-	-	0-5
		CEM II/B-V	65-79	-	-	-	-	21-35	-	-	-	-	0-5
		CEM II/A-W	80-94	-	-	-	-	-	6-20	-	-	-	0-5
		CEM II/B-W	65-79	-	-	-	-	-	21-35	-	-	-	0-5
	Portland-burnt shale cement	CEM II/A-T	80-94	-	-	-	-	-	-	6-20	-	-	0-5
		CEM II/B-T	65-79	-	-	-	-	-	-	21-35	-	-	0-5
	Portland-limestone cement	CEM II/A-L	80-94	-	-	-	-	-	-	-	6-20	-	0-5
		CEM II/B-L	65-79	-	-	-	-	-	-	-	21-35	-	0-5
		CEM II/A-LL	80-94	-	-	-	-	-	-	-	-	6-20	0-5
		CEM II/B-LL	65-79	-	-	-	-	-	-	-	-	21-35	0-5
			Composition: (mass in %) [a]										

Main cement types	Description of the 27 products (types of common cement)		Main constituents										Minor additional constituents
			Portland cement clinker	Granulated blastfurnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						Natural	Natural calcined	Siliceous	Calcareous				
			K	S	D [b]	P	Q	V	W	T	L	LL	
	Portland-composite cement	CEM II/A-M	80-94	6-20									0-5
		CEM II/B-M	65-79	21-35									0-5
CEM III	Blastfurnace cement	CEM III/A	35-64	36-65	-	-	-	-	-	-	-		0-5
		CEM III/B	20-34	66-80	-	-	-	-	-	-	-	-	0-5
		CEM III/C	5-19	81-95	-	-	-	-	-	-	-	-	0-5
CEM IV	Pozzolanic cement	CEM IV/A	65-89	-	11-35					-	-	-	0-5
		CEM IV/B	45-64	-	36-55					-	-	-	0-5
CEM V	Composite cement	CEM V/A	40-64	18-30	-	18-30			-	-	-	-	0-5
		CEM V/B	20-38	31-50	-	31-50			-	-	-	-	0-5

a The values in the table refer to the sum of the main and minor additional constituents

b The proportion of silica fume is limited to 10 %.

c In Portland composite cements CEM II/A-M and CEM II/B-M, in pozzolanic cements CEM IV/A and CEM IV/B, and in composite cements CEM V/A and CEM V/B, the main constituents other than portland cement clinker shall be declared by designation of the cement.

Annex A9: List showing total content of environmentally relevant heavy metals and trace elements in concrete constituents [26]

Stoff	Gesamtgehalte in mg/kg																	Bewertung der Umweltverträglichkeit
	As	Ba	Be	Bi	Cd	Co	Cr	Cu	Ga	Hg	Mo	Ni	Pb	Sb	Se	Tl	V	Zn	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Zemente																			
CEM I [8]	4 - 23	185 - 390	0,2 - 1,1	1 - 5	0,03 - 6	2,8 - 21	25 - 124	55 - 98	5 - 9	< 0,02 - 0,12		17 - 97	5 - 254	2 - 18		< 0,02 - 4,1	20 - 100	21 - 679	
CEM II [9]	2 - 76	37 - 450	0,1 - 3	0,06 - 1	0,01 - 3	2 - 25	7 - 144	4 - 129	0,1 - 17	< 0,2		12 - 100	4 - 247			< 1	16 - 94	26 - 660	
CEM II/A-S [9]					0,01 - 1		8 - 88			< 0,05			4 - 99			0,02 - 0,6		32 - 330	
CEM II/B-S [9]					0,01 - 1		7 - 88			< 0,05			4 - 99			0,2 - 0,6		26 - 330	
CEM II/A-D																			
CEM II/A-P [9]					0,02 - 1		12 - 90			< 0,03			7 - 103			< 0,4		44 - 340	
CEM II/B-P [9]					0,03 - 1		16 - 90			< 0,04			10 - 98			< 0,4		55 - 316	
CEM II/A-Q [12]							227			< 0,02						< 0,02			
CEM II/B-Q																			
CEM II/A-V [9]	2-76				0,02 - 3		11 - 144			0,03 - 0,2		17 - 100	6 - 247			0,04 - 0,8		40 - 577	
CEM II/B-V [12]							137			< 0,02						0,4			
CEM II/A-W																			
CEM II/B-W																			
CEM II/A-T [9]					0,04 - 2		11 - 87			< 0,1			5 - 102			0,1 - 0,6		47 - 344	
CEM II/B-T [9]					0,1 - 2		12 - 80			0,01 - 0,11			6 - 93			0,2 - 1		65 - 329	
CEM II/A-L [9]	2-14		0,2-3		0,01 - 1		8 - 86			< 0,02			4 - 100				16 - 94	32 - 660	bei Übereinstimmung keine weiteren Nachweise erforderlich
CEM II/B-L																			
CEM II/A-LL																			
CEM II/B-LL																			
CEM II/A-M																			
CEM II/B-M																			
CEM III [11]	0,8 - 2				< 0,1 - 1	< 0,2 - 2	20 - 80	5 - 17		< 0,1		4 - 25	<1 - 18			<0,5		5 - 80	
CEM III/A [9]					0,01 - 1		4 - 86			< 0,1			2 - 71			0,04 - 0,7		15 - 231	
CEM III/B [9]					0,01 - 1		3 - 83			< 0,2			2 - 42			0,1 - 0,8		9 - 132	
CEM III/C																			
CEM IV																			
CEM IV/A																			
CEM IV/B																			
CEM V																			
CEM V/A																			
CEM V/B																			
Spannbreiten für alle o. g. Zemente [10]	**< 1 - 53**		**< 0,02 - 2,5**		**< 0,1 - 8**	**1 - 28**	**12 - 105**	**2 - 282**		**< 0,02 - 0,34**		**6 - 80**	**0 - 203**	**< 1 - 35**	**< 1 - 2,6**	**< 0,5 - 2**	**15 - 200**	**15 - 450**	
Mittelwerte [10]	6,8		0,7		0,4	10	40	25		0,07		24	27	6			56	140	
Zem. Bestandteile																			bei Übereinstimmung keine weiteren Nachweise erforderlich
Hüttensand [11]					0,01 - 70		1 - 143			< 0,005 - 0,2		1 - 10	1 - 10			0,1 - 1		1 - 60	
gebr. Ölschiefer [11]					0,5 - 3		20 - 40			0,05 - 0,3			10 - 50			1 - 3		160 - 250	
Naturgips [6), 7)]	< 5 / 7	16 / 93	< 0,01 - 0,9	< 5 / 11	0,03 - 0,6	< 7 / 8	0,65 - 33	< 10 / 32	< 5 / < 5	< 0,005 - 0,08	< 5 / 6	0,3 - 13,5	0,46 - 21,4	5 / 17	< 0,46	< 0,05 - 0,2	0,93 - 27	1 - 61	kein Nachweis erforderlich
REA-Gips [7]	0,21 - 2,7		0,03 - 0,65		0,003 - 0,29	0,04 - 2,2	1 - 9,7	1,1 - 8,6		0,03 - 1,3		0,3 - 12,9	0,27 - 22		0,7 - 15,7	< 0,05 - 0,4	1,2 - 7,7	1,7 - 53,2	
Gesteinskörnung normal																			
Quarzit, Gestein [6, 11]	5 / 42	214 / 1264		< 5 / 7	0,01 - 1	7 / 37	26 / 229	< 10 / 85	5 / 22	0,008 - 0,1	< 5 / 5	< 7 / 73	< 10 / 70	6 / 12		< 0,1 - 1	18 / 105	11 / 112	
Kalkstein [6), 11]	< 5 / 28	52 / 783	< 0,01 - 12	5 / 13	0,04 - 0,5	< 7 / 28	7 / 35	13 / 87	< 5 / 7	0,005 - 0,1	< 5 / 9	< 7 / 21	< 10 / 186	10 / 27		0,06 - 1,8	5 - 80 [1)]	13 / 218 [1)]	kein Nachweis erforderlich
Granit [6]	5 / 49	361 / 1415				7 / 25	8 / 136	< 10 / 46	19 / 27		< 5 / < 5	< 7 / 48	18 / 53	8 / 13			15 / 102	55 / 122	
Basalt, Diabas, Gabbro [6]	< 5 / 25	600 / 1359			0,14 - 0,8 [3)]	35 / 63	215 / 654	44 / 97	20 / 27	0,09 - 0,1 [3)]	< 5 / 10	91 / 362	< 10 / 69			0,36	200 / 366	102 / 293	
Grauwacke [6]	9 / 41	364 / 743				16 / 30	58 / 102	17 / 78	16 / 25			< 7 /42	41 / 228				79 / 113	61 / 146	
Schmelzkammergr. [11]	7 - 41				< 0,5 - 1,9		134 - 159	135 - 160		< 0,1		104 - 117	82 - 156		<0,1		229 - 278	148 - 447	bei Übereinstimmung keine weiteren Nachweise erforderlich
Hochofenschacke [13]	0,2 - < 1	<1791-8957 [14)]			0,1 - < 1	2 - 8	24 - 40	9 - 10		< 0,1 - < 1	< 2	< 2	6 - 21		2	< 0,5 - <1	50	70 - < 100	
Stahlwerksschlacke [13]	0,2 - < 1				0,1 - < 1	4 - 10	340 - 2550	16 - 50		0,1 - < 1	80	< 2 - 9	5 - 8		0,4	< 0,5 - 2	600	30 - 150	

Stoff	Gesamtgehalte in mg/kg																		Bewertung der Umweltverträglichkeit
	As	Ba	Be	Bi	Cd	Co	Cr	Cu	Ga	Hg	Mo	Ni	Pb	Sb	Se	Tl	V	Zn	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
schwer																			
Baryt		588412[2]											Spuren						
Magnetit [11]						Spuren	Spuren					Spuren					< 5000 - 15000		
Hämatit							Spuren												Nachweis muss noch erbracht werden
Ilmenit																			
Ferrophosphor																			
Ferrosilizium																			
Eisengranalien																			
Stahlsand																			
Limonit		Spuren															Spuren		
normale Gesteins-körnungen für Strahlenschutzbeton																			
Serpentin [6]		18 / 82					1163 / 1669	81 / 180	8 / 11			965 / 1180					91 / 119	98 / 131	Nachweis muss noch erbracht werden
Colemanit																			
Borcalzit																			
Borfritte																			
Borkarbit																			
leicht																			
Naturbims [6), 11)]	7 / 14				0,4 / 1,3	7	70 / 220	11 / 26		0,03 / 0,15		32 / 44	33 / 59					110 / 170	kein Nachweis erforderlich
Tuff [6]	9 / 64	268 / 1103		< 5 / 14		16 / 80	65 / 745	22 / 140	18 / 42		< 5 / 12	34 / 648	8 / 237				124 / 355	90 / 451	
Lavaschlacke																			
Sinterbims																			Nachweis muss noch erbracht werden
Kesselsand																			
Ziegelsplitt [15]	<5 - 26	133 - 1734		< 2 - < 20	< 2 - < 10	32 - 64	< 10 - 198	< 2 - 65	1 - 24	< 0,5	< 10	4 - 68	7 - 147	1 - < 10		< 0,5		13 - 206	As-Auslaugung kontrollieren
Blähton bzw. Ton [6), 11)]	15 / 78	312 / 815	2 - 18		< 0,02 - 500	20 / 43	105 / 217 [1]	29 / 284	23 / 35	0,02 - 0,5	< 5 / 26	43 / 119	27 / 124 [1]	7 / 13		0,2 - 0,9	128 / 295 [1]	78 / 304 [1]	
Blähschiefer																			
Blähglas																			
Blähperlit																			
Blähglimmer bzw. Glimmerschiefer [6]	8 / 22				< 0,3 / 0,5		84	37 / 51		0,05 / 0,05		40 / 58	45 / 93					150 / 300	kein Nachweis erforderlich
Schaumsand, Schaumkies																			
Rezykl. Zuschlag [16]	5 - 14	355 - 445		< 5	< 2	33 - 72	36 - 67	10 - 44	6 - 7	< 0,005 - 0,2		13 - 30	34 - 265	< 5		0,05 - 0,11		73 - 155	
Zusatzstoffe																			
SFA [17]	0,6 - 365	612 - 2249	5 - 18	1 - 4	0,2 - 14,4	36 - 250	21 - 374	38 - 650	2 - 84	< 0,1 - 2,4		15 - 600	11 - 1040	< 0,5 - 90	1 - 35	0,6 - 15	230 - 500	47 - 1483	bei Übereinstimmung keine weiteren Nachweise erforderlich[5]
Silikastaub / Mikro-silika[4]	< 10	3,83	<10		<2	<2	<2	5,58		0,043	<5	<2	5,93	<10	<10	<10	<2	18,6	
Trass					0,1 - 1		40 - 90			< 0,01 - 0,1			30 - 70			0,1 - 1		110 - 190	
Farbpigment	Angabe von Schwermetallgehalten ist nicht sinnvoll, da sie z. T. Bestandteil der farbgebenden Verbindung (hohe Gehalte) sind, aber oxidisch gebunden vorliegen und daher nicht löslich sind.																		
Zusatzmittel	Hauptsächlich organische Verbindungen mit vernachlässigbaren Gehalten an Schwermetallen und Spurenelementen																		Nachweis muß noch erbracht werden
Zugabewasser Restwasser	vernachlässigbare Gehalte an Schwermetallen und Spurenelementen																		kein Nachweis erforderlich

1) in /40/ und /71/ werden für Ton und Kalkstein z. T. deutlich höhere Werte angegeben (Ton: max. 1500 mg/kg Cu, 461 mg/kg Pb, 3600 mg/kg V und 1300 mg/kg Zn, Kalkstein: 3000 mg/kg V und 1900 mg/kg Zn). In solchen Fällen ist die Umweltverträglichkeit ggf. zu überprüfen.
2) theoretischer Gehalt bei reinem $BaSO_4$
3) 90 % Perzentilwert
4) bestimmt nach NS 4770, säurelösliche Anteile, keine Angaben zum Probenumfang
5) bei Recyclinzuschlag nach DAfStb-Richtlinie sind ggf. zusätzlich die Gehalte an eluierbaren organischen Stoffen zu prüfen

Angaben zum Probenumfang:
6) Angabe in 50 % / 97,5 % Perzentilwert, 6827 Datensätze für Locker- und Festgesteine /79/
7) repräsentative Proben aus 12 Naturgips-Lagerstätten, 12 Steinkohle- und 3 Braunkohlekraftwerken /10/, ergänzt um Werte aus /40/ ohne Angaben
8) insgesamt 198 Proben verschiedener Zementwerke /7, 14, 40, 74/
9) berechnet /7/
10) Messungen an über 400 deutschen Normzementen, 1998 /20/
11) keine Angaben /5, 7, 40, 71 bzw. 74/
12) 1 Probe /22/
13) 1 Probe /76/ ergänzt um Werte aus /71/ ohne Angaben
14) 14 Schlacken (basisch und sauer) /78/
15) 22 Proben verschiedener Mauerziegel (HIZ, MZ, HFZ, FZ, KS, Pb, LB) /70, 82/
16) 5 Proben /80/
17) 25 Proben aus verschiedenen Anlagen /3, 14, 81/, ergänzt um Werte aus /74/ und /7/ ohne Angaben

Annex A10: LCI list from the AgBB evaluation scheme for VOC and SVOC as of: June 2003 [21]

The current version is published on the UBA homepage (www.umweltbundesamt.de)

	Substance	CAS No.	LCI [µg/m³]	TRGS 900 [µg/m³]	EU classification (EU-OEL** in µg/m³)	Remarks
1. Aromatic hydrocarbons						
1-1	Toluene	108-88-3	**1,900**	190,000		
1-2	Ethyl benzene	100-41-4	**4,400**	440,000		
1-3	Xylene, mixture of o-, m- and p-xylene isomers	1330-20-7	**4,400**	440,000	*221,000*	
1-4	p-Xylene	106-42-3	**4,400**	440,000	*221,000*	
1-5	m-Xylene	108-38-3	**4,400**	440,000	*221,000*	
1-6	o-Xylene	95-47-6	**4,400**	440,000	*221,000*	
1-7*	Isopropylbenzene	98-82-8	**1,000**	250,000	100,000 (Dir 96/94)	
1-8	n-Propyl benzene	103-65-1	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-9	1-Propenyl benzene (ß-methyl styrene)	637-50-3	**4,900**	490,000 for α-methyl styrene		
1-10	1.3.5-Trimethylbenzene	108-67-8	**1,000**	100,000	100,000	
1-11	1.2.4-Trimethylbenzene	95-63-6	**1,000**	100,000	100,000	
1-12	1.2.3-Trimethylbenzene	526-73-8	**1,000**	100,000	100,000	
1-13	2-Ethyltoluene	611-14-3	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-14	1-Isopropyl-2-methylbenzene (o-cymene)	527-84-4	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-15	1-Isopropyl-3-methylbenzene (m-cymene)	535-77-3	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-16	1-Isopropyl-4-methylbenzene (p-cymene)	99-87-6	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-17	1.2.4.5-Tetramethyl benzene	95-93-2	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-18	n-Butyl benzene	104-51-8	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-19	1.3-Diisopropylbenzene	99-62-7	**1,000**			cf. lowest LCI of saturated alkylbenzenes

	Substance	CAS No.	LCI [µg/m³]	TRGS 900 [µg/m³]	EU classifi-cation (EU-OEL** in µg/m³)	Remarks
1-20	1.4-Diisopropylbenzene	100-18-5	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-21	Phenyl octane and isomers	2189-60-8	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-22	1-Phenyldecane and isomers	104-72-3	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-23	1-Phenyl undecane and isomers	6742-54-7	**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-24	4-Phenyl cyclohexene (4-PCH)	4994-16-5	**860**			cf. styrene
1-25	Styrene	100-42-5	**860**	86,000		
1-26	Phenyl acetylene	536-74-3	**860**			cf. styrene
1-27	2-Phenylpropene (α-Methylstyrene)	98-83-9	**4,900**	490,000	*246,000*	
1-28	Vinyl toluene (all isomers: o-,m-,p-methyl styrenes)	25013-15-4	**4,900**	490,000		
1-29	Other alkylbenzenes if indiv. isomers cannot be evaluated differently		**1,000**			cf. lowest LCI of saturated alkylbenzenes
1-30*	Naphthalene	91-20-3	**50**	50,000	50,000	carc. cat. 3 (EU 29.ATP)
1-31	Indene	95-13-6	**450**	45,000		
2. Saturated aliphatic hydrocarbons (n-, iso- and cyclo-)						
2-1	3-Methylpentane	96-14-0	**7,200**	720,000		
2-2	n-Hexane	110-54-3	**180**	180,000	*Repr,Cat,3 72,000*	
2-3	Cyclohexane	110-82-7	**7,000**	700,000		
2-4	Methyl cyclohexane	108-87-2	**20,000**	2,000,000		
2-5	1.4-Dimethyl cyclohexane	589-90-2	**20,000**			cf. methylcyclo hexane
2-6	4-Isopropyl-1-methylcyclohexane	cis: 6069-98-3 trans: 1678-82-6	**20,000**			cf. methylcyclo hexane
2-7	C7-C16 hydrocarbons		**21,000**	2,100,000 for n-heptane		
3. Terpenes						
3-1	3-Carene	498-15-7	**2,000**			cf. α -pinene
3-2	a-Pinene	80-56-8	**2,000**			LOAEL 200 mg/m^3
3-3	ß-Pinene	127-91-3	**2,000**			cf. α –pinene
	Substance	**CAS No.**	**LCI [µg/m³]**	**TRGS 900**	**EU classifi-**	**Remarks**

				[µg/m³]	cation (EU-OEL** in µg/m³)	
3-4	Limonene	138-86-3	**2,000**			cf. α –pinene
3-5	Other terpene hydrocarbons		**2,000**			cf. α –pinene
4. Aliphatic alcohols and ethers						
4-1	Ethanol	64-17-5	**19,000**	1,900,000		
4-2	1-Propanol	71-23-8	**2,400**			OEL-Norway: 245 mg/m^3 (1999)
4-3	2-Propanol	67-63-0	**5,000**	500,000		
4-4	Tert-butanol, 2-methylpropanol-2	75-65-0	**620**	62,000		
4-5	2-Methyl-1-propanol	78-83-1	**3,100**	310,000		
4-6	1-Butanol	71-36-3	**3,100**	310,000		
4-7	1-Pentanol	71-41-0	**3,600**	360,000		
4-8	1-Hexanol	111-27-3	**3,100**			cf. 1-butanol
4-9	Cyclohexanol	108-93-0	**2,100**	210,000		
4-10	2-Ethyl-1-hexanol	104-76-7	**2,700**	270,000		
4-11	1-Octanol	111-87-5	**2,700**			ACGIH: 270mg/m^3 (1999)
4-12	4-Hydroxy-4-methyl-pentane-2-on (diacetone alcohol)	123-42-2	**2,400**	240,000		
4-13	C_4 – C_{10} - alcohols		**3,100**			cf. 1-butanol
5. Aromatic alcohols (phenols)						
5-1	Phenol	108-95-2	**190**	19,000	*7,800*	TRGS 905: Mut.Cat. 3
5-2*	Butylated hydroxytoluene (2.6-di-tert-butyl-4-methylphenol)	128-37-0	**100**	10 E		
6. Glycols, glycol ethers, glycol esters						
6-1	Propylene glycol (1,2-Dihydroxypropane)	57-55-6	**260**			cf. ethanediol ethylene glycol
6-2	Ethylene glycol (Ethandiol)	107-21-1	**260**	26,000	*52,000*	
6-3	Ethylene glycol-monobutylether	111-76-2	**980**	98,000	*98,000*	
6-4	Diethylene glycol	111-46-6	**440**	44,000		
6-5	Diethylene glycol-monobutylether	112-34-5	**1,000**	100,000		
6-6	2-Phenoxyethanol	122-99-6	**1,100**	110,000		
6-7	Ethylene carbonate	96-49-1	**260**			cf. ethanediol ethylene glycol
6-8	1-Methoxy propanol-2	107-98-2	**3,700**	370,000	*188,000*	
	Substance	**CAS No.**	**LCI [µg/m³]**	**TRGS 900 [µg/m³]**	**EU classifi-cation (EU-OEL** in µg/m³)**	**Remarks**

6-9	2.2.4-Trimethyl-1.3-pentane diol, monoisobutyrate (texanol®)	25265-77-4	**1,000**			Nielsen et al. (DK)
6-10*	Glycolic acid butyl ester (Hydroxy acetic acid butyl ester)	7397-62-8	**550**			cf. glycolic acid/ methabolite of Ethylene glycol ethane-1.2-diol (conversion via molecular weight)
6-11*	Butyldiglycol acetate (Ethanol, 2-(2-butoxyethoxy) acetate, BDGA)	124-17-4	**1,000**			cf. diethylene glycol-monobutyl ether
6-12*	Dipropylene glycol monomethyl ether	34590-94-8	**3,100**	310		
7. Aldehydes						
7-1	Butanal	123-72-8	**640**	64,000		
7-2	Pentanal	110-62-3	**1,700**	175,000		
7-3	Hexanal	66-25-1	**640**			cf. butanal
7-4	Heptanal	111-71-7	**640**			cf. butanal
7-5	2-Ethyl-hexanal	123-05-7	**640**			cf. butanal
7-6	Octanal	124-13-0	**640**			cf. butanal
7-7	Nonanal	124-19-6	**640**			cf. butanal
7-8	Decanal	112-31-2	**640**			cf. butanal
7-9	2-Butenal (crotonaldehyde, cis-trans-mix)	4170-30-3	**10**	1,000	Mut.Cat.3	
7-10	2-Pentenal (trans)	1576-87-0	**10**			cf. 2-butenal
7-11	Hexenal, trans-2-	6728-26-3	**10**			cf. 2-butenal
7-12	2-Heptenal cis: trans:	2463-63-0 18829-55-5	**10**			cf. 2-butenal
7-13	2-Octenal	2363-89-5	**10**			cf. 2-butenal
7-14	2-Nonenal (trans)	2463-53-8	**10**			cf. 2-butenal
7-15	2-Decenal	3913-71-1	**10**			cf. 2-butenal
7-16	2-Undecenal	2463-77-6	**10**			cf. 2-butenal
7-17	Furfural	98-01-1	**20**	20,000	Carc.Cat.3	
7-18	Glutaraldehyde	111-30-8	**4**	420		
8. Ketones						
8-1	Ethylmethylketone	78-93-3	**6,000**	600,000	*300,000*	
8-2	3-Methylbutanone-2	563-80-4	**7,000**	705,000		
8-3	Methylisobutylketone	108-10-1	**830**	83,000		
8-4	Cyclopentanone	120-92-3	**6,900**	690,000		
8-5*	Cyclohexanone	108-94-1	**400**	80,000	40,800	
	Substance	**CAS No.**	**LCI [µg/m³]**	**TRGS 900 [µg/m³]**	**EU classifi-cation (EU-OEL** in µg/m³)**	**Remarks**

8-6	2-Methylcyclopentanone	1120-72-5	**6,900**			cf. cyclopentanone
8-7	2-Methylcyclohexanone	583-60-8	**2,300**	230,000		
8-8*	Acetophenone	98-86-2	**490**			ACGIH: 49 mg/m³
8-9*	1-Hydroxyacetone (2 Propanone, 1-hydrocx-)	116-09-6	**260**			oxidation product of propylene glycol, cf. ethylene glycol
9. Acids						
9-1	Acetic acid	64-19-7	**500**	25,000		Indiv. subst. consider. (plausibility)
9-2	Propionic acid	79-09-4	**310**	31,000	31,000	
9-3	Isobutyric acid	79-31-2	**310**			cf. propionic acid
9-4	Butyric acid	107-92-6	**310**			cf. propionic acid
9-5	Pivalic acid	75-98-9	**310**			cf. propionic acid
9-6	n-Valeric acid	109-52-4	**310**			cf. propionic acid
9-7	n-Caproic acid	142-62-1	**310**			cf. propionic acid
9-8	n-Heptanoic acid	111-14-8	**310**			cf. propionic acid
9-9	n-Octanoic acid	124-07-2	**310**			cf. propionic acid
10. Ester and Lactones						
10-1	Methyl acetate	79-20-9	**6,100**	610,000		
10-2	Ethyl acetate	141-78-6	**7,300**	1,500,000	*734,000*	
10-3	Vinyl acetate	108-05-4	**36**	36,000	Carc.Cat.3	
10-4	Isopropyl acetate	108-21-4	**4,200**	420,000		
10-5	Propyl acetate	109-60-4	**4,200**	420,000		
10-6	2-Methoxy-1-methylethyl acetate	108-65-6	**2,700**	270,000	275,000	
10-7	n-Butyl formiate	592-84-7	**1,200**	120,000 for metylformiate		
10-8	Methyl methacrylate	80-62-6	**2,100**	210,000		
10-9	Other methacrylates		**2,100**			cf. methyl-methacrylate
10-10	Isobutyl acetate	110-19-0	**4,800**	480,000		
10-11	1-Butyl acetate	123-86-4	**4,800**	480,000		
10-12	2-Ethylhexyl acetate	103-09-3	**270**			OEL-DK: 270 mg/m3
10-13	Methyl acrylate	96-33-3	**180**	18,000		
10-14	Ethyl acrylate	140-88-5	**210**	21,000		
10-15	n-Butyl acrylate	141-32-2	**110**	11,000	*11,000*	
10-16	2-Ethylhexyl acrylate	103-11-7	**820**	82,000		
10-17	Other acrylates (acrylic acid ester)		**110**			cf. n-butyl acrylate
	Substance	**CAS No.**	**LCI [µg/m³]**	**TRGS 900 [µg/m³]**	**EU classifi-cation (EU-OEL** in µg/m³)**	**Remarks**

10-18*	Dimethyl adipate	627-93-0	**7,300**			cf. methanol (metabolite), conversion via molecular weight
10-19*	Dibutyl fumarate	105-75-9	**4,800**			cf. butanol (metabolite), conversion via molecular weight
10-20*	Dimethyl succinate	106-65-0	**6,200**			cf. methanol (metabolite), conversion via molecular weight
10-21*	Dimethyl glutarate	1119-40-0	**6,800**			cf. methanol (metabolite), conversion via molecular weight
10-22*	Hexamethylene diacrylate	13048-33-4	**10**			TSCA: 1mg/m³, TWA-8hr: 1mg/m³ (AIHA 1999)
11. Chlorinated hydrocarbons						
11-1	Tetrachloroethene	127-18-4	**340**	345,000	Carc.Cat.3	
12. Others						
12-1	1.4-Dioxan	123-91-1	**73**	73,000	Carc.Cat.3	
12-2	Caprolactam	105-60-2	**50**	5,000	*10,000*	
12-3	N-methyl-2-pyrrolidon	872-50-4	**800**	80,000		
12-4*	Octamethylcyclotetra-siloxane (D4)	556-67-2	**1,200**		Repr. Cat.3	Consider individual substance
12-5*	Hexamethylenetetramine	100-97-00	**30**			OEL:Norway /Sweden: TWA 3 mg/m³, Jan. 1999
12-6*	2-Butanonoxime	96-29-7	**20**		Carc.Cat.3	Consider individual substance
12-7*	Tributyl phosphate	126-73-8	**25**	2,500		
12-8*	Triethyl phosphate	78-40-0	**25**			cf. tributyl phosphate
12-9*	5-Chloro-2-methyl-2H-isothiazol-3-one (CIT) 2-Methyl-2H-isothiazol-3-one (MIT) mixture, ratio 3:1	26172-55-4 2682-20-4 55965-84-9	**1**	50		Evaluation for a ratio of 3:1

* : new or altered

**: As of: January 2003

Italics: Recommendations of the European Commission, adopted by the Scientific Committee for Occupational Exposure Limits (SCOEL), but not yet legally binding.

Annex A11: List of voluntary regulations for floorings

Textile floorings

This list contains only regulations that refer to the content and release of dangerous substances

Parameter	*Natureplus e.V. "Textile Bodenbeläge"* [190]	*Gemeinschaft umweltfreundlicher Teppichboden e.V. (GUT)* [109]	*Öko-Tex Standard 100* [191]	*Österreichisches Umweltzeichen UZ 35, "Textile Bodenbeläge"* [192]	*Nordic Ecolabelling "Textiles"* [187b]
Area of application	Textile floorings from renewable raw materials (animal hair, plant fibres)	Textile floorings	Textiles, also furnishing materials such as textile floorings	Textile floorings (fitted carpeting)	Fibre textiles (including carpets): cotton, new wool, flax, jute, ramie, regenerated cellulose, synthetic fibres
Prohibitions and restrictions (content)					
CMR substances (carcinogenic, mutagenic or reprotoxic)				**Restrictions on use of substances classified to 67/548/EEC as:** • T+, T • CMR • N	Prohibition on use of substances classified to 67/548/EEC or in any of the Nordic Countries as: • CMR
Heavy metals	Restriction of heavy metal content: Al, As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Sb, Tl, Zn, Zr	Prohibition of dyes and pigments containing heavy metals (Cd, Cr, Cr(VI), Hg, Pb) as constituents of the dyeing component	Restriction of heavy metal content: • Cr, Cr(VI), Co, Ni Restriction only for organic materials for: • As, Hg, Pb, Cd, Cu	Prohibition of dyes and pigments containing heavy metals (Cd, Cr, Cr(VI), Hg, Pb) as constituents in the dyeing component	Restriction of heavy metal content (dyes, pigments): • As, Pb, Cd, Co, Cu, Cr, Hg, Ni, Sn, Zn
Halogenated organic compounds	Prohibition of halogenated organic compounds			Prohibition of halogenated organic compounds	
Flame retardants	Prohibition of synthetic organic flame retardants (organophosphates) (12 individual substances)	Prohibition of halogenated and / or phosphorous-based flame retardants (PBB, TRIS; TEPA; SCCPs, PeBDE	Prohibition of flame retardants: • PBB, TRIS, TEPA	Prohibition of flame retardants: • containing antimony, arsenic or boron • boron-based flame retardants • with chlorinated paraffins or fluorine compounds	Prohibition of flame retardants: • boron-based flame retardants • chlororganic flame retardants

Parameter	*Natureplus e.V. "Textile Bodenbeläge"* **[190]**	*Gemeinschaft umweltfreundlicher Teppichboden e.V. (GUT)* **[109]**	*Öko-Tex-Standard 100* **[191]**	*Österreichisches Umweltzeichen Zu 35, "Textile Bodenbeläge"* **[192]**	*Nordic Ecolabelling "Textiles"* **[187b]**
Azo dyes that release carcinogenic amines	Prohibition of azo dyes that release carcinogenic amines	Prohibition of azo dyes that release carcinogenic amines	Prohibition of arylamines which are cleavable from colouring agents	Prohibition of azo dyes that release carcinogenic amines	Prohibition of arylamines which are cleavable from colouring agents
Dyes	Prohibition of carcinogenic or allergenic dyes	Prohibition of carcinogenic or allergenic dyes	Prohibition of carcinogenic or allergenic dyes		
Carriers		Prohibition of certain carriers (chlororganic carriers)		Prohibition of carriers	
Biocides	Prohibition on use of biocides: • organo-chlorine pesticide • organo-phosphor pesticide • pyrethroids (mothproofing agents) • herbicides	Prohibition of biocides: • TBT • pyrethroids except for permethrin Restriction of biocides: • chlorphenols (PCP, TeCP) • orthophenylphenol (OPP) • chlororganic and phosphororganic pesticides • herbicides • permethrin for woollen carpets up to 210 mg/kg	Restriction of pesticides for organic materials: • 55 individual substances Restriction for biocides: • chlorophenols (PCP; TeCP) • orthophenylphenol (OPP) • TBT (organic tin compounds)	Prohibition of pesticides: • according to restricted use pesticides list of GUT • PCP Restriction of mothproofing to 40 mg/kg permethrin	Restriction of pesticide content for wool Restriction for: • chlorophenols (preservative agent) • PCB (softener, carrier, flame retardant) • halogenated mothproofing agents

Parameter	*Natureplus e.V. "Textile Bodenbeläge"* [190]	*Gemeinschaft umweltfreundlicher Teppichboden e.V. (GUT)* **[109]**	*Öko-Tex-Standard 100* **[191]**	*Österreichisches Umweltzeichen UZ 35, "Textile Bodenbeläge"* **[192]**	*Nordic Ecolabelling "Textiles"* **[187b]**
Other			Restriction for • chlorinated benzene and toluene	Prohibition of: • butadiene • vinyl chloride	Prohibition of: • anti-matting agents • organic tin compounds (after-treatment) • PVC Restriction for: • APEO (alkyl phenol ethoxylates) (surface-active agent) • LAS (linear alkylbenzene sulphonates) (surface-active agent) • DADMAC (diallyl dimethyl ammonium chloride) (softener) • phthalates (softener) • EDTA (chelating agent) • halogenated solvents (carrier)
		Prohibition of zinc diethyl dithiocarbamate (ZDEC) as a vulcanisation accelerator for the manufacture of foam backings	Restriction for formaldehyde	Prohibition on use of vulcanised foams as backing	Restriction for free formaldehyde (300 ppm)
	Restriction for latex: • PCP	Restriction for latex: • styrene • ethylbenzene • 4-PCH • 4-VCH			Use of secondary textiles: Restriction on the content of EOHC for secondary fibres

Parameter	*Natureplus e.V. "Textile Bodenbeläge"* **[190]**	*Gemeinschaft umweltfreundlicher Teppichboden e.V. (GUT)* **[109]**	*Öko-Tex-Standard 100* **[191]**	*Österreichisches Umweltzeichen UZ 35, "Textile Bodenbeläge"* **[192]**	*Nordic Ecolabelling "Textiles"* **[187b]**
Prohibitions and restrictions (Emission)					
VOC and SVOC	Restriction for VOC: • VOC classified as CMR according to *Gefahrstoffverordnung* – GefStoffV ('German Dangerous Substances Ordinance') • sum of VOC (TVOC) • sum of sensitising substances (according to MAK ('maximum concentration at workplace') and *BgVV* ('German Federal Institute for Health Protection of Consumers and Veterinary Medicine') • sum of the saturated n-aldehydes • special individual substances Restriction for: • SVOC	Restriction for VOC: • sum of VOC • sum of aromatic hydrocarbons • toluene • styrene • 4-vinyl cyclohexene • 4-phenyl cyclohexene	Restriction for VOC: • sum of VOC • sum of aromatic hydrocarbons • toluene • styrene • 4-vinyl cyclohexene • 4-phenyl cyclohexene	Restriction for VOC: • sum of VOC • sum of aromatic hydrocarbons • toluene • styrene • 4-vinyl cyclohexene • 4-phenyl cyclohexene	
Formaldehyde	Restriction for formaldehyde		Restriction for formaldehyde	Restriction for formaldehyde	
Odour	Restriction for odour emission	Restriction for odour emission	Restriction for odour emission	Restriction for odour emission	
Other	Restriction for latex: • nitrosamines • carbon disulfide	Restriction for: • vinyl acetate • vinyl chloride	Restriction for: • vinyl chloride • butadiene	Restriction for: • vinyl acetate	

Resilient floorings

Field	***Natureplus e.V.* *"Linoleum-Bodenbeläge"*** **[190b]**	***Kork-Logo* *"Kork-Bodenbeläge"*** **[132]**	***Österreichisches Umweltzeichen UZ 42, "Elastische Bodenbeläge"*** **[169]**
Area of application	Linoleum flooring (not valid for composite materials e.g. with cork, foam backings or hardboards)	Cork floorings	Resilient floorings as defined by EN 12466 (e.g. PVC, polyolefins, rubber, linoleum)
Prohibitions and restrictions (content)			
CMR substances			Restriction on use of substances classified to 67/548/EEC [3] as: • T+, T • CMR • N
Heavy metals	Prohibition of use of compounds As, Pb, Cd, Hg	It is not necessary to verify heavy metals because they are not contained in relevant amounts	Prohibition on use of heavy metals: • Pb, Cd, Hg, Cr(VI)
Halogenated organic compounds	Prohibition of halogenated organic compounds		Prohibition of halogenated organic compounds (e.g. binders, flame retardants) (limit value for content of halogens F, Cl, Br)
Biocides	Prohibition of biocides (e.g. triclosan)	Prohibition of pesticides (the use is not required, no test required)	Prohibition of fungicides and bactericides Prohibition of TBT (organic tin compounds) (limit value for tin)
Azo dyes that release carcinogenic amines	Prohibition of azo dyes that release carcinogenic amines	Prohibition of azo dyes that release carcinogenic amines	
Pigments		Prohibition of hazardous pigments containing heavy metals	
Flame retardants		Prohibition of flame retardants	

Field	*Natureplus e.V.* *"Linoleum-Bodenbeläge"* **[190b]**	*Kork-Logo* *"Kork-Bodenbeläge"* **[132]**	*Österreichisches Umweltzeichen UZ 42,* *"Elastische Bodenbeläge"* **[169]**
Other	Surface coating: Prohibition of: • aromatic compounds • surface-active agent based on alkyl phenol ethoxylates (APEO) • glycol compounds • halogenated organic compounds • cobalt compounds (desiccant)		Restriction for rubber floorings: • N-nitrosamines
			Restriction for PVC floorings: • vinyl chloride (with restriction)
Prohibitions and restrictions (Emission)			
VOC and SVOC	Restriction for VOC: • sum of VOC (TVOC) • VOC (CMR substances) • sum of aromatic hydrocarbons • sum of sensitizing VOC • sum of the saturated n-aldehydes • special individual substances Restriction for: • SVOC	Cork floorings with polyurethane binder: No emission of MDI or TDI monomers (examination is not necessary)	Restriction for VOC: • sum of VOC (TVOC) • sum of aromatic hydrocarbons (incl. styrene) • halogenated VOC • hexanal (odorant, irritant) • nonanal (odorant / irritant) • styrene (odorant / irritant)
Formaldehyde	Restriction for formaldehyde		
Odour	Restriction for odour emission		

Floorings made of wood and wood-based panels

Field	*Blauer Engel, RAL-UZ 38 "Produkte aus Holz und Holzwerkstoffen"* **[182]**	*Natureplus e.V. Bodenbeläge aus Holz und Holzwerkstoffen* **[186b]**	*Nordic Ecolabelling "Panels for the building industry" [184]*	*Österreichisches Umweltzeichen UZ 07, "Holz und Holzwerkstoffe"* **[183]**
Area of application	Wood and wood-based panels, of which more than 50 per cent of their volume comprises wood, wood flour and/or derived timber products (e.g. laminate floorings, prefabricated parquet, linoleum made of wood flour, floorings with painted surfaces, panels, furniture, interior doors)	Floorings made of wood and wood-based panels	Wood and wood-based panels (e.g. veneer, fibreboard, chipboard) for interior and exterior (products for wall panelling, roofs, flooring, furniture) **Gypsum and mineral-based products (e.g. rock-wool and glass-wool)**	Wood-based products for indoor use and elements manufactured from them, such as floor, wall and ceiling elements
Prohibitions and restrictions (content)				
CMR substances			Restriction of substances classified in any of the Nordic Countries (Material Safety Data Sheets): • toxic • CMR • sensitising • N (Declaration by the manufacturer)	Restriction on use of substances classified to 67/548/EEC as: • T+, T • CMR • N
Halogenated organic compounds		Prohibition of halogenated organic compounds	Prohibition of halogenated organic compounds	
Formaldehyde			Restriction of content for free formaldehyde	
Biocides		Prohibition of biocides (e.g. triclosan) Prohibition of wood preservatives	Prohibition of biocides or other chemicals that are forbidden in Denmark, Finland, Iceland, Norway or Sweden	
Flame retardants		Prohibition of flame retardants	Prohibition of halogenated organic flame retardants	

Field	***Blauer Engel, RAL-UZ 38 "Produkte aus Holz und Holzwerkstoffen"*** **[182]**	***Natureplus e.V. Bodenbeläge aus Holz und Holzwerkstoffen*** **[186b]**	***Nordic Ecolabelling "Panels for the building industry" [184]***	***Österreichisches Umweltzeichen UZ 07, "Holz und Holzwerkstoffe"*** **[183]**
Surface coatings	Prohibition of: • substances classified to Directive 67/548/EEC as T+, T, CMR • substances classified to TRGS 905 as CMR	Prohibition of: • glycols and their esters and ethers • halogenated organic compounds • metal compounds (desiccant) • aromatic solvents	Information about substances that are to be marked according to the EU Directive or Scandinavian law as: • N Restriction of content or emission of organic solvents Prohibition on use of plastic products containing chlorine for the surface treatment (Declaration by the manufacturer)	<u>Surface coatings and/or surface treatment:</u> Prohibition of: • halogenated organic compounds • aromatic hydrocarbons • biocides (except for pot preservation) • flame retardants on the basis of halogens, Sb, As, Bor • heavy metal compounds based on Pb, Cd, Cr(VI) (restriction for Co and Mn) Restriction for: • organic solvents
Other			Prohibition of: • PCB • alkylphenols • phthalates • aziridine or polyaziridines • pigments and additives based on compounds Pb, Sn, Cd, Cr, Hg (Declaration by the manufacturer) Restriction on the content of: • aromatic solvents (Declaration by the manufacturer) • alkylphenol ethoxylates or other alkylphenol derivatives (Test)	

Field	***Blauer Engel, RAL-UZ 38 "Produkte aus Holz und Holzwerkstoffen"*** **[182]**	***Natureplus e.V. Bodenbeläge aus Holz und Holzwerkstoffen*** **[186b]**	***Nordic Ecolabelling "Panels for the building industry" [184]***	***Österreichisches Umweltzeichen UZ 07, "Holz und Holzwerkstoffe"*** **[183]**
Prohibitions and restrictions (Emission)				
VOC and SVOC	Emission restriction for: • sum of VOC (TVOC) • sum of SVOC	Emission test for VOC: • VOC (CMR substances) • sum of VOC (TVOC) • sum of aromatics • sum of sensitizing VOC • sum of saturated n-aldehydes • special individual substances Emission test for: • SVOC		Restriction for the emission of • VOC • SVOC • CMT-VOC
Formaldehyde	The use of wood-based panels: Restriction on the emission of formaldehyde	Restriction on the emission of formaldehyde	The use of wood-based panels: Restriction on the emission of formaldehyde (Test)	The use of wood-based panels • Restriction on the emission of formaldehyde (Test) Wood-based products with binders containing formaldehyde: Restriction for formaldehyde
Odour		Restriction on the emission of odours		
Other	Restriction on the emission of CMT substances	Products with polyurethane binder: Emission test for: • monomeric isocyanates		Wood-based products with binders based on polymeric MDI • No emission of monomer MDI Wood-based products with phenol-based binders: • Restriction on the emission of phenol

Annex A12: Limit values for wood chips used in the manufacture of wood-based panels according to the German Waste Wood Ordinance (*Altholzverordnung*) [97]

Element/compound	Concentration (milligrams per kilogram dry mass)
Arsenic	2
Lead	30
Cadmium	2
Chromium	30
Copper	20
Mercury	0.4
Chlorine	600
Fluorine	100
Pentachlorophenol	3
Polychlorinated biphenyl	5