

# **Hygienic requirements for cement-bound materials intended for use in drinking water supply systems (concrete containers) – testing and evaluation – special case hygienic requirements for in-situ-concrete and in-situ-cement-bound materials**

## **Author**

Dipl.-Ing. Peter Frenz  
Technical Manager Corrosion Protection & Water Storage  
Water Department

Phone: +49 228 9188-654

Fax: +49 228 9188-988

E-Mail: [frenz@dvqw.de](mailto:frenz@dvqw.de)

DVGW Head Office

Josef-Wirmer-Str. 1-3, 53123 Bonn, Germany

Web site: [www.dvqw.de](http://www.dvqw.de)

## **Introduction and Background**

Council Directive 98/83/EC *on the Quality of Water Intended for Human Consumption (DWD)* [1] establishes a high level of protection for the consumer and requires Member States to ensure that substances and materials used in preparation and distribution of drinking water do not reduce that level of protection.

In accordance with Article 10, construction and other materials that when in contact with water release substances in concentrations higher than considered inevitable by the generally accepted engineering standards, or that directly or indirectly infringe the human health regulations stipulated by this Ordinance, or that alter the odour or flavour of the water, shall not be used for linings intended for use in contact with drinking water.

### **Article 10:**

*"Quality assurance of treatment, equipment and materials Member States shall take all measures necessary to ensure that no substances or materials for new installations used in the preparation or distribution of water intended for human consumption or impurities associated with such substances or materials for new installations remain in water intended for human consumption in concentrations higher than is necessary for the purpose of their use and do not, either directly or indirectly, reduce the protection of human health provided for in this Directive; the interpretative document and technical specifications pursuant to Article 3 and Article 4 (1) of Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products ... shall respect the requirements of this Directive."*

The former Federal Health Agency has not issued any recommendations on cement-bound and lining materials. As the physical behaviour of such materials differs from that of plastic materials, the Plastics and Drinking Water Recommendations cannot be borrowed verbatim.

This article describes the requirements for and the testing of cement-bound materials intended for use in drinking water supply systems especially for drinking water reservoirs. In focus is the practicable use of the rules for in-situ-concrete and in-situ-cement-bound materials:

- Which requirements and hygienic aspects have to be taken into account for design and technical specifications and which mistakes have to be avoided?
- Which conformity document/certificates have to be demanded from potential tenderers during contract award and accepting tenderers?
- What has the quality management respectively to in-situ-concrete due to hygienic aspect to consider?

### **Test method**

The base of the test method for in-situ-concrete and in-situ-cement-bound materials is EN 14944 [2, 3], *Influence of cement-bound products on water intended for human consumption - Test methods* even if this standard is for factory-made cement-bound materials:

EN 14944-1 [2], *Influence of cement-bound products on water intended for human consumption - Test methods – Part 1: Influence of factory-made cement-bound products on organoleptic parameters*

EN 14944-3 [3], *Influence of cementitious products on water intended for human consumption - Test methods - Part 3: Migration of substances from factory-made cementitious products*

These two parts of the standard describe methods for the determination of the influence of factory made cementitious products on the organoleptic characteristics of drinking water as

odour, flavour, colour and turbidity and the migration of substances into test waters after contact with the products.

A test method for the production of migration water is described and a reference to the standards for the determination of the organoleptic parameters is given.

They are applicable to factory made cementitious products, e. g. cement mortar linings to metallic pipes, tanks, concrete pipes etc., intended to be used for the transport and storage of water intended for human consumption, including raw water used for the production of drinking water.

The next chapters describe how the test specimens and the test method are specified and give guidance for evaluation.

### **Test specimens and migration testing**

The following test specimens may be used:

- Product test specimens (e.g., pipes and pipe fittings and containers);
- Test specimens consisting of a mortar or concrete of a specified composition including the source material to be tested;
- Test specimens in conformance with a specific formulation (e.g. dry batch).

The examination of mortar linings and casings and/or coatings of pipes or concrete pipes and concrete containers is usually carried out on pipe sections, pipe segments or cored samples, and also, in some exceptional cases, on prisms of identical composition.

Cements, aggregates, additives, admixtures, pigments, fibres and consumables as well as near drinking-quality water and residual waters intended for use in mortar shall be tested in mortar (on the basis of EN 196-1 [4]: one part cement, three parts standard sand - and/or the aggregate to be tested –, water-cement ratio 0.50), and, when intended for use in concrete, in a concrete containing 330g of cement, 165g of drinking water and 1,900g of unsplit aggregate - and/or the aggregate to be tested –, particle-size distribution curve B8, in accordance with DIN 1045-2 [5]. When testing additives or admixtures, for instance, it may be necessary to vary the amount of water in order to achieve the appropriate consistency; this shall be mentioned in the test report. Whether or not an additive or admixture will be counted as water in the mixture depends on the standard applied and/or the approval of the substance by the construction supervision authorities.

If prefabricated dry batches (preparations) are used, tests shall be carried out on the cured products. In this case, application conditions shall not be more favourable than in real-life situations and shall conform to the manufacturer's instructions.

For concretes and mortars, prisms measuring 4cm x 4cm x 16cm shall be used as test specimens. Test slabs may also be used (e.g. cement mortar for container linings) whenever justified by the circumstances.

### **Test specimens for microbiological testing in accordance with DVGW Code of practise W 270 [6]**

Cements, aggregates, additives, admixtures, pigments, fibres and consumables intended for use in mortar shall be tested in mortar (on the basis of EN 196-1 [4]: one part cement, three parts standard sand, water-cement ratio 0.50), and, when intended for use in concrete, in a concrete containing 330g of Portland cement, 165g of drinking water and 1,900g of unsplit aggregate, particle-size distribution curve B8, in accordance with DIN 1045-2 [5]. When testing additives or admixtures, for instance, it may be necessary to vary the amount of water in order to achieve the appropriate consistency; this shall be mentioned in the test report. Whether or not an additive or admixture will be counted as water in the mixture depends on the standard applied and/or the approval of the substance by the construction supervision authorities.

If prefabricated dry batches (preparations) containing organic additives, admixtures, pigments or fibres are used, the tests shall be carried out on the cured products. In this case,

application conditions shall not be more favourable than in real-life situations and shall conform to the manufacturer's instructions.

Slabs measuring at least 20cm x 20cm x 1cm shall preferably be used as test specimens. The ratio of the diameter of the maximum grain size of the aggregate to the thickness of the test specimen shall be at least five. In other words, concrete containing aggregate with a maximum grain size of 8mm shall be at least 4cm thick. The examination of mortar linings and/or coatings of pipes or concrete pipes may also be carried out on pipe sections or pipe segments.

Specified surface area-to-volume ratio [cm <sup>2</sup> ml <sup>-1</sup> ]	Number of Prisms	Prism dimensions [cm <sup>3</sup> ]	Actual surface area-to-volume ratio [cm <sup>2</sup> ml <sup>-1</sup> ]
1 : 1	6	4 x 4 x 16	1 : 1.3
1 : 4	3	4 x 4 x 16	1 : 3.5
1 : 6	2	4 x 4 x 16	1 : 5.7

**Table 1 – Number and dimension of prisms/cubes required to achieve the surface area-to-volume ratios specified for the tests**

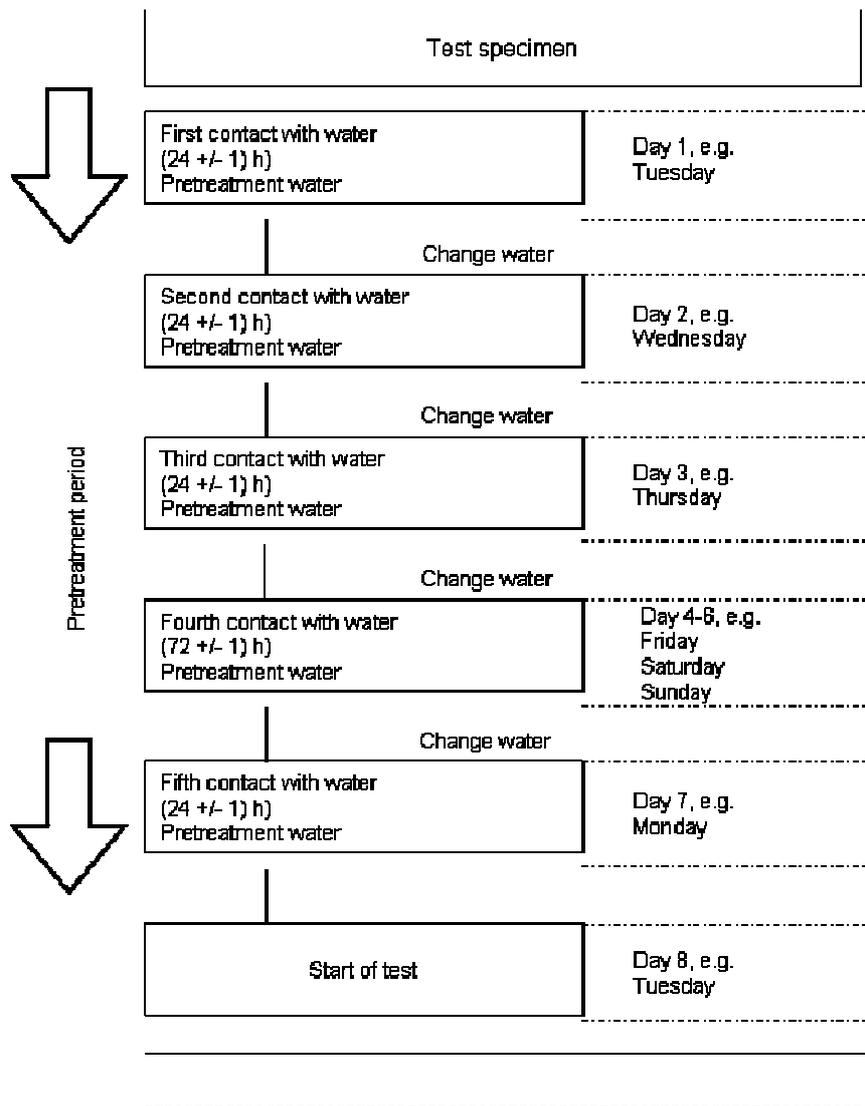
#### **Production and pretreatment of test specimens**

Test specimens shall be made by lining moulds with e.g. a plasticiser-free synthetic film, followed by placing the mortars and concretes specified above in the formwork. When testing consumables such as, for instance, formwork release agents, these materials shall be applied to the formwork as in real-life applications, distinguishing between absorptive and non-absorptive formwork. The mortar, concrete, etc. shall stay inside the mould for 24 hours minimum, making sure that the atmospheric humidity of the ambient air is > 90%.

Test specimens shall be removed from the moulds no sooner than after 24 hours and stored for a maximum of 28 days in accordance with DIN EN 196-1 [4], the last eight days of storage doubling as pretreatment time. Pretreatment water shall be prepared by dissolving (222 +/- 2) mg anhydrous calcium chloride (CaCl<sub>2</sub>) and (336 +/- 2) mg sodium hydrogen carbonate (NaHCO<sub>3</sub>) in one litre of demineralised water. The pH is determined according to ISO 15023 [7] and adjusted to 7.4 +/- 0.1 by passing air and/or CO<sub>2</sub> through the solution. The hardness level shall be 200mg l<sup>-1</sup> CaCO<sub>3</sub>; the alkalinity level 244mg l<sup>-1</sup> HCO<sub>3</sub> (in accordance with EN 14944-1 [2]). Alternatively, drinking water identical in composition to the pretreatment water specified above may also be used.

Pretreatment shall be carried out according to the diagram shown below (Fig. 1). Any deviations shall be mentioned in the test report.

After pretreatment, test specimens shall be rinsed with drinking water; the required tests shall be carried out immediately afterwards.



**Figure 1 – Pretreatment, time schedule**

### Testing

The test water obtained during contact testing with reference water shall be examined for external quality. The contact test shall last 72 hours and shall be repeated twice. Water of the composition described in table 2 shall be used as reference water.

Parameter	Method of analysis	Requirement
Electrical conductivity ( $\mu\text{S cm}^{-1}$ )	DIN EN 27888	500 +/- 50
pH	ISO 10523	7.3 +/- 0.2
Organic carbon ( $\text{mg C l}^{-1}$ )	DIN EN 1484	< 0.2
Calcium ( $\text{mg Ca}^{-1}$ )	ISO 6058	80 +/- 10
Alkalinity ( $\text{mg HCO}_3^- \text{l}^{-1}$ )	DIN EN ISO 9963-1/-2	350 +/- 50
Silicate ( $\text{mg SiO}_2 \text{l}^{-1}$ )	ISO 16264	15 +/-5
Odour (TON)	DIN EN 1622	<2

Flavour (TFN)	DIN EN 1622	<2
Colour (m <sup>-1</sup> )	DIN EN ISO 7887	<0.1
Turbidity (FNU)	DIN EN ISO 7027	<0.1

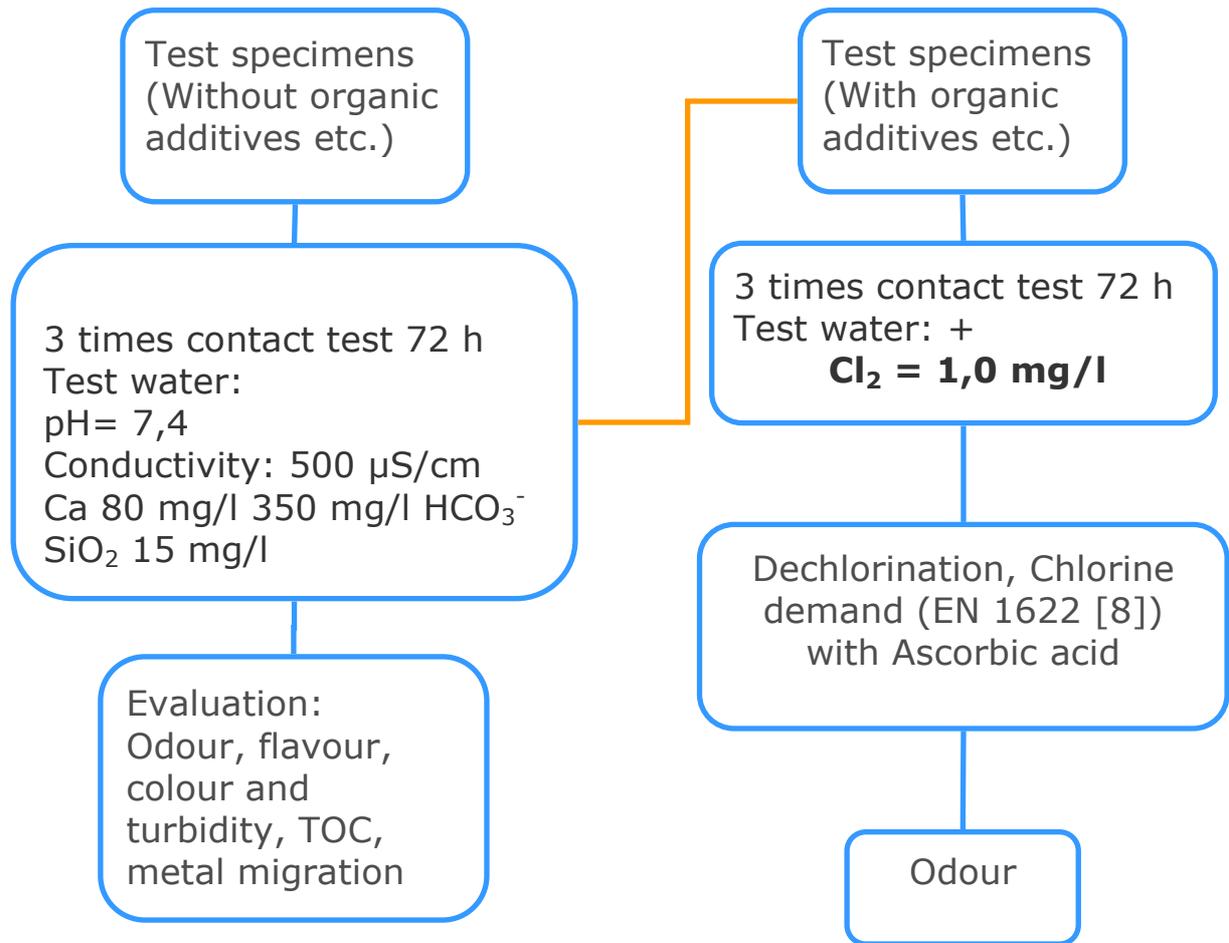
**Table 2 – Reference/test water composition**

When examining organic additives, admixtures, pigments, fibres and consumables, water of the composition described in EN 14944 [2, 3] with - after adding a sodium hypochlorite solution - a free chlorine content of (1.0 +/- 0.2) mg/l<sup>1</sup> in the form of Cl<sub>2</sub> shall be used as reference water.

When testing mortar linings and casings and/or coatings of pipes or concrete pipes and concrete containers, test specimens shall be dimensioned so that the specified surface area-to-volume ratio is either met or observed as best as possible. When testing prisms, the number of test specimens defined in Table 1 shall be used in order to obtain the specified surface area-to-volume ratio for the predefined total volume of 3,800ml approx. (test water and test specimen) of the test vessel.

After contact testing has been concluded, the pH of the test water shall be adjusted to 7.0 +/- 0.1. If the test was carried out with chlorinated water, the test water shall be dechlorinated with ascorbic acid solution in accordance with EN 1622 [8]. The threshold odour number (TON) shall be determined in accordance with EN 1622 [8] and the turbidity and colour of the test water shall be determined in accordance with EN ISO 7027 [9] and EN ISO 7887 [10], respectively. The values obtained from the last test water sample, which form the basis of the evaluation, shall be lower than or identical to those of the previously tested test water samples.

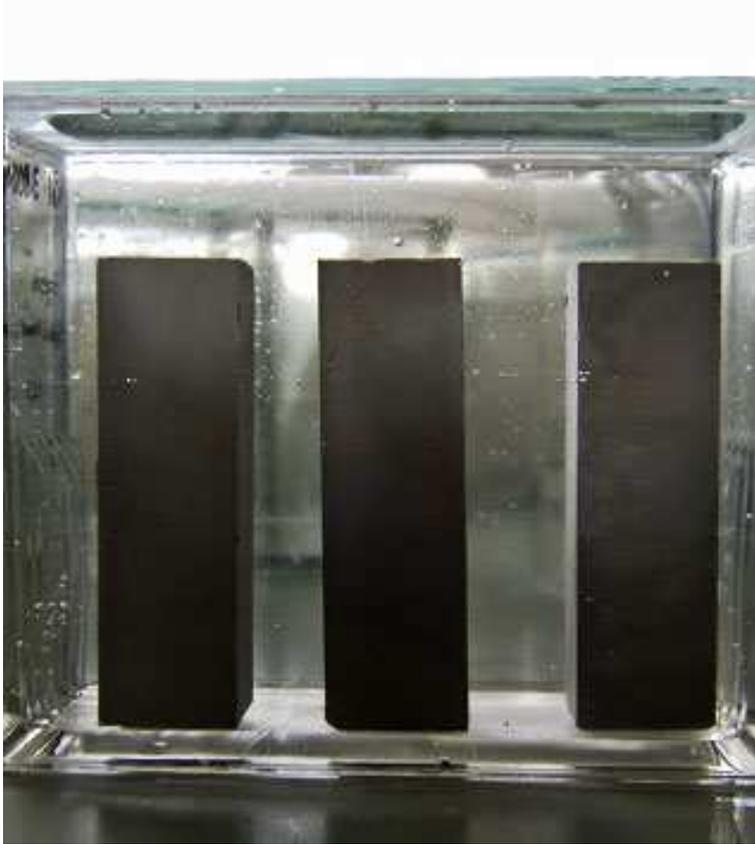
The test water sample obtained in the contact test with the reference water shall be analysed for the release of TOC, arsenic, lead, cadmium, chromium, lithium and nickel. The contact test shall last 72 hours and shall be repeated twice. Microbiological behaviour shall be tested in accordance with DVGW W 270 [6].



**Figure 2 – Test scheme**



**Figure 3 – Product test specimens (e.g., pipes and pipe fittings and containers)**



**Figure 4 – Product test specimen prisms**

**Requirements**

The hygienic safety of cement-bound materials can be verified either on the finished product, or for the individual source materials.

Table 5 lists the fields of application for both cement-bound materials and components intended for use in drinking water supply systems.

If the absolute content in the cement [percent by mass] of the elements listed in the following is below the specified values, the test water need not be screened for these elements in question.

Arsenic	0.01	percent by mass
Cadmium	0.001	percent by mass
Chromium	0.05	percent by mass
Nickel	0.05	percent by mass
Lead	0.05	percent by mass

**Table 3: Absolute content in the cement [percent by mass] of the elements listed**

Table 5 presents an overview of the fields of application of and the amount of inspection required for cement-bound materials and components intended for use in drinking water supply systems.

Hygiene requirements (cf. Table 4) are subdivided into source material requirements and product requirements. The use of additives, admixtures, pigments or fibres requires testing with mortar or concrete, always using the maximum dosage in accordance with manufacturer's specifications. Product requirements are also considered met if all source materials involved have passed the test. The use of a combination of several organic additives is not permitted in the field, however.

Additives, admixtures, pigments, fibres and consumables shall be technically necessary and listed accordingly on a positive list together with their constituents, if applicable.

All auxiliary materials used for additives, admixtures, pigments, fibres and consumables shall conform also to the positive list.

Any concrete areas inside of drinking-water containers shall be produced with formwork that does not require the use of formwork release agents (draining formwork).

Circumstances necessitating formwork that does require the use of auxiliary construction material/formwork release agents/forming oils shall be discussed separately with the client.

Any areas stripped of their formwork that still contain any of these substances shall not come into contact with the drinking water and/or, for that matter, any potential dripping or condensation water. Such circumstances require further measures like e.g. cleaning measures in order to remove the auxiliary construction material, or the insertion of a waterproofing layer between the concrete area stripped of its formwork and the water by adding a layer of mortar of a minimum thickness of 10 mm or by another suitable technique.

The migration rates ( $\text{mg m}^{-2}\text{d}^{-1}$ ) calculated using test waters shall not exceed the limit values that apply to cement-bound materials intended for use in contact with drinking water. Furthermore, migration values must not increase between the 1<sup>st</sup> and the 3<sup>rd</sup> extraction.

<b>Field of application</b>	<b>Materials and components</b>	<b>Source materials</b>	<b>Products</b>
I	Cement mortar linings for cast-iron and steel pipes	Table: not included into the text	Table: not included into the text
II	Concrete pipes $\geq$ DN 300, concrete containers, cement mortar for containers	Table 6a	Table 6b
III	Tile adhesive, grout, cement mortar linings for fittings, repair mortar for e.g. welds, concrete pipes for raw water conduits, cement mortar coatings on tapings	Table: not included into the text	Table: not included into the text
IV	Components in drinking-water	Table: not included into the text	Table: not included into the text

	protection areas I, II or III		
--	-------------------------------	--	--

**Table 4 – Hygiene requirements for cement-bound materials and components intended for use in drinking water supply systems**

Tests	Drinking-water supply/ raw water supply	Components in drinking- water protection areas
<b>Migration tests</b>		
<b>External quality</b>		
Colour	+	-
Odour	+	-
Turbidity	+	-
Foaming tendency	+	-
<b>Water tests</b>		
TOC release	+	-
Arsenic release <sup>1)</sup>	+	+
Lead release <sup>1)</sup>	+	+
Cadmium release <sup>1)</sup>	+	+
Chromium release <sup>1)</sup>	+	+
Lithium release <sup>2)</sup>	+	-
Nickel release <sup>1)</sup>	+	+
<b>Microbiological test</b>		
DVGW W 270 <sup>3)</sup> [6]	+	-

Test: +; no test: -

1) Test required only if element contents are exceeded.

2) Test required only if lithium compounds are used as admixtures.

3) Test required only if organic additives, admixtures, pigments, fibres or consumables are used.

**Table 5 – Fields of application and amount of inspection for cement-bound materials and components intended for use in drinking water supply systems**

Cement	Cements in accordance with EN 197-1 [11] and DIN 1164 [12] or other cements approved by the construction supervision authorities as well as calcium aluminate cements in accordance with EN 14647 [13].
Aggregate	Clean unsplit or split aggregate in accordance with EN 13139 [14] and EN 12620 [15].
Addition water	Addition water shall conform to DIN 1045-2 [5]. Suitable waters are drinking water or near drinking-quality water or residual waters whose acid potassium permanganate index – relative to O <sub>2</sub> - does not exceed

	20mg l <sup>-1</sup> . These tests can be omitted if drinking water is used.
Additives	Additives shall conform to DIN 1045-2 [5]. Inorganic additives consisting of the components and organic additives consisting of the components of the “positive list” may be used. BfR Recommendation LII shall be observed at all times to ensure the purity of inorganic additives.
Admixtures	Admixtures shall conform to DIN 1045-2 [5]. Concrete plasticisers, water reducers and retarders consisting of the components of the “positive list” may be used. Admixtures consisting of the components of the “positive list” may be used for cement mortars intended for container linings if their constant composition is ensured by quality assurance measures in accordance with EN ISO 9000 [15] through EN ISO 9004 [16].
Pigments	Pigments shall conform to DIN 1045-2 [5]. Pigments consisting of the components of the “positive list” may be used. Pigments consisting of the components of the “positive list” may be used for cement mortars intended for container linings if their constant composition is ensured by quality assurance measures in accordance with EN ISO 9000 [15] through EN ISO 9004 [16].
Fibres	Fibres shall be approved by the construction supervision authorities. Fibres consisting of the components of the “positive list” may be used. Fibres consisting of the components of the “positive list” may be used for cement mortars intended for container linings if their constant composition is ensured by quality assurance measures in accordance with EN ISO 9000 [15] through EN ISO 9004 [16].
Consumables	Consumables consisting of the components of the “positive list” may be used if their constant composition is ensured by quality assurance measures in accordance with EN ISO 9000 [15] through EN ISO 9004 [16].

**Table 6 a – Requirements for source materials for concrete pipes ≥ DN 300, concrete containers and cement mortar for container linings (Application field II)**

Tests	Requirements
External quality: turbidity, colour, odour and foaming tendency	When tested, the test water shall not show any changes for a surface area-to-volume ratio of 1:4 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of organic compounds, counted as total organic carbon (TOC)	When tested, TOC release shall not exceed 10mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of arsenic ions or arsenic compounds, counted as arsenic <sup>1</sup>	When tested, the release of arsenic shall not exceed 0.05mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of lead ions or lead compounds, counted as lead <sup>1)</sup>	When tested, the release of lead shall not exceed 0.1mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of cadmium ions or cadmium	When tested, the release of cadmium shall

compounds, counted as cadmium <sup>1)</sup>	not exceed 0.05mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of chromium ions or chromium compounds, counted as chromium <sup>1)</sup>	When tested, the release of chromium shall not exceed 0.3mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of lithium ions or lithium compounds, counted as lithium <sup>2)</sup>	When tested, the release of lithium shall not exceed 0.3mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Release of nickel ions or nickel compounds, counted as nickel <sup>1)</sup>	When tested, the release of nickel shall not exceed 0.2mg m <sup>-2</sup> d <sup>-1</sup> for a surface area-to-volume ratio of 1:1 (cm <sup>2</sup> ml <sup>-1</sup> ).
Microbiological requirements	When using organic additives, admixtures, pigments, fibres or consumables, the microbiological behaviour of these substances shall conform to the requirements set forth in DVGW W 270 [6] with regard to mortar and/or concrete.

1) Test required only if element contents are exceeded.

2) Test required only if lithium compounds are used as admixtures.

**Table 6 b – Requirements for concrete pipes ≥ DN 300, concrete containers and cement mortar for container linings, and/or applicable test specimens (Application field II)**

## **Positive list (list of toxicologically assessed basic materials suitable for use in drinking-water supply)**

The Positive List lists those substances for which toxicological testing is not required.

Most of the toxicological assessment base on experience and publications of the European Food Safety Authority (EFSA) and national agencies. The European Food Safety Authority provides the European Commission with independent scientific advice on all matters with a direct or indirect impact on food safety. It is a separate legal entity, independent from the other EU institutions.

Here, the term "Positive List" has not to be understood that these substances can be used without testing in cement-based materials for contact with drinking water as described above.

Rather, the correspondence of a substance with the positive list is the basic condition for pigments, fibres and auxiliary building materials being used in cement-based materials for contact with drinking water.

Even for cementitious materials, which consist exclusively of listed substances must meet the necessary hygienic tests of the product in each case and to demonstrate by examination as described in chapters above.

In the following the toxicologically assessed basic materials are listed:

### Inorganic additives

- Coal fly ash according EN 450-1 [17]
- Silica dust (powder or in aqueous suspension) of Technical Approval
- Tempered minerals of Technical Approval
- Natural pozzolanic additives

### Organic additives

Dispersions and polymer powders, which correspond to the recommendation of the BfR XIV [19].

### Admixtures - Inorganic constituents

- Fillers, which correspond to the recommendation of the BfR LII [18]
- Aluminates of sodium and potassium
- Carbonates of sodium 1, potassium, and lithium
- Ortho-and polyphosphates of sodium 1 potassium 1 and calcium
- Lithium polysilicate
- Sulphate of aluminium 1, sodium, potassium, lithium, magnesium, iron and tin

### Admixtures - Organic constituents

- Ligninsulfonate
- Melaminsulfonate
- Naphthalinsulfonate
- Polycarboxylate, which correspond to the recommendation of the BfR XIV [19]
- Citric acid, tartaric acid and its sodium and potassium salts
- Sugar and sugar derivatives
- Formiate
- non-ionic / anionic surfactants

- Soaps of natural resins
- Stearate
- Cellulose ether
- Cellulose fibres
- Starch ether

### Pigments

Against the use of pigments for colouring cementitious materials for contact with drinking water are no objections, provided that they correspond to the recommendation of the BfR IX [20] and under normal use no traces of substances pass into the drinking water.

### Fibres

Against the use of fibres for colouring cementitious materials for contact with drinking water are no objections, if the starting material of the fibers water is suitable for contact with drinking.

The starting materials for polymer fibers have to be assessed and correspond to the BedarfsgegV annex 3 [21].

- Glass fibers Fillers, which correspond to the recommendation of the BfR LII [18]
- Steel fibers
- Polymer fibers (molecular weight greater than 1000)

### Auxiliary building materials/consumables

- Assessed materials in accordance with EFSA
- Paraffin, liquid, purity requirements corresponding to BuGBI 25 (1982), P. 192 [22]
- Separating film formers: hydrocarbons corresponding to BfR XXV [23], boiling range 250 °C up to 350 °C
- Additives for separating film formers corresponding to BedarfsgegV
- Straight-chain, saturated or unsaturated fatty acids with an even number of carbon atoms C8-C20 (E 570) and its calcium and sodium salts (E 470)
- Amides of straight-chain, saturated or unsaturated fatty acids with an even number of carbon atoms C8-C20
- Glycerine ester of straight-chain, saturated or unsaturated fatty acids with an even number of carbon atoms C8-C20
- Dioctyl sulfosuccinate, sodium salt
- C8-C20 aliphatic acids esterified with mono-and / or up to (2-hydroxyethyl) amine

### Additives in additives, admixtures and auxiliary building materials/consumables

As preservatives in additives, admixtures and auxiliary building materials/consumables, small amounts ( $\leq 0.5$  wt -%, based on the additive, admixtures or the auxiliary building material/consumables) can be used the following substances:

- Formaldehyde-releasing compounds
- Isothiazolinones

As defoamers in additives, admixtures and auxiliary building materials/consumables, small amounts ( $\leq 0.5$  wt -%, based on the additive, admixtures or the auxiliary building material/consumables) can be used the following substances:

- Tributyl phosphate corresponding to BfR XIV [19]
- Polydimethylsiloxane corresponding to BfR XV [24]

- Fatty alcohols, fatty acids as aqueous emulsion

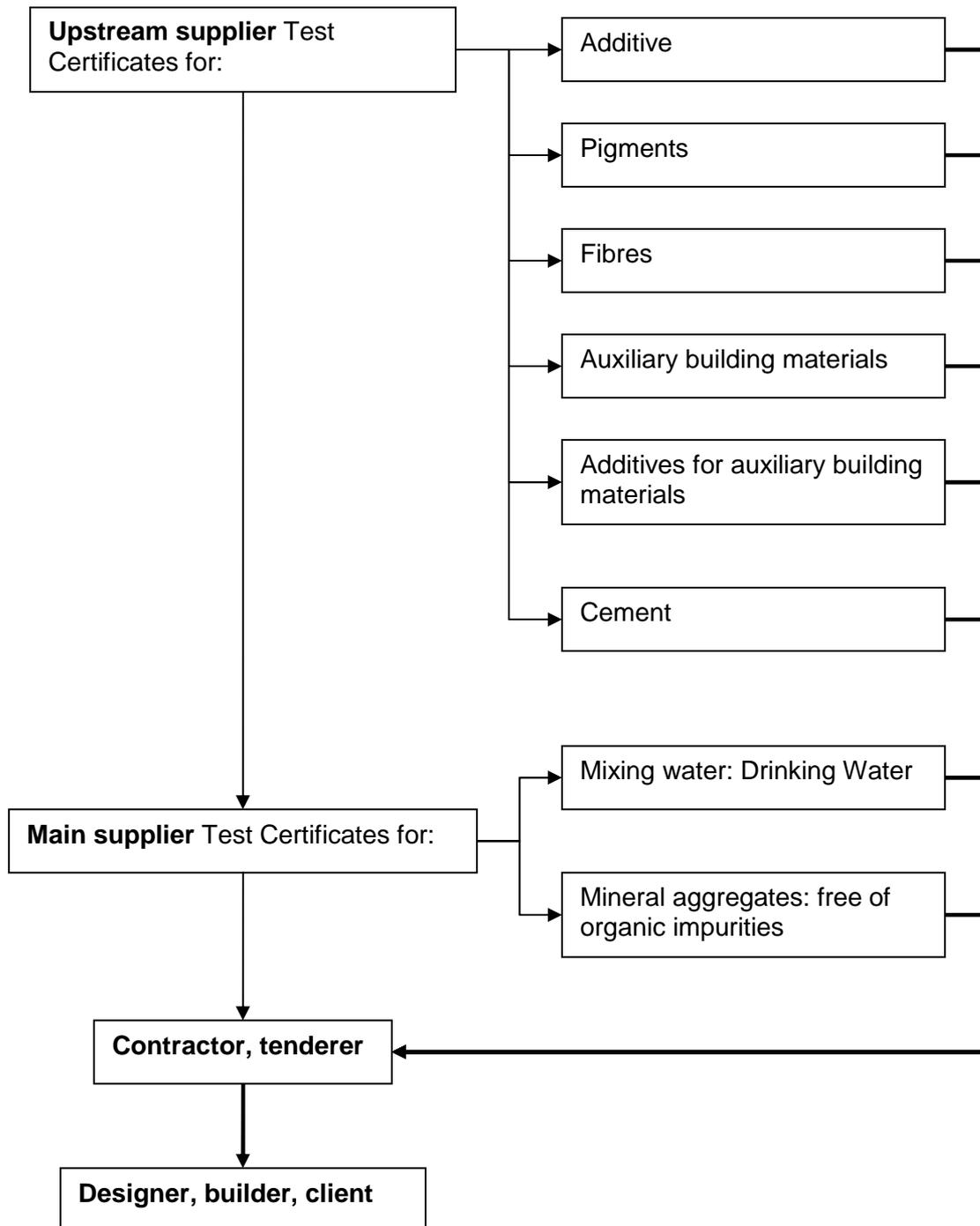
### **Conformity documents/certificates**

For demonstrating the conformity of the hygienic suitability of cement-bound materials the demand of test certificates during the tendering procedure and construction is necessary. These are taken into account in awarding contracts.

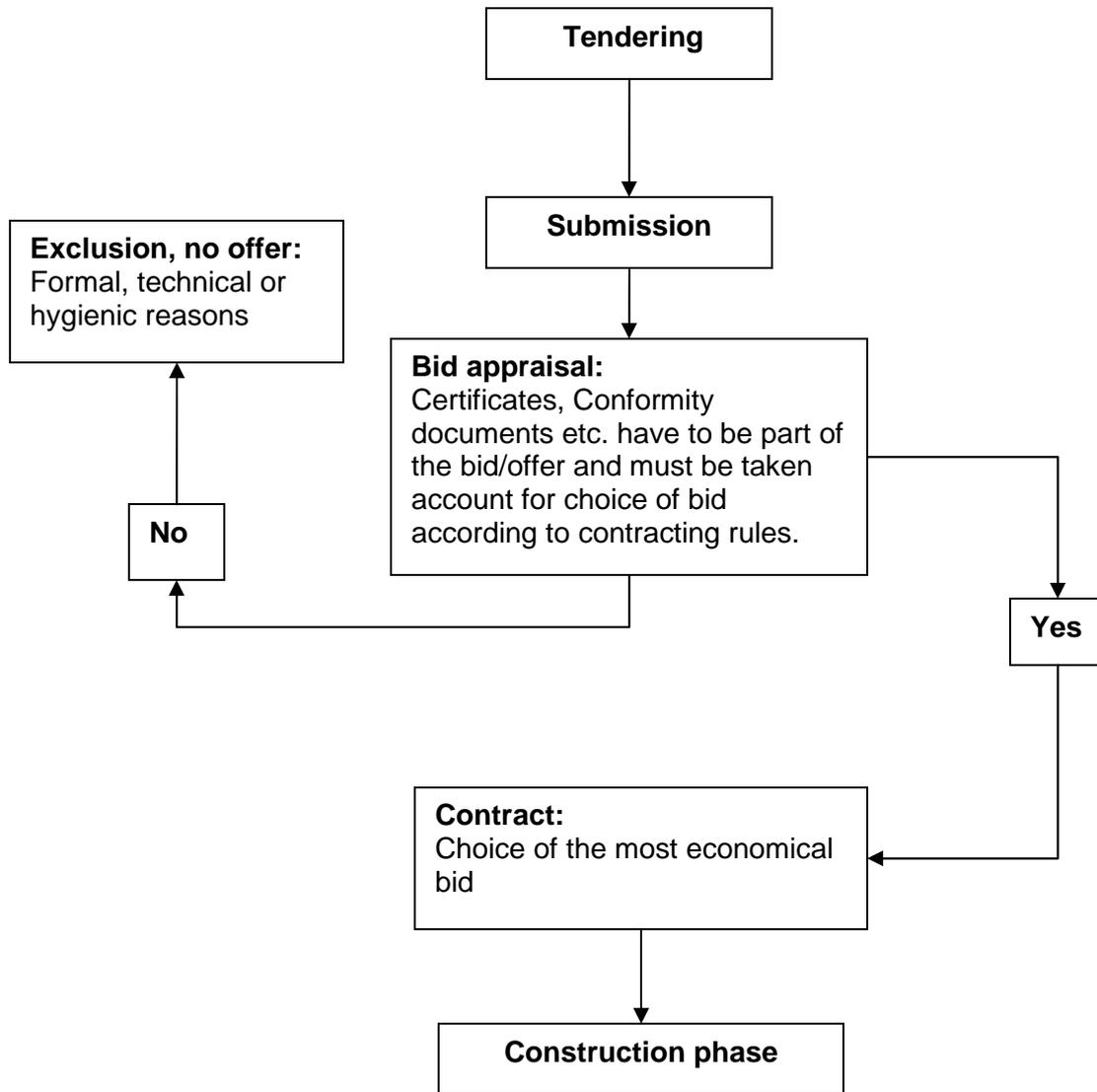
As may be required generally the separate certificates in the respective maximum concentration for the starting materials, it is reasonable that the main supplier (concrete producers, concrete factory) requests them from its Upstream suppliers (etc., cement manufacturers, additive manufacturers).

If no certificates requested during the tendering and awarding, it is often useful to conduct the hygienic test in the preparatory phase of construction. The duration of such an assessment must be taken into account for construction phase. Nevertheless, all substances have to fulfill the requirements of the positive list.

In the following diagrams the relevant procedures and responsibilities are illustrated.



**Figure 5 – Responsibility for conformity documents/certificates**



**Figure 6 – Relevant procedure for requesting conformity documents/certificates**

**Quality management and supervision during construction phase regarding the use of appropriate hygienic cementitious materials**

A suitable method of final quality control of the finished construction product is preparation of test specimens and their testing. The tests on the specimens should be performed due to the large expenditure, only in case of clarifying responsibility in case of damage. This serves to clarify the subsequent liability. The specimens are therefore to be considered primarily as reserve samples. The following sections explain what to consider in the preparation of test pieces on the building site. A distinction is made between specimens, which are used for migration testing and microbiological testing.

**Test specimens**

**Preparation of Test specimens for subsequent migration test:**

The production and storage of the specimen should be done by a contractor commissioned by the approved and notified testing laboratory. The production of the specimen may also be carried out by a specialist of the contracting body itself or by the building owner authorized specialists. The size and number of Test specimens are directed according to the type of test.

The Test specimens should be randomly produced and taken at the beginning and end of concreting.

For preparation of the Test specimens forms should be used according to the formwork surfaces, such as those used on the construction site of concrete surfaces for contact with drinking water (including for example, drainage fleece). Otherwise, the shape should be lined with a plasticizer-free plastic foil before the mortar or concrete are filled into the mold. If suitable auxiliary building materials, such as release agents, are used, the formwork has to be applied with these agents, instead of the foil. In general it is necessary to refrain from the use of formwork oil.

Furthermore, the preparation of specimens for a comparison test to a test specimens without releasing or lined with fleece but required only a plasticizer-free foil, is necessary. This is the only chance to verify if the cause of damage is due to the concrete by itself or caused by the formwork conditions.

As test specimens for the subsequent migration test of concrete are cubes of dimensions 10 cm x 10 cm x 10 cm according to EN 12390-2 [25] useful. Where justified, also test plates may be used (e.g. cement mortar linings for reservoirs). For the subsequent microbiological testing Test specimens should be provided with a surface of at least 800 cm<sup>2</sup>. Cubes of dimensions 10 cm x 10 cm x 10 cm fulfill this condition.

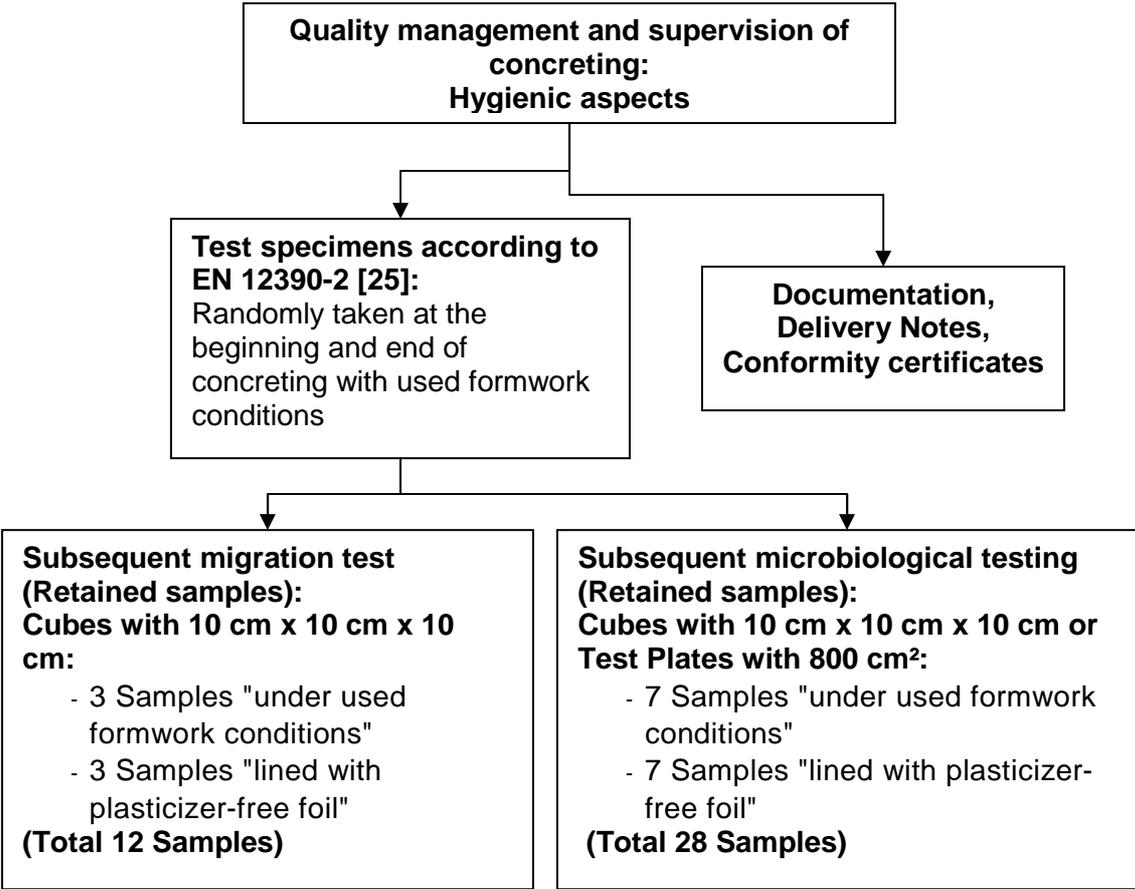


Figure 6 – Scheme of the approach to quality assurance and verification during the construction phase

## Conclusions

It is clear that the technical standards for concrete do not consider the hygienic aspects and requirements for use in drinking water. The hygienic aspects for concrete or cement-based materials used in contact with the drinking water, regulates the above described testing and evaluation.

To avoid damage to the drinking water it is necessary to take into account the hygienic requirements in practice. Often the lack of knowledge of the non-hygienic suitability of cement-based materials inserted the cause of unwanted change of the drinking water quality.

The illustrations show that the choice of a suitable concrete for drinking water tanks/containers brings a lot of effort for the designer and construction supervisor with it. A technical competence and thematic analysis by the engineer and designer is therefore essential.

The material specific hygiene requirements have as much priority as the technical requirements and must be respected.

## Literature:

- [1] Council Directive 98/83/EC on the Quality of Water Intended for Human Consumption (DWD)
- [2] EN 14944-1, Influence of cement-bound products on water intended for human consumption - Test methods – Part 1: Influence of factory-made cement-bound products on organoleptic parameters
- [3] EN 14944-3, Influence of cementitious products on water intended for human consumption - Test methods - Part 3: Migration of substances from factory-made cementitious products
- [4] EN 196-1, Methods of testing cement - Part 1: Determination of strength
- [5] DIN 1045-2, Concrete, reinforced and prestressed concrete structures - Part 2: Concrete - Specification, properties, production and conformity - Application rules for EN 206-1
- [6] DVGW Code of practise W 270, Microbial Enhancement on Materials to Come into Contact with Drinking Water – Testing and Assessment
- [7] EN ISO 15023-1, Plastics - Poly(vinyl alcohol) (PVAL) materials - Part 1: Designation system and basis for specifications
- [8] EN 1622, Water quality - Determination of the threshold odour number (TON) and threshold flavour number (TFN)
- [9] EN ISO 7027, Water quality - Determination of turbidity
- [10] EN ISO 7887, Water quality - Examination and determination of colour

- [11] EN 197-1, Cement - Part 1: Composition, specifications and conformity criteria for common cements
- [12] DIN 1164, Special cement - Composition, specifications and attestation of conformity, DIN 1164-10, Special cement - Part 10: Composition, requirements and conformity evaluation for special common cement
- [13] EN 14647, Calcium aluminate cement - Composition, specifications and conformity criteria
- [14] EN 13139, Aggregates for mortar
- [15] EN ISO 9000, Quality management systems - Fundamentals and vocabulary
- [16] EN ISO 9004, Managing for the sustained success of an organization - A quality management approach
- [17] EN 450-1, Fly ash for concrete - Part 1: Definition, specifications and conformity criteria
- [18] BfR (Federal Institute for Risk Assessment) Recommendation LII., Fillers for plastic requisites. Federal Law Gazette 40 (1997), p. 109 et seq.
- [19] BfR Recommendation XIV, Dispersed synthetic resins. Federal Law Gazette 45 (2002), p. 463 et seq.
- [20] BfR Recommendation IX, Colouring agents for dyeing plastics and other polymers used for requisites. Federal Law Gazette 37 (1994), p. 363 et seq.
- [21] BedarfsgegV annex 3 Ordinance on requisites of December 23, 1997 (Federal Law Gazette I (1998), p. 5 et seq., latest amendment on January 7, 2004, Federal Law Gazette I (2004), p. 31 et seq.
- [22] BuGBI Federal Law Gazette 25 (1982), P. 192
- [23] BfR Recommendation XXV, Paraffin waxes, microcrystalline waxes and their wax, resin and plastics mixtures, Federal Law Gazette 42 (1999), p. 280 et seq.
- [24] BfR Recommendation XV, Silicones. Federal Law Gazette 46 (2003), p. 444 et seq.
- [25] EN 12390-2, Testing hardened concrete - Part 2: Making and curing specimens for strength tests