MaiD Final report

Material and product innovation through knowledge based standardization in drinking water sector

– Report 3

Nordic Innovation

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through knowledge based standardization in drinking
water sector
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A Nordic Innovation project

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Preface

This document is the final report (Report 3) of the Nordic cooperation project entitled: "MaiD – Material and product innovation through knowledge based standardization in drinking water sector". The project has been funded by the Nordic Innovation and the MaiD project partners in Denmark, Finland, Norway and Sweden. MaiD was implemented from May 2014 to June 2017. The background for this project has been the different practice to verify that drinking water products are fit for use (i.e. in accordance with the regulations) in the Nordic countries. The practice and regulations are also different for indoor and outdoor water installations among these countries. Hence, different burdens regarding approval testing and certification for the industry operating on the Nordic market are created, which makes it challenging to maintain a level playing field.

The main objective of MaiD was to identify the key components that should be included in the national approval procedures in the Nordic countries in order to safeguard drinking water, material quality and ensure a level playing field. The recommendations to the national procedures have been based on European standards and practice as far as possible. The report has been prepared by the following institutions in the project steering committee:

SINTEF (Norway), Satakunta University of Applied Sciences (SAMK)/WANDER (Finland), Swerea KIMAB (Sweden) and Danish Technological Institute (Denmark).

The report has been written as recommendations to the Authority Advisory Group (AAG) and the Industry Advisory Group (IAG) which have contributed with information regarding current legislation, certification and approval practice, potential innovation hindrances etc. The following institutions have been participating in these two advisory groups (alphabetic order):

City of Gothenburg, department of sustainable waste and water (Sweden) (AAG)	Norwegian building authority (Norway) (AAG)
Cupori (Finland) (IAG)	Norwegian Food Safety Authority (Norway) (AAG)
Danish Environment Protection Agency (Denmark) (AAG)	Norwegian Water BA (Norway) (IAG)
Danish Industry (Denmark) (IAG)	Oras (Finland) (IAG)
Danish Transport, Construction and Housing Authority (Denmark) (AAG)	Raufoss Water and Gas (Norway) (IAG)
ESBE AB (Sweden) (IAG)	Rørentreprenørene (Norway) (IAG)
Finance Norway (Norway) (IAG)	Rørforeningen (Denmark) (IAG)
Finnish Association of Building Service Industries (Finland) (IAG)	Standards Norway (Norway) (AAG)
FM Mattsson Mora Group (Sweden) (IAG)	Scandinavian Copper Development Association (IAG)
Kiwa Sweden (Sweden) (IAG)	SP Technical Research Institute of Sweden (Sweden) (IAG)
Ministry of Environment, Department of the Built Environment (Finland) (AAG)	Swedish Association of Plumbing and HVAC Contractors (Sweden) (IAG)
Ministry of Social affairs and Health (Finland) (AAG)	Swedish Chemicals Agency (Sweden) (AAG)
National Board of Housing, Building and Planning (Sweden) (AAG)	Uponor (Finland and Sweden) (IAG)
National Food Agency (Sweden) (AAG)	VA og VVS produsentene VVP (Norway) (IAG)
Nordic Brass Gusum (Sweden) (IAG)	Valves & Fittings of Sweden (Sweden) (IAG)
Norske Rørgrossister Forening (Norway) (IAG)	Veltek (Denmark) (IAG)

Table of content

Abstract

Important stakeholders in the drinking water sector has contributed to the implementation of the MaiD project. The project network has consisted of building and health authorities, manufacturing industry, professionals and industrial bodies, certification bodies and R&D institutions from Denmark, Finland, Norway and Sweden. MaiD has organised plenary Nordic meetings annually in addition to the international workshop in Stockholm. Furthermore, results have also been exchanged and knowledge has been gained through several networking activities at European level (e.g. contributions to highly relevant symposiums[1)]).

To process and handle the recommendations given by MaiD, it is therefore suggested to continue the established network. Furthermore, in view of the European Commission work regarding the drafting of new mandates for products in contact with drinking water, and the initiatives ongoing in the 4MS Common Approach, the Nordic network is considered to be an excellent platform for further developments on a European level.

The findings in MaiD are useful when further developments at a Nordic level are activated. The building regulation form in the Nordic countries regarding hygienic properties differs from more performance based to functional based requirements. In addition, outdoor water installations are only covered by the building rules in Norway. The approval and certification practice also differ to a certain extent both for organic and metallic products. Several of the recommended measures are easily processed in a continuation of the Nordic network (e.g. synchronising limit values, updating old procedures etc.).

In relation to the relevance of the test waters used in the available leaching tests, a Nordic drinking water survey was conducted. It revealed that the water compositions vary between the Nordic countries, in particular regarding the alkalinity and hardness. Hence, the rig test for metallic materials (EN 15664) is a relevant test method since three different test water compositions are specified and at least one of the test waters is compatible with the Nordic conditions. However, a short-term leaching test for the final product initial surface is considered relevant for metallic products. In test methods where several conditions for the test water exists (test temperature, disinfection pre-treatment and chlorination), a clear guidance should be developed and provided.

1 3rd Symposium on Materials and Products in contact with Drinking Water organised by EurEau, European Copper Inssti-tute, Plastics Europe and European Drinking Water, Brussels 18. May 2017.

The applicability of the 4MS Common Approach has been evaluated. The principles of the Common Approach are considered applicable in the Nordic countries, as it is based on the same hygienic properties (taste and odour, leaching, microbial growth and leaching of unsusceptible substances) and assessed according to EN standards developed for the purpose.

The assessment and approval schemes need to be designed and maintained in such a way that hygienic and mechanical properties are emphasised equally. For metallic products, corrosion failures can be developed several years after installation and during the propagation period increased leaching may happen without disclosing them. Hence, corrosion properties may be assessed on a more routine basis (e.g. part of continuous production control).

1 Introduction

1.1 Background

The withdrawal of the Mandate M136 by the EU Commission has delayed the progress towards CE marking under Construction Products Regulation (CPR) for products in contact with drinking water. This situation may lead to a strengthening of national certification and approval schemes in Europe. In the recent study conducted for the European Commission, the Drinking Water Directive (DWD) was reviewed with the aim to evaluate the impact of the different relevant policy options for a better regulation (Mashkina et al., 2017; Klaassens et al. 2016). Article 10 of the DWD regulates the impact of materials, substances and products in contact with drinking water (MPDW). Klaassens et al. (2016) concluded that Article 10 has not been effective as it did not provide any regulatory framework at EU level. They also emphasise that a diversity in approval systems among Member States is emerging which creates an additional administrative burden to enterprises operating in more than one Member State.

It is well known that the implementation of Art. 10 has caused many discussions for many years due to the lack of guidance on the outline and the operation of the assessment and the approval systems for MPDW. In addition, the absence of harmonized product standards makes it challenging for this product group to be CE-marked. Mashkina et al. (2017) emphasise that by leaving the implementation to individual member states, has turned out to be challenging and time consuming, which is also seen as a free trade hindrance within Europe. In another recent study, it was indicated that the national requirements and their costs for hygienic and mechanical testing of products act as burdens on industry and that export to other member states would be higher otherwise (Naismith et al., 2017).

The work on harmonisation of criteria for MPDW by European Commission and standards by European Organisation of Standardisation (CEN/TC 164/WG3 – Effects of materials in contact with drinking water) started already in 1998 with the intention to establish a common European Acceptance Scheme (EAS). Since this European work failed to be accomplished in 2007, the four EU Member States at that time, France, Germany, the Netherlands and the United Kingdom (4MS) started to consider the development of common acceptance practice. This work was to a large extent based on the European work already conducted or initiated in relation to EAS (e.g. EN test methods developed in CEN/TC 164, draft composition lists, etc.)

The 4MS announced in January 2011 that they have formalized arrangements to work together on this important aspect of the regulatory frameworks they have, to ensure the hygienic safety of drinking water. The 4MS intend to adopt common, or directly comparable, practices for[2]:

2 UBA (2016). https://www.umweltbundesamt.de/en/topics/water/drinking-water/distributing-drinking-water/approval-harmonization-4ms-initiative (Accessed 31st of May 2016).

- The acceptance of the constituents used in materials in contact with drinking water
- The testing of materials
- The use of common test methods and setting acceptance levels
- The specification of tests to be applied to products
- Reviewing factory production control and setting audit testing requirements
- Assessing the capabilities of certification and testing bodies

The objective of the Common Approach is not to introduce a single assessment system that operates in exactly the same way in each country. It defines a suite of policies and practices that may be adopted within the existing national legal and institutional frameworks. The aim is therefore to ensure that products are assessed consistently, and with the same outcome irrespective of where the work is carried out.

In the Nordic countries, the procedure to verify that drinking water products are fit for use (i.e. in accordance with the regulations) are today based on different practices (voluntary and mandatory approvals, different limit values, different test methods etc.). The practice and regulations are also different for indoor and outdoor water installations among these countries.

This situation creates administrative burdens regarding approval testing and certification for the industry operating on the different Nordic markets, like what has been found for enterprises that operates on several European markets where diversity in the approval systems exists (Klaassens et al., 2016). This may cause enhanced production costs and slow down the material and product development due to confusion of the prevailing approval practice. The recent European Commission study states that such a situation is a free trade hindrance (Mashkina et al., 2017). Furthermore, the innovation in the drinking water sector may be significantly impacted. The burden for more expensive products, may at the end be placed on the end users.

Based on the described situation, coordinating efforts across the borders are obviously important. In this regard, the Nordic Innovation project MaiD (Material and product innovation through knowledge based standardization in drinking water sector) was carried out in 2014–2017.

1.2 Goal and purpose

Ever since the European Acceptance Scheme was abandoned in 2007, a concern has arisen amongst authorities, industry as well as approval bodies concerning further development of certification and approval of MPDW and implementation of the Drinking Water Directive on national level. The issue has been the background for a series of meetings on Nordic level, involving representatives from authorities, industry and approval bodies in Finland, Sweden, Denmark and Norway. These discussions formed a common background for the involved parties in MaiD and the project objective.

The main goal of MaiD was to identify the key components that could be included in the national approval procedures in the Nordic countries to safeguard drinking water, material quality and a level playing field. The key components should also be based on European standards and practice as far as possible.

The purpose was therefore to:

- Evaluate the current Nordic approval, acceptance practice and related standards for materials and products in contact with drinking water and identify the mechanism(s) that will increase innovation in the drinking water sector. This also includes evaluation of the current situation of CE marking of construction products in contact with drinking water.
- Identify possible Nordic requirements regarding water quality that needs to be addressed in existing test methods and standards to ensure at least the present level of protection regarding health and safety.
- Evaluate the applicability of the 4MS acceptance procedure and related standards to Nordic conditions. Furthermore, potential modifications will be suggested based on the differences in water qualities.
- Give recommendations on how the laboratory capacity can be strengthened in the Nordic countries to provide the services expected from the Nordic industry regarding testing and acceptance of materials in contact with drinking water based on relevant identified standards.

2 Hygienic and durability properties of the products

2.1 Drinking Water Directive (DWD) – protection of the human health

Its general objective is to prevent adverse effects on human health of any contamination across the EU and to ensure that drinking water at the consumer tap is wholesome and clean. It requires Member States to establish safety precautions to maintain safe water quality. The DWD actions provide for a rather general EU framework setting quality standards and demanding that Member States ensure monitoring, compliance with the standards and provide the appropriate information to consumers. Concrete actions are left to the Member States.

The intervention logic of DWD is to address all possible contamination causes, including from treatment and distribution, by setting strict EU wide minimum parametric values to be complied with at the consumer tap, see Fig. 1.

Hence, the parametric values at the consumers tap is the basis criteria for most of the leaching tests applied to materials and products in contact with drinking water (MPDW) in Europe.

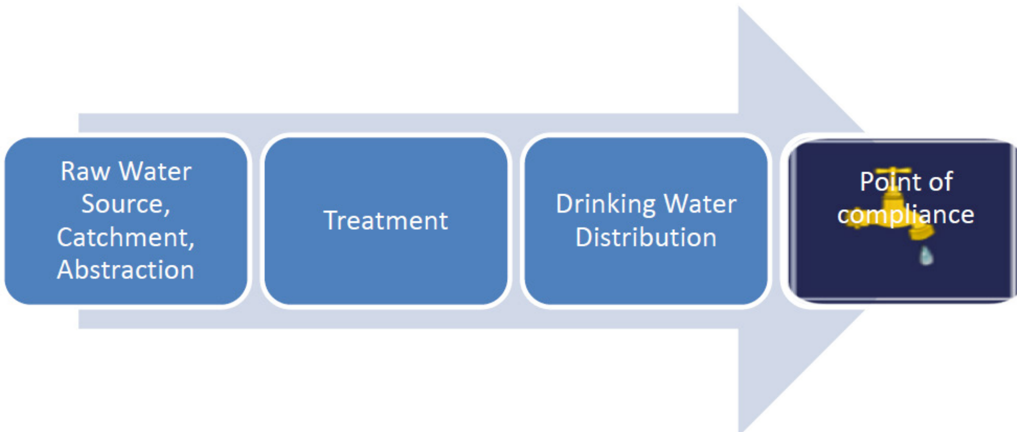


Fig. 1
Drinking water supply principle (European Commission, 2016)

2.2 Hygienic properties of the MPDW

2.2.1 Properties and testing

The hygienic properties of the MPDW are always derived from the hygienic properties and requirements to a healthy, tasty and colorless drinking water. The main hygienic properties for materials and products to be considered are shown in Table 1. These properties are uniformly considered in most European countries. However, how the assessment of the properties is conducted may vary among countries:

- Not using the EN test method developed for the purpose, i.e. use of a national standard
- One or more properties are assessed and approved based on recognition of a foreign approval using the EN test.
- Assessment of a property according to the same test standard and approval based on different limit values.

In Chapter 5 the legislation and assessment methods are described and summarized.

Table 1
The hygienic properties and their EN test methods for MPDW.

Hygienic property	Metallic	Organic	Cementitious
Taste and odour	Not relevant	EN 1420, EN 1622 and EN 14395-1	EN 14944-1
Enhancement of microbial growth (EMG)	Not relevant	EN 16421	EN 16421
Leaching of inorganic substance	EN 15664, EN 16057, EN 16058, NKB 4[a]	If relevant: The same tests as for organic substances	EN 14944-3
Leaching of organic substance	Not relevant	EN 12873, EN-ISO 8795 and EN 15768	EN 14944-3, EN 15768

[a] Nordic leaching test method

2.2.2 Leaching mechanisms

Leaching of substance may be defined as the transfer of a chemical species from a solid phase to the aqueous phase. Solubility controlled, diffusion controlled and surface wash-off leaching are the main leaching processes occurring in most of the solid-aqueous systems encountered (bedrock in groundwater and surface water, concrete in contact with water, metals in contact with drinking water etc.). Solubility controlled leaching depends mainly on the chemical stability of the parent chemical complex and the main leaching mechanisms are usually precipitation and dissolution, ion exchange, sorption to reactive surface and complex formation to humic substances.

This can mechanistically be described by thermodynamic reaction constants when approaching chemical equilibrium conditions for different material types (Engelsen and Gulbrandsen-Dahl, 2015, Engelsen et al. 2010, Schock et al., 1996). Diffusion controlled leaching is driven by the concentration gradient (i.e. the chemical potential) of the substance in the solid and aqueous phases. In addition, concentration gradients occur within the solid phase due to depletion. The mechanism can be described by Fick's second law of mass diffusion. Surface wash off is a physico-chemical process where the substance is rapidly transferred to the aqueous phase without following the diffusion law's or the solubility. It may be closely related to erosion.

If the leaching processes and mechanisms mentioned above are applied for describing the release of metals from brass surface to drinking water, several of the mentioned mechanisms may come in force. Depletion of a target element in the outermost brass layer will cause diffusion controlled leaching which slows down with the square root of time. Species in water (dependent on water quality) may form complexes with corrosion products that cause solubility controlled leaching for normal stagnation times like 8–12 hours. Lead release from brass alloys forms secondary corrosion products like hydroxide and carbonate species e.g. $PbCO_3$, $Pb_3(OH)_2(CO_3)_2$ and $Pb(OH)_2$. These species may form protective layers on the surface. Thus, in a stagnation period the aqueous concentration of Pb is dependent on the solubility of the parent species. This is controlled by the stability constant and pH is therefore one of the main solubility controlling factors. In analogy, the leaching of Cu from copper pipes is controlled by the solubility and thus pH of the corrosion products e.g. Cu_2O, CuO, $Cu_4SO_4(OH)_6$ or $Cu_2(OH)_2CO_3$. In addition, the concentration of oxygen, sulphate and bicarbonate in the water will also determine which minerals that are formed. $Cu(OH)_2$ is medium soluble and is normally transformed to malachite at appropriate pH and bicarbonate concentration. At pH lower than 6.5, most of the layers are dissolved (or not forming) and Cu^{2+} is directly released. In addition, natural organic matter (NOM) like humic substances has strong complexing properties that may increase the solubility of Cu^{2+} and most likely other metal cations like Zn^{2+} and Pb^{2+}.

2.3 Important mechanical properties of the MPDW

2.3.1 Corrosion

Dealloying, and dezincification of brasses in particular, may be critical in contact with soft waters and was the most frequent corrosion form in Norwegian water supply until the 1980's. With introduction of requirements for use of dezincification resistant (DZR) alloys in these systems, dezincification failures have decreased dramatically. However, dezincification still appears from time to time and is typically due to use of alloys with not the correct chemistry or thermal mechanical treatment to achieve dezincification resistance. It is vital to maintain dezincification resistant properties in materials in contact with drinking water to avoid these failures also in the future.

Based on the experience from failure analyses at SINTEF Raufoss Manufacturing over the last 15 years the most frequent corrosion forms in Norway today seems to be stress corrosion and galvanic corrosion. The latter corrosion failures are typically due to connection of non-compatible materials with respect to galvanic potential. Fig. 2 shows galvanic corrosion of aluminium due to contact with brass. This corrosion failure was accelerated due to unfavourable combination of a large brass (noble) surface areas electrical connected to an aluminium component with a smaller surface area.

In the later years stress corrosion of brass has been a one of the most frequent failure modes of corrosion in drinking water systems (e.g. Norway). Stress corrosion failure is caused by constant stress exposure of the component above a critical level, and combined with a corrosive atmosphere, which can be ammonia, amines, water and moist. The stresses can be either residual or external, and the most efficient relief measure is reduced stress level. Stress concentra-

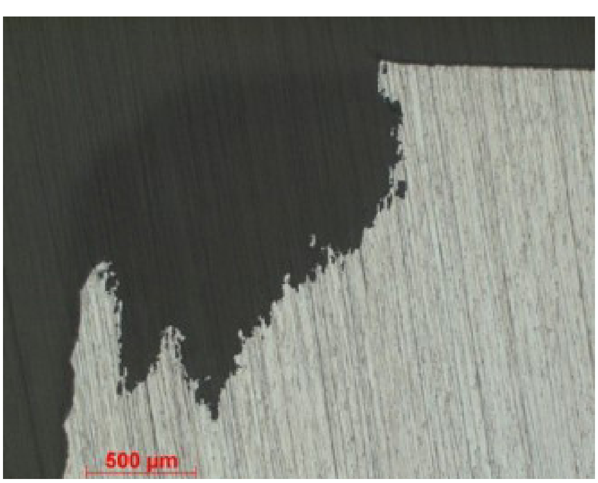


Fig. 2
Galvanic corrosion of aluminium which was directly connected to a large brass component.

tions at the crack tip causes a micro galvanic cell which cause an accelerated crack propagation and results in brittle fractures in a sound material. An example of stress corrosion cracking in a component without material failures is shown in Fig. 3. Secondary cracks is seen below the main failure and is typical for this failure mode.

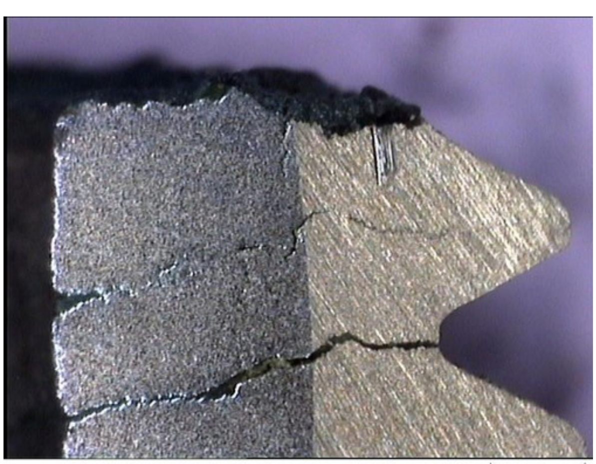
The causes for stress corrosion can be residual stresses from manufacturing such as deformations from too hard machining, wrong design of the component which results in to high internal stresses during normal service conditions (i.e. too thin wall thickness), wrong assembly due to high moment, or component mismatch during assembly. Machined threaded parts seem to have an overrepresentation within stress corrosion failures.

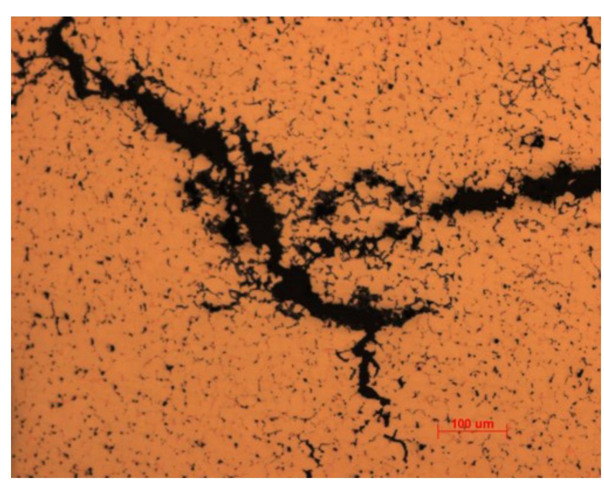
2.3.2 Overview of durability and mechanical properties

The mechanical properties with corresponding performance criteria have been summarised for the main drinking water products in domestic installation. The basis for the selected properties was the existing documentation required to place a product on the market and to properly install it in works so that the works comply with the building regulation. Valves, fittings and pipes were mainly included and the overview and can be found in Rod et al. (2017).

Regarding the corrosion properties of valves and fittings, the resistance against dezincification and stress corrosion is assessed according to ISO 6509 and ISO 6957, respectively. The criteria for the dezincification resistance is a dezincification depth of < 200 μm (or average ≤ 200 μm and maximum ≤ 400 μm) which is based on values given in the product standards and practised in the Nordic countries except in Denmark.

Fig. 3
Stress corrosion cracking in brass caused by to high moment during assembly





It can also be mentioned that ISO 6509-2: 2017 specifies assessment criteria for dezincification resistance:

a. Final forgings and castings after machining, including continuously casted bars:
   - Average dezincification depth ≤ 100 µm
   - Maximum dezincification depth ≤ 200 µm
b. Extruded bars / profiles for machining purposes:
   - Average dezincification depth in longitudinal direction ≤ 300 µm and maximum dezincification depth ≤ 400 µm
   - Average dezincification depth in transverse direction ≤ 100 µm and maximum dezincification depth ≤ 200 µm

2.4 The importance to consider both hygienic and durability properties

In addition to hygienic safety, there are other essential characteristics of products that are regulated on national level. To ensure the level playing ground these issues must be considered in addition to drinking water directive issues.

In the regulation, there are requirements concerning materials and mechanical properties of construction products. For water pipes, it is important that also the mechanical properties (leak tightness, corrosion resistance, etc.) are adequately addressed in the approval and certification practice. For instance, in Norway and Finland, dezincification resistant (DZR) materials are required as dezincification was the most frequent corrosion form until the 1980s. It is important to ensure that the corrosion resistance of the newer types of DZR brasses are providing the same protection level against failure (e.g. intergranular corrosion) as the current DZR brasses we have experiences with for nearly 30 years.

The key point in the assessment and approval of MPDW is that the schemes for hygienic and mechanical properties need to be treated with equal importance. On the one hand, the consumers are concerned about the hygienic properties in Table 1 since they directly impact our health through the consumption of drinking water. Therefore, products that not complies with these properties should not be placed on the market. On the other hand, the mechanical properties that ensure the safe and durable products need to be treated with equal importance so that the risk for mechanical failures (e.g. pipe fractures) are kept at a minimum during the product service life (e.g. > 30 years). Mechanical failures may cause serious negative health effects (increased leaching, contamination from external sources etc.) and severe damage to infrastructure.

Hence, when positive lists (substances, material compositions etc.) are developed and used for assessments and approvals with respect to hygienic properties, it is crucial to equally consider the mechanical properties for new MPDW. This may be challenging because mechanical failures that occur after a long time in service, may only be disclosed by full scale-tests or modified laboratory tests since practical experience is limited for new materials.

3 Materials and products used in water supply

3.1 Domestic water distribution

A brief overview of the types of materials used in the domestic drinking water installations is presented in Table 2. The material market share has only been estimated for Denmark.

Denmark

It was not possible to find any sales figures or other statistical data that can provide a reliable overview of which components that are sold in Denmark and whether these components are used for installation in drinking water systems or in heating systems. Anyway, such information will not provide an overview of which products and materials that have previously been used and still are part of the installations. Therefore, experienced service engineers and fitters who regularly inspect installations in Denmark were contacted. Copper and galvanized steel are not used in certain areas of Denmark due to the corrosion risks.

Finland

Cold and hot water pipes installed inside buildings are copper, cross-linked polyethylene (PEX) or multilayer pipes with PEX or PE-RT, and also stainless steel pipes. Galvanized steel was a common material in cold water pipes, but has not been installed since the 1970s because of its poor corrosion resistance in Finnish water. Some galvanized steel pipes are still in use. There are no statistics available for the percentages of different material types installed in cold and hot water systems inside buildings.

Norway

In new domestic buildings, 90 % of the pipes consist of PEX. Rest of the pipes are made of copper and steel. In shafts PE are used. In apartment buildings and office buildings, copper pipes are more frequently used. Where aggressive water is recognized, stainless steel pipes are used. Multilayer pipes are today also being used.

Table 2
Materials used for domestic drinking water installations.

Material	Denmark	Sweden	Norway	Finland
PEX	30 %	Used	Used	Used
PE-RT	5 %	Used	Used	Used
PE	0 %	Used	Used	Used
Multilayer pipes (PE and aluminium)	5 %	Used	Used	Used
Stainless steel	10 %	Used	Used	Used
Brass material Fittings, valves, etc.	5 %	Used	Used	Used
Galvanized steel pipes	25 %	Not used	Not used	Not installed since 1970s
Copper	20 %	Used	Used	Used

Sweden

There was no statistic available about products used in house installations in Sweden. According to VVS Företagen, plastic (PE) is the dominant material in new installations, while older installations mostly are made of copper regarding pipes (Johansen et al. 2012). An estimate may be that about 80% of the current installation consists of copper pipe. In addition, fittings and couplings exist of many different materials; brass, stainless steel, nickel-plated or chrome-plated materials. In recent years there has been a huge development of taps with various functions and design, and the consumer can choose among many different types of products and material combinations produced from several different manufactures.

3.2 Outdoor water distribution

A brief overview of the types of materials used in the water supply is presented in Table 3.

Denmark

The figures are derived from a survey of the 36 largest water works in Denmark and are provided by Danish Water and Waste Water Association (DANVA).

Sweden

The data represents 44 out of 290 municipalities in Sweden. The current age and materials distribution for Swedish pipe networks were mapped by a questionnaire survey performed in 2009 (Malm and Svensson, 2011).

Norway

Data is based on Vannverksregisteret year 2011. Data given as the % material present of total length of water main in 2011. The share between grey and ductile cast iron is based on the share present in the water main at Oslo waterworks (61/39). Today only ductile cast iron with cement lining and PE are used in new constructions.

Table 3
Materials used in the outdoor water supply system.

Material	Denmark	Sweden	Norway	Finland[a]
Grey cast iron	14.7 %	35.3 %	20 %	19 / 4 / 0 %
Ductile cast iron	3.5 %	19.8 %	12 %	31 / 20 / 0 %
Eternit	3.9 %	1.0 %	6 %	3 / 1 / 1 %
PVC	44.5 %	12.5 %	37 %	18 / 12 / 17 %
PE	29.4 %	22.4 %	21 %	22 / 42 / 70 %
Others	3.9 %	0.7 %	2 %	5 / 2 / 5 %
Plastics, non-specified	No data	No data	2 %	2 / 19 / 7 %
Concrete	No data	1.5 %	No data	No data
Steel	No data	2.5 %	No data	No data
Steel galvanized	No data	1.5 %	No data	No data
Unknown	No data	2.7 %	No data	No data

[a] Large / Middle size / Small waterworks

Finland
Data is based on a survey carried out 2006 (Kekki et al., 2007)

Materials in new constructions:
- Ductile cast iron 9 %
- PVC 16 %
- PE 70 %
- Non-specified plastics 5 %

4 Nordic water compositions

4.1 Results from the survey

The drinking water qualities in the Nordic countries have been surveyed and the main results are presented in Table 4. Details are specified in Kaunisto et al. (2017). Large differences in the water compositions among the countries were found. This is summarized in the following. The drinking water in Denmark has high alkalinity, hardness, chlorides and sulphates whereas the opposite situation can be found in Norway. The main reason is that the raw water is mostly taken from groundwater and surface water in Denmark and Norway, respectively. Approximately 10% of the Norwegian population consumes drinking water produced from groundwater and according to Andersen (2016), a few areas in the Eastern and Northern region of Norway has calcareous bedrock that cause increased hardness of the drinking water. The alkalinity and hardness in the Danish waters varied to a large extent.

Table 4
Water compositions in the Nordic countries. The results are given as average values and its standard deviations (std).

	pH	Alkalinity (mmol/L)	Hardness (mmol/L)	Chlorides (mg/L)	Sulphates (mg/L)	Conductivity (µS/cm)	TOC (mg/L)[a]
Denmark							–
-average	7.6	3.93	2.44	49	54	598	
-std	0.2	2.6	1.2	25	29	229	
Finland							
-average	8.0	0.96	0.61	9	24	175	1.34
-std	0.4	0.5	0.3	8	24	80	0.8
Norway							
-average	7.8	0.61	0.42	7	7	106	2.51
-std	0.3	0.2	0.1	5	6	24	0.9
Sweden							
-average	8.1	1.4	0.81	13	15	226	2.97
-std	0.2	0.7	0.4	11	12	87	0.8
All							
-average	8.0	1.24	0.97	16	23	244	2.1
-std	0.3	0.9	0.8	19	23	175	1.1

[a] Includes only exact values; in some reports data on TOC were given as < 2 mg/L.

The Finnish and Swedish waters are produced from both surface and natural/artificial groundwater sources and the drinking water composition produced from surface water was roughly the same for both countries (not shown in Table 4). Furthermore, the hardness and alkalinity were also comparable to the Norwegian waters. It can be noted that the Norwegian waters were slightly more acidic. Regarding the Finnish and Swedish waters produced from groundwater, a higher alkalinity and hardness were found, as expected. Moreover, the Swedish waters produced from groundwater had higher alkalinity than the Finnish drinking waters.

Hence, the survey clearly showed both similarities and large differences within and among the Nordic countries and it is therefore not possible to define only one typical water composition for the Nordic region.

4.2 Compatibility with the test waters specified in EN 15664-2

The rig test for leaching from metallic materials is specified in EN 15664-1 (design and operation).
The test can be used for three purposes:

1. Assess a material as a reference material for a category of materials using the results of several investigations in different waters covering a broad range of water compositions.
2. Assess a material for approval by way of comparative testing.
3. Obtain data on the interaction of local water with a material.

Thus, three different test water compositions are specified in EN 15664-2 which are shown in Table 5. It is emphasised that T1-T3 represent so called "corner waters" which means that an exact match between the local drinking water composition and the test waters may not be necessary. This may be illustrated by for example considering a low alkaline water composition (0.5-1.3 mmol/L) with a pH of around 7.3. This water composition falls between T2 and T3. However, with respect to the Cu, Pb and Zn leaching from brass material, T2 is more

Table 5
Test water compositions in the rig test specified in EN 15664-2.

Test water[a]	pH	Alkalinity (mmol/l)	$[Cl^-] + [SO_4^{2-}]$ (mmol/L)	TOC (mg/L)
T1	7.1-7.5	> 5.0	> 3	> 1.5
T2	6.7-7.1	0.5-1.3	No specification	No specification
T3	8.0-8.4	0.7-1.3	No specification	No specification

[a] Oxygen saturation > 70 % for all test waters

Table 6
Evaluation of the compatibility with the test waters in EN 15664-2.

<table>
<tr><th>Test water</th><th>Denmark</th><th>Finland</th><th>Norway</th><th>Sweden</th></tr>
<tr><td>T1</td><td>Compatible</td><td>Low</td><td>Applicable for few lime areas in Norway</td><td>Fair for groundwater part</td></tr>
<tr><td>T2</td><td>Low</td><td rowspan="2">Compatible</td><td rowspan="2">Compatible</td><td>Low</td></tr>
<tr><td>T3</td><td>Low</td><td>Compatible (surface water part)</td></tr>
</table>

severe and will therefore cover the water composition with a pH of 7.3.

Based on a total evaluation, the compatibility of the surveyed water compositions to the test waters in EN 15664-2 is given in Table 6.

4.3 Compatibility with the test water specified in NKB

The test water used in the NKB test has a pH of 7 and alkalinity of around 1 mmol/L. Compared directly to the surveyed water compositions, it obviously resembles the low alkaline waters found in Norway, Finland and Sweden. However, the test water is more acidic than the real drinking waters in these countries. This may indicate that the NKB test water may be more aggressive towards Pb, Zn and Cu leaching than real waters with the same low alkalinity and a higher pH.

It can also be mentioned that the NKB test water is falling under test water 2 in EN 15664-2.

4.4 Compatibility with the test water specified for cementitious products (EN 14944-1 and EN 14944-3)

For cementitious products, the test water is specified in EN 14944-1 (organoleptic parameters) and EN 14944-3 (migration). Both methods specify hard test water (80-100 mg/L as Ca) with high alkalinity (2-5.7 mmol/L). Regarding the organoleptic properties, the reference water is specified to be natural water. However, compared to the reference water in EN 1622 for organic products (section 4.5.1), EN 14944-1 specifies the chemical composition regarding pH, conductivity, calcium, alkalinity, silica, odour and taste. This may narrow the variability in the test performance.

However, both test waters in EN 14944 have high alkalinity. The test results may not be representative for regions that have soft waters with low alkalinity (e.g. Norway) as soft waters are more aggressive to the cement paste.

4.5 Compatibility with the test water specified for organic materials

4.5.1 Test methods for organoleptic properties (taste and odour)

The test standards EN 1420 and EN 14395-1 specify the migration part prior to the assessment of organoleptic properties in piping systems and storage systems, respectively. Following the migration, the determination of taste and odour is conducted according to EN 1622.

Regarding the specification of the reference water (to be used as blank, test water and migration water), both migration standards refer to EN 1622 which specifies the reference water in the following way:

- Reference water is described as water without any perceptible odour and flavour by test panel specified in the standard.
- Reference water can be tap water, mineral bottled water, or prepared by column filtration applying activated carbon.

- Preferably it should be appropriate to the area and where possible similar in mineral character to the type of water being tested.
- Test water (reference water used for migration tests) is either chlorinated or non-chlorinated reference water.

Hence, it is left to the product standards, national regulations or the approval and certification body to specify the type of reference water, test temperature, disinfection pre-treatment and chlorination. Although the principle with the method is to use a reference water declared to have no odour or taste by the test panel, different impact on the products may occur between the different water types. Therefore, test results may differ depending the water quality.

Since drinking water should be accepted by the consumer, taste and odour testing is recommended to perform with local drinking water. Origin of reference water and test water type (chlorinated or non-chlorinated) must be reported together with the results. The results will then be valid only for that type of water, and the test must be repeated with other type of water if requested.

At least the test method should be validated with local drinking water to set the national acceptance criteria. Whenever correlation between the national acceptance criteria and test results from other countries are known, it is possible to consider mutual recognition.

4.5.2 Test methods for leaching of organic substances

The leaching standard EN 12873 consists of the following parts:

- Part 1: Test method for factory-made products made from or incorporating organic and glassy (porcelain/vitreous enamel) materials;
- Part 2: Test method for non-metallic and non-cementitious site-applied products;
- Part 3: Test method for ion exchange and absorbent resins;
- Part 4: Test method for membrane water treatment systems.

In these test methods, demineralised water is specified as test water, which minimise the variation originating from the water composition. Test temperature and the use of chlorinated test water need to be specified before the tests are to be performed.

4.5.3 Test methods for enhanced microbial growth (EMG)

The standard EN 16421 specifies three different assessment methods for the enhancement of microbial growth (EMG):

- Method 1 determines the Biomass Production Potential (BPP) by using changes in ATP concentrations as a surrogate measure for active biomass. This method, developed by the Dutch, has been further enhanced as part of the CPDW project 2003 and 2006.
- Method 2 uses a volumetric measurement of the biofilm. This, German method, was first published as DVGW W 270 in 1984 and is used for certification purposes with limit values established for many years.
- Method 3 uses dissolved oxygen depletion in water as a surrogate measure of microbial activity (Mean Dissolved Oxygen Difference – MDOD). This British method, first issued as BS DD82 in 1982 and published as BS 6920 Section 2.4 (1988 and 2000), is used for materials approval with limit values.

As already emphasised in the standard, each method uses different performance characteristics, which allows its use for specific materials or product types but also has limitations. For example, multi-layer pipes cannot currently be tested with the BPP (Method 1) and the MDOD-method (Method 3), and greases or lubricants cannot currently be tested with the BPP (Method 1) and Volumetric-method (Method 2). Thus, harmonised product standards will provide the specific methodology to be followed and will take into account the material of construction and the type of components.

EN 16421 also emphasise that a variety of factors may influence the capacity of living organisms to respond in a predictable manner and thus validation procedures are an essential part of any biological assay. Therefore, validation is achieved by using a reference materials in all three methods.

Furthermore, local tap water is specified as the test water to be used in the methods. There are significant differences in the chemical and microbiological quality of drinking water in Europe, and thus also in the test water quality, although the local drinking water fulfils the requirements of EU's Drinking Water Directive. Such differences will also be seen in the drinking water in the Nordic countries. Since the three methods are based on different principles, correlation will still be challenging to achieve mutual acceptance.

5 Legislation and practice for marketing and use in Nordic countries

The legislation and practice for marketing and use in the Nordic countries have been surveyed and the main results are presented in the following sections. Details are specified in Rod et al. (2017).

5.1 Metallic materials

The specification of general health requirements and specific product performance criteria are shown in Table 7. It can be seen that the specification of performance criteria are placed at different levels. This may influence the flexibility of the approval schemes (e.g. a change in a performance criteria Norway may not require a change in the main regulation. This can be conveyed by the building authority to the approval body through other channels).

The material and product performance criteria for metallic materials are specified in Table 8 and there are significant differences between the Nordic countries. Table 8 indicates that the limit values used in NKB, will most likely be harmonised. However, the option to use either NKB or EN 15664, lead to different practice even within the same country. If the NKB is used, a short-term test directly on the finished product is applied, whereas EN 15664 (long-term) is conducted on a machined laboratory sample.

In principle, both test types would be beneficial to conduct for the same material and product, as the short- and long-term leaching properties are assessed. Moreover, a product test will ensure the principle of testing the surface of a final product. The latter may play a role as the surface and corrosion properties of the test specimen prepared for EN 15664 may be significantly different from the properties of a final product with the same material composition. For products, this may be induced by the differences in mechanical manufacturing methods, heat treatments and surface finishing efforts. It was discovered as early as in the 1920s, that small amounts of As will decrease the dezincification rate of brass (Bengough, 1924). It has been found later that intergranular corrosion observed in DZR brass was related to the heat treatment procedure and the contents of As, P and Fe. Sundberg et al. (2003) found that As contents above 0.10 %, increased the risk for intergranular corrosion. They suggested a mechanism that involved reaction with impurities of Fe (and P) which caused precipitation (e.g. $(CuZn)_2FeAs$) in the grain boundaries during annealing or slow cooling.

Hence, as the corrosion properties change with varying manufacturing processes, this may also alter the leaching properties.

Table 7
Criteria for marketing and use of metallic taps, valves and fittings in the Nordic Countries.

Criteria	Norway	Sweden	Finland	Denmark
General Health requirements in building regulation	Yes	Yes	Yes	Yes
Approval required in regulation	No	No	No	Yes
Product performance criteria written directly in the regulation	No	No	Yes	Yes
Product performance criteria in the guideline to regulation	No	Yes	No	No
Product performance criteria in the standard test method	Yes	No	No	No

Table 8
Limit values for three main assessed element for metallic taps in the Nordic Countries.

Element	Test method	Norway	Sweden	Finland	Denmark [a]
Pb	NKB	20 µg [d]	5 µg	20µg [d]	5 µg
	EN 15664	Not used	5 µg/L	Not used	5 µg/L
Cd	NKB	2 µg	2 µg	2 µg	2 µg
Ni	NKB	Not used	Not used	Not used	80 µg [b]
	EN 16058	Not used	Not used	Not used	20 µg [c]

[a] Currently, German, Dutch and Swedish approval and certification are accepted in Denmark. The 4th alternative is through the Danish GDV (Godkendt til drikkevand). Note also that drinking water in Denmark is defined as cold water intended for human consumption, implying that shower mixers are exempted from the drinking water approval scheme.

[b] One product to be tested, but average of 3 test samples if any part in contact with water is chrome plated.

[c] Optional, but not used in practice

[d] Proposed revision to 5 µg

5.2 Organic materials

An overview of the requirements for hygienic properties and the tests methods for the organic materials is given in Table 9. It seems that the Nordic countries will mostly use the EN standards specified in Table 1. Regarding the EMG (Enhancement of Microbial Growth) requirement, it may be challenging to consider three different methods in EN 16421, i.e. for countries (e.g. Norway) that accept approvals each based on two separate methods in EN 16421.

Table 9

Overview of standards and requirements for organic materials and products.

Assessments for organic materials	Norway	Sweden	Finland	Denmark
General Health requirements in building regulation	Yes	Yes	Yes	Yes
Approval required in regulation	No	No	No	Yes

Assessment of hygienic properties in the approval and certification practice

Product types assessed:	Pipes and hoses	All organic products[b]	Pipes, multilayer pipes, fittings/connectors	All organic products
Evaluation based on only composition:	No	No	Fittings/connectors	No
Taste and odour assessed for:	Pipes and hoses	All organic products	Pipes	All organic products
Taste and odour, test standard used:[a]	EN standards	EN standards	SFS 2335 Annex A	EN standards
Taste and odour, accepted approvals from other country:	D, NL, DK	D, NL	No	D, NL, SE
Leaching is required:	Yes	Yes	Yes	Yes
Leaching, test standard used[a]:	EN standards	EN standards	EN standards	EN standards
Leaching, accepted approvals from other country:	D, NL, DK	D, NL	No[c]	D, NL, SE
Enhancement of microbial growth required:	Yes	Yes	Under assessment[d]	Yes[e]
Enhancement of microbial growth, test standard used[a]:	EN standards	EN standards	Under assessment[d]	EN standards
Enhancement of microbial growth: Accepted approval from other country	D, NL, DK	D, NL	No	D, NL, SE

[a] Relevant EN standards given in Table 1

[b] Organic components in a composed product with water contact area of < 3 mm^2 are considered to have low risk and are not reviewed.

[c] Test reports, on which the approval is based, will be studied by type approval body appointed by the Ministry of Environment Finland (at the moment VTT Expert Services). If test methods used and test results correspond to Finnish regulation and type approval decrees, VTT will give type approval without further type testing.

[d] Under assessment by Ministry of Environment in Finland.

[e] Only for filters

5.3 Cementitious materials

For cementitious products, no specific requirements are implemented in the Nordic countries yet. Thus, only the general health requirements that the material shall not have negative impact on the drinking water. It can be mentioned that the test water defined in EN 14944-1 and EN 14944-3 may not be representative for the drinking water with low alkalinity.

6 4MS Common Approach

6.1 Background for MPDW in Europe

The history of standardisation and harmonisation of methods and criteria related to the Basic Work Requirement 3 (BWR 3) in the Construction Products Regulation, the successor of Essential requirement 3 (ER 3) in the Construction Products Directive, started in the early 1990s. The background and major decisions taken in this period can briefly be summarised as follows:

- Early 1990s: A common understanding that ER3-methods need to be harmonised.
- 1994: CEN identified the existing strong regulatory provisions in the water supply.
- 1998: A feasibility Study involving the Commission and four Member States concluded that it is possible to develop a harmonised European Acceptance Scheme (EAS). Hence, the EAS may contain common performance criteria, assessment procedures and test methods.
- 1999: The Regulators Group for Construction Products in contact with Drinking Water (the RG-CPDW) was established to manage the development process of EAS.
- 2001: Mandate M136 was issued in May 2001, and the related decision on the Attestation of Conformity in May 2002. The RG-CPDW produced an Interim Proposal (the "EAS on Paper") for consultation in November 2001.
- 2003: The Commission outlined the approach to the EAS in a Communication in 2003.
- 2005: Expert Group – CPDW replaced RG-CPWD.
- 2006: Principles of EAS are abandoned.
- 2007: France, Germany, the Netherlands and the United Kingdom (the 4MS), agreed to pursue a common approach to the assessment of products in contact with drinking water.
- 2008/2009: The 4MS Common Approach starts to develop.
- 2010/2011: Declaration of Intent is signed between The Ministry of Work, Employment and Health of the French Republic, the Federal Ministry of Health of the Federal Republic of Germany, the Ministry of Infrastructure and Environment of the Kingdom of the Netherlands and the Department for Environment, Food and Rural Affairs of the United Kingdom. One of the objectives is to establish convergence of the operations of the national approval systems with the intention of reducing, and if possible eliminating, duplicate testing and assessment in the countries represented in the declaration.

- 2011/2012: Assessment procedure and composition list for metallic materials become available. Assessment procedure for a suite of Positive List (PL) substances for organic materials. In addition, a first version of a combined PL is made available. Furthermore, the assessment procedure for cementitious products is also launched.

It is emphasised that the 4MS Common Approach is largely based on work already done in relation to the development of EAS. Furthermore, the European standardisation committee CEN has developed test methods in CEN/TC 164/WG3 for the hygienic purpose since late 1990s and up to very recently. Most of these test methods are published and intended to be used in Common Approach.

6.2 4MS Common Approach and current status

6.2.1 General principle

The four European countries, France, Germany, the Netherlands and the United Kingdom (4MS) announced in January 2011 that they have formalized arrangements to work together on this important aspect of the regulatory frameworks they have, to ensure the hygienic safety of drinking water. The 4MS intend to adopt common, or directly comparable, practices for[3]:

The acceptance of the constituents used in materials in contact with drinking water
- The testing of materials
- The use of common test methods and setting acceptance levels
- The specification of tests to be applied to products
- Reviewing factory production control and setting audit testing requirements
- Assessing the capabilities of certification and testing bodies

The objective of the Common Approach is not to introduce a single assessment system that operates in the same way in each country. It defines a suite of policies and practices that may be adopted within the existing national legal and institutional frameworks. The aim is therefore to ensure that products are assessed consistently, and with the same outcome irrespective of where the work is carried out.

6.2.2 Tests to be used for products and mutual recognition principle

The 4MS have been investigating differences in testing practices in the four countries. What this has shown is not so much that the tests performed are different, but that the philosophies and practices that determine which tests are carried out are significantly different. Testing practices are also influenced by legal requirements, institutional arrangements and the roles played by regulators and certifiers, and these are quite different in the 4MS countries.

This has led the 4MS to conclude that it will be impossible in the foreseeable future to develop standard practices to be carried out in the same way in each

3 UBA (2016). https://www.umweltbundesamt.de/en/topics/water/drinking-water/distributing-drinking-water/approval-harmonization-4ms-initiative (Accessed 31st of May 2016).

country. What they will now be studying is how they can ensure that the practices which are in use give comparable levels of protection. If this can be assured, approvals given in one country can be accepted by the others without further testing (mutual recognition).

6.2.3 Overview of the current material and substance lists

The Common Approach intends to make use of common material, constituent and substance lists for accepting materials and products. These lists cover products made of metallic, organic and cementitious materials and are summarised in Table 10.

Table 10
Overview of the listing of substances, materials and compositions used in 4MS.

Product type	Name on the list	Type of list
Metallic	Composition list (CL)	Acceptable chemical compositions of the materials used in the products. It includes the compositions of Copper, Copper alloys, steel and iron. Established based on leaching according to EN 15664.
Organic	Positive List for Organic Materials (PL).	Substances to be used in the production. It includes monomers, additives, aids to polymerization and polymer production aids. Established based on toxicological evaluation of each substance. Applications for the approval of non-EFSA substances will be made to one of the 4MS regulatory bodies, who will carry out the required toxicological and limit evaluation, and offer their "Opinion" to the other 4MS countries for endorsement.
	Combined List	List of substances under 4MS evaluation e.g. substances that lacks proper EFSA evaluation or new substances that have been listed in one of the 4MS.
	Obsolete list	Substances on the Combined List that are not known to be used anymore in certified or approved products.
Cementitious	Positive Lists for cementitious materials (PL-CM)	Acceptable input substances to be used in cementitious products, including organic and inorganic substances. Some substances found in the ingredients of accepted generic constituents may not be suitable to appear on Positive Lists (e.g. Ca, Al, Si etc.). For organic substances, the general approach for organic materials will be used. A review will be made of inorganic substances currently subject to controls in the 4MS, and proposals will be developed for the evaluation and acceptance of such substances.
	List of Accepted Generic Constituents	Minerals or preparations acceptable to be used to make a cementitious material or product. The list also specifies the properties that need to be tested (e.g. leaching, EMG etc.).

Metallic materials and products

The metallic material composition list (CL) specifies the chemical compositions of the accepted metallic materials. The principle procedure for accepting products can be distinguished between the requirements for long-term and short-term behaviour. To comply with the former requirement (acceptable long-term leaching), products need to be made of a CL-material. The short-term behaviour is fulfilled by ensuring product specific surface properties are acceptable and relevant test procedures for the surface properties are under development. In the current acceptance procedures, materials that contain more than 1% Pb need to test the final product according to EN 16057 (Common Approach, 2016a). This is to ensure that the Pb-layer after the manufacturing process is not causing unacceptable short-term leaching. When using EN 16057, the maximum level of acceptable acid extracted Pb needs to be developed. Furthermore, the unavoidable Ni deposited on the inner surface of Ni-Cr-plated products need to be tested according to EN 16058.

Organic materials and products

The positive list (PL) will include substances permitted to be used in all types of organic materials. The list will contain monomers and other starting substances, additives, polymer production aids (PPA) and aids to polymerization (AP), but not pigments and colorants (Common Approach, 2016b). For the inclusion of a substance on the PL, a toxicological assessment of the substance, including its possible reaction products is required. For substances that are not on the European Food Safety Authority (EFSA) list (Union list substances of 10/2011/EC), the toxicological assessment should be based on the EFSA principles. Depending on the assessment outcome, substances may be restricted in form of a limit value in the drinking water (leaching limit), or with a total content limit in the product, or with other kinds of restrictions (like molecular weight or viscosity). The common procedure will be based on the continued operation of national assessment systems, but with their outcomes subject to peer review by the other MS's. The draft opinions will be reviewed by the appropriate bodies within each of the other MS's, who will offer their comments. When consensus is achieved, the substance will either be added to the Core List, or will be rejected (Common Approach, 2016b).

Cementitious materials and products

For accepting cementitious materials, the Positive Lists for cementitious materials (PL-CM) and List of Accepted Generic Constituents (LAGC) are used (Common Approach, 2012). Regarding the former list, a list of Accepted Admixtures Constituents List (AACL) is currently being formed (Common Approach, 2016c) as admixtures is constituting most of the synthetic organic substances in concrete (normally added to less than 1% of cement weight). AACL contains the substances accepted to produce an admixture used in cementitious products. For the listing of a substance, an assessment of the substance including its toxicological evaluation and its possible reaction products has been carried out, or that it has been deemed as being a substance of a non-hazardous nature. Depending on the assessment outcome, some substances may be restricted in form of a limit value of the substance in the drinking water (leaching limit) or in form of a restriction of its use within the admixture (Common Approach, 2016c).

The LAGC includes the technical specifications for the constituents (cement, admixtures, aggregates etc.). Conformity with these specifications is necessary for a product to be accepted. The list indicates for each constituent the nature (organic and/or inorganic) of substances for which compliance with the PL-CM must be controlled and which tests have to be performed when a constituent product or a final product is assessed.

7 Laboratory capacity in the Nordic countries

Assessment of the hygienic properties according to the relevant standards (mostly EN standards developed in CEN/TC 164), create a certain demand for laboratory capacity. The test methods in Table 1 differ in sophistication level,

Table 11

Laboratory capacity regarding assessment of hygienic properties of MPDW. Accredited tests are indicated with a cross whereas non-accredited tests are indicated with crosses in brackets. Toxicological assessments are only indicated by a cross since evaluation is difficult to classify as accredited.

Hygienic property	Test standard	Denmark				Finland		Norway	Sweden	
		Teknologisk Institut	Force Technology	DHI	Eurofins Product Testing	VTT Expert Services	NIHW[a]	SINTEF	RISE	KIWA Sverige
Metallic products										
Leaching	EN 15664		(X)							
	EN 16057		(X)					(X)		
	EN 16058		(X)							
	NKB 4	X			X	X		X	X	X
Organic products										
Toxicological ass.	No standard			X	X		X		X	X
Taste and odour	EN 1420	X			X			(X)		X
	EN 14395							(X)		X
	EN 1622	X			X			(X)		X
	SFS 2335[b]					X				
EMG[c]	EN 16421				X					X
Leaching	EN 12873	X			X	X		(X)	X	X
	EN-ISO 8795					X		(X)		
	EN 15768									

[a] National Institute for Health and Welfare

[b] SFS 2335 Plastic pipes. PE pressure pipes. Quality requirements, Appendix A: Plastic pipes. Determination of defect odour and flavour migrating from the pipes to water. Sensory evaluation. (in Finnish)

[c] Enhancement of Microbial Growth (EMG)

testing time and how easy the interpretation of results is (e.g. lack of pass/fail criteria). For instance, the lead extraction test (EN 16057) are conducted within less than one day (20 consecutive extractions of 2 minutes each), whereas the long-term leaching rig test (EN 15664) have an exposure time of minimum 26 weeks. Furthermore, the testing time for a plastic pipe according to EN 12873-1 is minimum 10 days including flushing (1 hour), stagnation (1 day), pre-washing (1 hour) and migration (9 days). In addition, EN 15768 is developed to screen migration water for organic substances prepared from EN 12873 which is an indicative analysis method that require sophisticated analytical equipment (GC-MS) operated by highly skilled personnel. These factors together with the market demand largely determine the laboratory capacity in a region.

The results from the brief survey of the laboratory capacity in the Nordic countries are shown in Table 11. Regarding metallic products, high capacity was only found for the NKB method. Laboratories accredited for this test were present in all the four countries. It can also be seen that there are somehow lack of capacity regarding the EN-test methods for the same product group. Regarding the rig test EN 15664, a general challenge is to perform the test without modification of the prescribed input waters.

For products made of organic materials the situation is different. A frequently used leaching test method is EN 12873 and accredited laboratories exists in Denmark, Finland and Sweden. The same is also the case for the taste and odour method EN 1420 and for toxicological assessments. Regarding the test methods for determining enhancement of microbial growth (EMG) EN 16421, Eurofins in Denmark has recently been accredited for this test method. The GC-MS method EN 15768 is currently not available as a routine method in the Nordic region.

Lack of laboratory capacity was found for products made of cementitious materials as there are no laboratories accredited for any of the methods.

8 Recommendations and suggestions for following-up tasks

8.1 Introduction

Based on the findings in the MaiD project, recommendations and suggestions are discussed in the following chapters. The main objective for the recommendations is to ensure the hygienic safety and durability of the products in service life and to minimise the innovation hinders.

In addition, the Industry Advisory Group (IAG) in MaiD has prepared a short Position Note reflecting the view from the industry on harmonized standards and article 10 of Drinking Water Directive, test water applicability regarding local conditions, test and analysis methods, long-term durability and 4MS positive list for assessing the safety of materials. The Position Note is attached to this report as Annex 1.

8.2 Continuation of the Nordic MaiD network

MaiD has established a unique network which consists of building and health authorities, manufacturing industry, professionals and industrial bodies, certification bodies and R&D institutions from Denmark, Finland, Norway and Sweden. Through plenary meetings, workshops and project meetings, the awareness has significantly been increased for all stakeholders regarding:

- The present regulation and certification practice
- Overview of the main drinking water qualities
- The test methods used for certification and approval of MPDW
- Ongoing initiatives at European level

Through the stakeholder interactions over several years in the MaiD project, a common knowledge platform has been created. This common platform is decisive to have, when the complex aspects mentioned above are to be developed in a way that reduces the hindrances for innovation in the drinking water sector.

Furthermore, the time frame for the development of a new mandate for MPDW (M136 has been withdrawn in 2016) is difficult to assess as the drafting process is currently in an early stage. Hence, the time frame for the harmonisation of product EN standards (hENs) is therefore uncertain.

In addition, the MaiD project revealed that different practices exist within the Nordic countries regarding approval and certification of these products. This situation is challenging for the industry and represents increased testing, more difficult to define a uniform strategy for product development and lower market predictability. It may appear as an innovation hindrance, as indicated by recent European studies (Naismith et al., 2017; Mashkina et al., 2017).

To utilise the results of the MaiD project in a rational way, it is recommended to continue with the Nordic network as a unique place for sharing the experiences and knowledge that will be gained in the future process.
The specific tasks of the network may be defined based on the recommendations given in the following sub-chapters.

8.3 Metallic materials

The test standard EN 15664 (part 1 and 2) can be used for the approval of the material compositions and aims to assess the long-term leaching characteristics of metallic materials. The exposure is of minimum 26 weeks conducted with 3 different natural test waters. The test conditions are more relevant than conditions of continuous through-flow or sit and soak tests and are applicable to all metallic materials in the distribution systems. Hence, the implementation of such a method will lead to materials on the market that are pre-tested under test water conditions that are closer to the actual consumer scenario compared to the frequently used batch-tests in Europe today (e.g. NKB 4).

The Nordic drinking water quality survey (Chapter 4) revealed that it is not possible to define only one typical water composition for the Nordic region. Hence, for metallic materials, EN 15664 is beneficial as it uses 3 different water compositions.

However, certain issues need to be addressed when applying EN 15664 to test material compositions acceptable for products. In the following these issues are discussed.

8.3.1 Assessment of initial surface properties

Assessment of the short-term surface leaching properties (initial surface) are difficult because the products with pre-accepted materials may be marketed and sold without further testing of the leaching properties (e.g. Sweden). Due to the production processes (casting, machining, chromium-nickel plating etc.) of finished products, the leaching from the surfaces during the first period of the service life of the product is not covered by only using EN 15664. This is also supported by the conclusion in the recent study of Turkovic et al. (2014). They studied the leaching and corrosion behaviour of low-lead and red brass materials with Pb contents of 0.01-0.2% and 3.9%, respectively, in 5 different water compositions. The test methods used were EN 15664 (long-term) and ANSI/NSF 61 section 9 (21 days short-term product test). The study demonstrated significantly improved leaching performance for the low-leaded brasses. They also concluded that the short- and long-term properties should be assessed for new low-leaded brass to cover the bulk and initial surface leaching characteristics.

Furthermore, Turkovic et al. (2014) emphasises that brass materials are fit for use in drinking water installations due to the formation of protective scales from solid corrosion products on the wetted inner surfaces. Formation of this layers reduce the corrosion reactions and metal leaching. However, it takes a certain time to build up these layers which is also dependent on the water composition. During the time, the protective layers are formed, an exceedance of the regulated leaching values may occur.

Hence, a product test should be applied to address the short-term leaching properties. A short-term test will typically disclose certain leaching behaviour the first 2–4 weeks.

8.3.2 Products with pre-accepted material composition

It seems rational to apply the method to assess a reference material that can represent a category of materials with a defined composition range. Materials within this range, only need to verify the chemical composition of the material. With such an approach, a list of accepted materials can be created (e.g. 4MS Common Composition List) which decrease the testing burden and most likely increase the market predictability for the industry.

The role of such a composition list becomes compulsory in the approval and certification process, since it is based on health requirements solely which should not be compromised. Furthermore, the impact of mechanical properties (leak tightness, corrosion resistance, etc.) are typically not occurring within the testing time of any leaching methods performed in laboratory (e.g. corrosion failures may occur many years after installation). These properties, have potentially serious impact on health when failures occur, due to inadequate material choice. It is therefore important that the risk for corrosion failure is adequately evaluated for materials that are listed on a composition list based on leaching tests.

This may impact positive on the future material and product development in the way that mechanical and leaching properties are equally focused because they are interconnected. Thus, the risk for costly and unhealthy future failures, may be minimised.

8.4 Organic materials

Organic MPDW comprise a huge number of chemical substances and creates a challenge to fully control the health impact by the released substances. This is due to several reasons including; several substances used today have a partly or fully unknown toxicological nature, lack of analytical methods with sufficient sensitivity to identify and quantify "rare" substances and impractical and too costly to measure all potential released substances in a leaching test.

Furthermore, the leaching of organic substances is less sensitive to water composition than metallic and cementitious materials are. This indicates that the release level of organic substances can be accumulated and assessed in a faster and generic way than for instance heavy metals from metallic products that are greatly influenced by the pH, DIC, PO_4^{3-} etc. in the water.

Hence, a list of acceptable substances (positive list) used in manufacturing of organic products may offer consistency to water compositions and is therefore recommendable to develop and use. However, it is difficult by a single positive list of organic substances to cover all substances including those that cannot be predicted from the formulations (e.g. degradation products).
A positive list needs to be assisted by a rational toxicological procedure where both unintentional occurring substances (e.g. substances present due to degradation, transformation, etc.) and new substances are assessed sufficiently in a reasonable timeframe. Minimizing the assessment time for new substances is crucial for the product development and thus to prevent that a positive list hinders the innovation.

Furthermore, an important purpose of a positive list is to provide guidance of which substances that need to be determined in the EN 12873 leaching test on the final product. Typically, substances on a positive list that appear with a leaching limit or are somehow restricted need to be measured in the migration water. In addition, assessments for unsuspected organic substances according to EN 15768 (GC-MS) will also need to be conducted in the migration water from the final product. The positive list approach including testing on the final product was already proposed on a European basis within the development of the European Acceptance Scheme (EAS, 2005).

Regarding the method for enhancement of microbial growth (EN 16421), the standard includes three methods which use different performance characteristics, as emphasised earlier. Harmonised product standards will provide the specific methodology to be followed, which will consider the material of construction and the type of components. The timeframe for the harmonisation process is uncertain as the mandating process has just started. Furthermore, some correlation of the results for different water compositions obtained with the same method is needed, to develop mutual acceptance in the Nordic countries.

8.5 Cementitious materials

It seems that a certification and approval system for cementitious products and cementitious materials need to be implemented. Such a system may be similar to the procedures for products used for indoor water installations. The inorganic materials used (water, cement, sand and stone), in addition to grinding aids at concentrations less than 0.2%, are expected to be regulated "straight-forward" by using the content-approach. The organic admixtures need to be evaluated and drafted and placed in an admixtures positive list. In addition, an appropriate test water needs to be defined for soft water with low alkalinity.

8.6 Applicability of the 4MS Common Approach

8.6.1 Metallic materials and products

The principles of the Common Approach to assess materials and products according to the bulk (long-term leaching) and the surface properties (final product surface), also seem applicable to the Nordic countries. A common European short-term test for product surface with assessment criteria still needs to be developed. It is foreseen that the laboratory capacity is sufficient for the short-term and long-term test and that the focus on the corrosion properties are at the same level as the hygienic properties.

8.6.2 Organic materials and products

The principle of Common Approach is applicable in the Nordic countries since it is based on positive lists of substances in production and leaching tests on the final product surfaces. Furthermore, this was the main working principles in the earlier EAS work and the main working items in CEN for this material group.

In practice, the Common Approach will take longer to implement for organic materials than for the metallic materials. The Core List (Positive List) within 4MS is anticipated to be finalised in 2022 due to the many types of organic formulations present in products, the number of single substances used, absence of toxicological data and the need for analytical methods to be developed.[4]

4 Common Approach, 2016. Common Approach 4/5 MS – Work program and planning, Joint Management Committee 30.03.2016.

The Common Approach covers all products and materials used in the outdoor water installations (e.g. site applied products like glues, injection masses etc.) and not only Construction Products Regulation (CPR) products. Compared to the situation today in the Nordic countries, this may represent an improved safety level regarding these products.

For the more conventional CPR products it is emphasised that Denmark, Norway and Sweden already accepts products approved from Germany and the Netherlands (4MS countries) which means that roughly the same substances assessed in 4MS are accepted in several Nordic countries. In this regard, it can be mentioned that the hygienic assessments are only requested for certain organic products in some countries (e.g. Norway) and an assessment covering all organic products is beneficial.

8.6.3Cementitious products

This group of materials and products is used for outdoor water installations. The approval and certification in the Nordic countries is in most cases not applied for outdoor products and not for cementitious materials (Rod et al., 2017). Organic substances used in the manufacturing will follow the approach used for organic materials. However, this will not be such a challenging exercise as for the organic materials, since the lists are likely to have something under 400 entries (Common Approach, 2012). Based in the current situation, the Common Approach is evaluated to be applicable for the Nordic countries for cementitious materials and products.

8.7 Assessment of initial surface properties (short-term leaching product test) metallic materials

8.7.1 Test method

Many short-term leaching tests exists globally and in Europe. Their limitations and challenges are usually related to extraction time, extraction/flushing regime, chemical composition of the test water, variation in the product surfaces in water contact, costs and pass/fail criteria.

In the Nordic countries, the general practice has been to use NKB 4 (sanitary taps), NKB 9 (non-return valves), NKB 13 (shut-off valves) and NKB 18 (metallic fittings for PB and PEX tubes). The leaching test is the same for all NKB methods and is well established in the Nordic region for the past 30 years.

To improve this test, it is proposed to update the method description with the following:

1. The test should be carried out with minimum 3 replicates. This will allow statistics to identify outliers (non-representative samples). In a recent Danish study, the NKB test was conducted with 5 replicate samples for 2 different types of kitchen faucets (final products). The repeatability expressed as relative standard deviations were in the range of 13-18% in this study (Kloppenborg and Nielsen, 2017).

2. pH should be measured in the final leachate (exposure water) at the sampling days 9 and 10. As pH in the test water is 7 ± 0.1, it is important to measure the end-pH at the 24 h exposure period. This pH will largely control the solubility of the Pb species present and a decrease in pH will significantly increase the leaching of metal cation (e.g. Pb^{2+}, Cu^{2+}, Ni^{2+}, etc.) complexes. The extent of variation in pH within a test series (e.g. 3-5 replicate samples) can also indicate the uncertainty that is caused by the differences in the product surface itself, i.e. low variation of the end-pH with high variation of the leached quantities among the replicates, indicates larger differences of the product surface.
3. The volume of the leachates (exposure water) should be measured during the whole exposure period. Differences in volume indicate differences in the water contact areas which impact the leached quantity. Stable volumes improve the precision and accuracy of the method as the results are expressed in total released quantities (µg).
4. The method specifies 1 hour of flushing with tap water. The effect of tap water quality during flushing is proposed to be evaluated so that the relevance can be assessed.
5. Draft recommendation for which heavy metals that are relevant to measure in the leachate.
6. A guideline should be written to assist the obtained leaching results with reasonable tolerances when compared to the pass/fail criteria. The tolerances must reflect the total uncertainty of the method.

Furthermore, it is proposed to conduct a round robin test with the modified procedure to assess the reproducibility and robustness of the NKB method.
Awaiting an EN standard with pass/fail criteria, it is recommended to use the NKB method as a short-term test for assessing the initial surface properties.

8.7.2 Harmonising the limit value for Pb

It is proposed to use 5 µg as the limit value for NKB 4 and the starting point for the dimension based values for shut-off valves, non-return valves and fittings in the other NKB methods, since the limit value of 20 µg is based on old assumptions (Engelsen, 2017). In Denmark and Sweden, 5 µg is already implemented.

Furthermore, the dimensional based limit values used in NKB 9, NKB 13 and NKB 18 are slightly different calculated in Denmark and Sweden even though 5 µg is used as the basic value. It is proposed that a common procedure of the dimension based calculations are specified.

8.8 Durability

The assessment and approval schemes for hygienic and mechanical properties need to be treated with equal importance, in particular for metallic products and materials. Although the corrosion caused by dezincification is mechanistically complex, the corrosion speed is, among other parameters, dependent on the Cl^-, SO_4^{2-} and alkalinity in the drinking water. From the review of Zarver et al. (2010) the dezincification probability increases with increasing Cl^- concentrations especially in drinking water with low alkalinity. Furthermore, increased HCO_3^- concentration tend to partly offset the dezincification potential caused by chlorides (e.g. Zhang and Edwards, 2011). According to Russell and Croll (2012), this form of corrosion increases when the chloride (mg/L) to alkalinity (mg/L as $CaCO_3$) ratio exceeds 0.5. At pH above 8 the meringue-like deposits are formed that may lead to blockage due to precipitation of zinc carbonate minerals with low solubility (e.g. $Zn_5(CO_3)_2(OH)_6$). Furthermore, intergranular corrosion attack (IGA) is more difficult to identify but important to consider as IGA is interconnected with dezincification due to the formation of precipitates containing As and P (e.g. Fe_2P) on the grain boundaries.

Hence, corrosion properties of DZR products may be part of continuous production control. Assessments of the dezincification resistance can be performed according to EN ISO 6509. For IGA assessment, method development will be required as no adequate routine method exists today.

In addition to materials, it is important to regulate the supply water quality in such a way that the water quality does not cause unpredictable corrosion behaviour of the installations. The regulation should give limit values to supply water so that the aggressiveness of the water is always within known values.

9 Conclusion

MaiD has established a unique network which consists of building and health authorities, manufacturing industry, professionals and industrial bodies, certification bodies and R&D institutions from Denmark, Finland, Norway and Sweden. To utilise the results of the MaiD project in a rational way, it is recommended to continue with the Nordic network as a unique place for sharing the experiences and knowledge that will be gained in the future process. It is also considered to be a rational forum to discuss and process some of the recommendations given in MaiD.

The building regulation form in the Nordic countries regarding hygienic properties are different. In Denmark, the regulations are more performance based than in Sweden and Finland whereas it is entirely functional based in Norway. Furthermore, the Norwegian building rules are also covering outdoor water installations. The approval and certification practice also differ to a certain extent both for organic and metallic products. Several of the recommended measures are easily processed in a continued Nordic network (e.g. synchronising limit values, updating old procedures etc.).

The test water composition is crucial when the hygienic performance of the products is assessed including leaching of chemical substances, taste and odour and enhanced microbial growth. Test results should provide sufficient information regarding the hygienic safety level defined in the regulation and the choice of test method need to be considered in relation to the actual drinking water quality as far as possible. The composition of the drinking water varies between the Nordic countries in particular the alkalinity and hardness. In test methods where several conditions for the test water exists (test temperature, disinfection pre-treatment and chlorination), a clear guidance should be developed and provided. Likewise, the rig test for metallic materials (EN 15664) is relevant since three different test water compositions are specified and at least one of the test waters is compatible with the Nordic conditions. It seems though that increased capacity of the test service will be beneficial. In addition, a short-term leaching test for the final product initial surface is considered relevant for metallic materials.

The 4MS Common Approach was initiated as the work on the European Acceptance Scheme (EAS) ceased. In general, the principles of the Common Approach are applicable in the Nordic countries as it is based on the same hygienic properties (taste and odour, leaching, microbial growth and leaching of unsusceptible substances) and assessed according to EN standards developed for the purpose.

The assessment and approval schemes need to be designed and maintained in such a way that hygienic and mechanical properties are emphasised equally. For metallic, products corrosion failures can be developed several years after installation and during the propagation period increased leaching may happen without disclosing them. Hence, corrosion properties may be assessed on a more routine basis (e.g. part of continuous production control).

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Annex - Maid Industrial Advisory Group

Position Note regarding the project results

The procedure to verify that drinking water products are fit for use (i.e. in accordance with the regulations) are today based on different practices in the Nordic countries (voluntary and mandatory approvals, different limit values, different test methods etc.). The practices and regulations are also different for indoor and outdoor water installations among these countries.

This position note is to convey the issues the Industrial Advisory Group (IAG) considers vital to be taken into account when laying out new regulation either on national or on European level. These are, in short:

- Harmonized standards and article 10 of drinking water directive
- Test water applicability with regard to local conditions
- Test and analysis methods
- Long term durability
- 4MS positive list for assessing the safety of materials

Construction product regulation and drinking water directive

The Article 10 of the Drinking Water Directive concerns all materials in contact with water and refers specifically to the construction product regulation that regulates how the construction products can be put on the market. The product regulation is based on Construction Products Regulation and the harmonized standards that are published in OJ. However, for construction products in contact with drinking water there are no harmonized standards.

Currently there are at least two regulatory activities ongoing on European level. Firstly, the revision of the overall Drinking Water Directive and the necessary Impact Assessment have been included in the Commission Work Programme 2017 (COM(2016)710 final). A study of materials in contact with drinking water was published in spring 2017 the results of which will possibly be utilized in the revision.

Secondly, related to Construction Products Regulation, three draft mandates for standardization have been circulated by EU Commission. The mandates when given and accepted open the work towards CE marking under Construction Products Regulation. Considering the normal pace of progress the first new standards based on the possible mandates can be foreseen to be published earliest in the beginning of 2020s.

While in lack of any regulation at European level, national procedures have been developed in many member states. Based on the on-going activities at the regulatory levels, coordinating efforts across the borders are important.

It is essential that new harmonized standards are developed so that the unclear and confusing situation on the market can be corrected. In order to create standards that allow for a level playing field for all players, in the development work - and in the mandate for it - attention should be paid on taking into account the different national requirements already from the beginning.

Test water applicability with regard to local conditions

In the Maid project, a survey concerning Nordic drinking water quality was conducted. It indicates that supplied drinking water quality varies a lot but the three test waters in the standard EN 15664-2 can be assessed to cover the major drinking water compositions in the Nordic countries. Therefore, metal alloys that have passed the rig test and have been put into the 4MS Composition List are safe to use in the Nordic countries in the long term if drinking water is non-aggressive according to national recommendations. In some test method standards, like taste and odour test of plastic products, there are several options for test water. Since test water quality has an influence on test results, the test water quality should be specified by regulators in conjunction with product approval test specification.

It is important to develop test methods and procedures that cover sufficiently the needs of national and European regulators. The test methods should be able to give a performance level or performance class for an essential characteristic of a product together with a known uncertainty.

Our suggestion is to reconsider the test water set and if needed amend the test water sets of the various standards so that the sets represent well enough the water qualities in different locations. For example, testing with three test waters in the standard EN 15664-2 gives sufficient information on the metals release. In case of very aggressive local drinking water either water treatment should be improved to decrease aggressiveness or special guidance by water supplier or local authorities is needed for materials selection. The test water quality should be commonly specified for Nordic countries by regulators and guidelines should be given for mitigation of possible risks caused by extreme waters (limit values and/or product selection).

Test and analysis methods, and limit values

Methods

In Maid's report concerning Regulations and approval systems in the Nordic Countries it can be seen that the practice of referring to test methods is obscure. The practices also vary when comparing the countries in the study. It is time consuming and difficult to find out what are the test methods referenced to in the regulation.

We see it important to use commonly accepted test and analysis methods that are publicly and easily available, and referenced in a way that makes it possible to identify the method unambiguously. It can be reasoned that there is some need for method development and therefore there are some detailed remarks that are of importance.

1. The need for using NKB4 test for products made of brass instead of EN 15664 for materials stems from the observation that the control of the short-term surface leaching properties seems to disappear because the products with pre-accepted materials can be marketed and sold without further testing of the leaching properties. Due to the production processes (casting, machining, chromium-nickel plating etc.) of finished products, the leaching from the outermost surfaces during the first period of the service life of the product is not covered by only using 4MS Composition List.
2. NKB4 was developed when the allowed lead concentrations in drinking water were on a higher level than they are today. Now, when the authorities seem to lower the limit values the method uncertainty seems to become too high in comparison to the limit value. The uncertainty should be taken into account in evaluating the test results in relation to product acceptance into the market. At the moment the uncertainty leads to situations where the same product is accepted in one market and not in another market. Test method development is needed to assure a level playing field on the market and to compare alternative approaches to current testing methods.
3. The availability of testing services must be secured. For type approval the common practice that the authorities have adopted is that the type approval tests must be executed by accredited testing laboratory. For EN 15664 standard there is only one laboratory whose results are accepted for 4MS list, and no accredited testing body at all. There are only few laboratories that can execute partial tests as a service.
4. The materials and resources for tests must be available. For instance, what is the availability of test waters for EN 15664?
5. There are at least two methods referred to in regulation for testing odor and taste. The reasons for using different methods should be analyzed and agree on a common method. The opinion of IAG is that preference is to use an EN-standard and, in case justified, to improve it to meet the required performance of another alternative standard(s).

Limit values

In the summary table supporting the report concerning Regulations and approval systems in the Nordic Countries it can be seen that the limit values for releases of harmful substances vary somewhat in different Nordic countries.

We see that the limit values must be set in such a way that the drinking water directive requirements, when exist for certain parameters, are fulfilled. There are, however, differences in water quality and water systems in different countries and therefore, when setting the limit values, the national or territorial aspects shall be taken into account. Also, the type of usage can be taken into account by e.g. allowing different limit values for kitchen and for sanitary equipment.

In conjunction with setting the limit values an approach of assessing the test method's uncertainty and product manufacturing tolerances must be given. When the absolute value of the uncertainty of the test method is of the same magnitude as the absolute value of the limit value, a clear guideline is needed for assessing how to evaluate the test results.

Long term durability

In addition to hygienic safety there are other essential characteristics of products that are regulated on national level. To ensure the level playing ground these issues must be considered in addition to drinking water directive issues.

In the regulation, there are requirements concerning materials and mechanical properties of construction products. For water pipes, it is important that also the mechanical properties (leak tightness, corrosion resistance, etc.) are adequately addressed in the approval and certification practice. For instance, in Norway and Finland, dezincification resistant (DZR) materials are required as dezincification was the most frequent corrosion form, and a major problem until the 1980s. It is important to ensure that the corrosion resistance of the DZR brasses are providing the same protection level against failure (e.g. intergranular corrosion) as the current DZR brasses we have experiences with for nearly 30 years. Test for DZR ought to be a part of a product test or even more likely a part of continuous control of the manufacturing process at the plant.

In addition to materials, it is important to regulate the supply water quality in such a way that the water quality did not cause unpredictable corrosion behavior of the installations. The regulation should give limit values to supply water so that the aggressiveness of the water was always within known values.

The general principle of the 4MS Common Approach

The four EU Member States, France, Germany, the Netherlands and the United Kingdom (4MS) announced in January 2011 that they have formalized arrangements to work together on this important aspect of the regulatory frameworks they have, to ensure the hygienic safety of drinking water.

The objective of the Common Approach is not to introduce a single assessment system that operates in the exactly same way in each country. It defines a suite of policies and practices that may be adopted within the existing national legal and institutional frameworks. The aim is therefore to ensure that products are assessed consistently, and with the same outcome irrespective of where the work is carried out.

It seems clear that by implementing the Common Approach, the outcome is an increased use of so called positive lists where acceptable chemical substances and materials are specified. Such approach may create more predictability for the stakeholders (e.g. industry and authorities) due to the clarity of complying to a list or not, and that the room for interpretations is relatively small. Furthermore, the fundamental goal for the hygienic lists is to protect the human health, which in principle is country independent, i.e. the human tolerable dose of a chemical substance is the same across Europe. Therefore, creating and using of European material lists is most important.

IAG supports the use of 4MS approach. IAG also supports that the use of positive lists for materials and substances could be supplemented with testing of parts and depending on usage also finished products. For achieving this, there is a need for developing testing methods to meet the testing quality requirements on the market. Many of the substances and materials in the positive lists undergo changes in the processes of converting substances and materials to products and parts used in products and therefore, testing the products or parts can be essential. There is a need to have an EN interpretation document (additional part to EN-standard) on how the test results of EN 15664 standard should be interpreted. This would help achieving the transparency when adding new substances and materials to positive list. In addition to test method development, also the procedures for approval shall be developed further so that inclusion of new substances and materials on positive lists and exclusion of them from the positive lists would be more transparent and open for participation to all involved parties on the market.

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