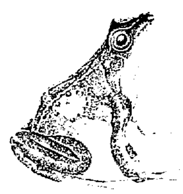
Conversion Factors for Leaching Tests (DWQ 9007)

Report to the Department of the Environment



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CONVERSION FACTORS FOR LEACHING TESTS (DWQ 9007)

Report to the Department of the Environment

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SUMMARY

Leaching tests on products for use in contact with drinking water are undertaken to assess whether the leaching of any impurity from the product would be acceptable or not as far water quality and human health are concerned.

Approval schemes in different countries take different approach how to make this assessment on the basis of results from leaching tests. These range from extensive field tests, simulating actual conditions of use, where the concentrations measured are used directly in the assessment, to a single standardised short-term test, where the test results are adjusted, using conversion factors (depending on the product and its intended use) to estimate the actual concentrations in field use.

CEN TC164/WG3/AHG2 is drafting standard methods for migration tests from non-metallic products which will include calculation of the actual concentration in field use from the test results. A number of conversion factors, derived from those used in the existing schemes, has been proposed and are being discussed within CEN.

This report reviews the current approaches in the UK, Germany, France, the Netherlands and the USA, and compares the different conversion factors for plastic pipes proposed for the CEN migration tests.

Most progress has been achieved in defining a factor **F2** , which should correct for differences between laboratory and field use conditions in surface area to volume ratio and contact time of water with the product, but a number of differences still exists.

Decisions are needed concerning adjustments due to decreasing migration with time (factor **F1**, extended leaching), and whether a typical or 'worst-case' situation should be used when calculating the **F2** factor. Any solution to these questions need to satisfy regulations on water quality and should be based on expert toxicological advice.

1. INTRODUCTION

Leaching tests on products for use in contact with drinking water are undertaken to assess whether the leaching of any impurity from the product either:

- would result in the breach of the EC Directive on Drinking Water Quality 80/778/EEC (or the relevant National Regulations), or
- would exceed a maximum permissible level set in a standard, a positive list, etc., or
- would pose unacceptable health risk to the consumer.

Approval schemes in different countries take different approach to make this assessment on the basis of results from leaching tests. These range from extensive field tests, simulating actual conditions of use, where the concentrations measured are used directly in the assessment, to a single standardised short-term test, where the test results are adjusted, using various conversion factors (depending on the product and its intended use) to estimate the actual concentrations in field use.

When determining the appropriate conversion factors some or all of the following factors are taken into consideration:

- differences in surface area to volume ratios between laboratory and actual field use conditions;
- differences in the time that the product is in contact with water during the laboratory tests and under actual field use conditions;
- changes of leaching rates of the contaminants from the product with time; and
- degree of safety, i.e. assuming average or 'worst case' conditions of field use.

The two existing CEN Draft standards for leaching/migration tests, i.e. the Draft prEN Standard for factory-made products, drafted by CEN TC 164/WG3/AHG2, and prEN 852-1 for plastic pipes, drafted by TC 155/WG2, are both based on a uniform test, for a variety of products, using a set surface to volume ratio (0.5 to 1 $cm^2\ ml^{-1}$) and three subsequent stagnation periods of 72 hours (24 hours for tests with hot water). The results are expressed as daily migration rates per unit of surface area, thus representing a characteristics of the material, assuming to be specific for that material under the condition of the test (temperature, pre-treatment, water quality, etc.).In order to estimate the actual concentrations of the leaching contaminants for a variety of products in field conditions conversion factors therefore need to be applied.

Several proposals for conversion factors for plastic pipes have been made and these are being discussed both by the WG2 and AHG2. Less attention has so far been paid to conversion factors for other factory-made products, also to be tested in accordance with these draft standards, such as fittings or coatings. Conversion factors for other then factory-made products, for which standard tests have not yet been drafted (site-applied products, ion exchange resins, membranes, etc.), will need to be considered separately, depending on conditions of the tests (e.g. the relationship between test and field conditions would be different for dynamic testing).

This review compares the different approaches adopted by major existing approval schemes, summarises the principles of the current proposals for conversion factors for the CEN standards, and assesses the outstanding problems.

2. EXISTING APPROVAL SCHEMES

The major approval schemes, i.e. those in France, Germany, the Netherlands, the UK and the USA, all use leaching tests for non-metallic products for use in contact with drinking water to estimate the possible concentrations of the contaminants in water supply and then compare the estimates with concentrations regarded as acceptable as far as water quality or human health are concerned.

However, only two of the schemes (Netherlands and USA) are actually applying defined conversion/ normalisation factors. Other schemes have adopted a different approach to achieve compatibility, for different products, between test results and acceptable levels of the contaminants.

2.1 UK approval scheme

For approvals under the Water Supply (Water Quality) Regulations, factory-made products are submitted to three consecutive stagnation periods of 24 hours, 48 hours and 72 hours, in laboratory leaching tests.

For plastic pipes, the pipe of the smallest diameter for which an approval is sought, is filled with the test water. For other factory-made product the same surface area to volume (S/V) ratio as that specified in the Draft prEN Standard from the AHG2 has now been adopted (0.5 to 1 $cm^2\ ml^{-1}$).

A committee of experts, the Committee on Chemicals and Materials of Construction for Use in Public Water Supply and Swimming Pools (CCM) then estimates (on a case-by-case basis), from the concentrations determined in the tests and information on the intended use, provided by the applicant, the likely exposure of consumers to the leaching contaminants under 'worst case' situation.

From toxicity data provided by the applicant or from data available in public domain, toxicological experts on the Committee then assess whether the likely exposure concentration would pose an unacceptable health risk. The exposure concentration estimated from the results for the final stagnation period are taken into account, as well as the rate of decrease in the concentrations. Where appropriate, more extensive leaching tests might be required.

The leaching of metals from non-metallic materials, including plastic pipes, is usually tested in accordance with British Standard BS6920, where the S/V ratio is 0.15 $cm^2\ ml^{-1}$, the tests include up to seven 24-hours stagnation periods, and the concentrations in the final extract are compared directly, regardless of the actual S/V ratio for the intended use, with set values, corresponding to the MACs in the EC Directive on Drinking Water Quality.

Contaminants, for which the MACs are set, only seldom originate from non-metallic materials in contact with water supplies. Amongst the exceptions, metals, hydrocarbons and PAHs are of concern in some products. In common with most of the other approval schemes, the UK approach to assessment would not exclude the possibility that the concentration of the regulated contaminants in water samples, taken soon after the installation of some products, could exceed the MAC in the EC Directive on Drinking Water Quality.

NOTE: Site applied pipe linings are tested in a manner that simulates their field use. Therefore the measured concentrations of the contaminants are compared directly, without any conversion.

2.2 French approval scheme

Leaching tests in accordance with standard T 90/M Doc.8 use variable S/V ratios depending on the intended use of the product. S/V ratios are specified for the four following groups of products (Table 2.1):

Table 2.1 Categories of products in France

Products		Surface to volume ratio in the test ($cm^2\ l^{-1}$)
A	Domestic pipes	240
B	Pipes in public water supply and domestic tanks	60
C	Reservoirs for public water supply	30
D	Sealants for public water supply	3

The leaching test consists of just one stagnation period of 24 hours, during which the leaching is usually at its maximum.

Concentrations of commonly measured contaminants, determined in the extract are then compared directly with maximum permissible values which are set at 20% of the relevant MACs in the EC directive. The Ministry of Health sets limits for substances which are not included in the Regulations, using available toxicity data. As in the UK, the criteria on which the individual toxicological assessment is based are not publicly available.

2.3 German approval scheme

The approach adopted in Germany is set out in KTW Recommendations issued by the Working Group 'Drinking Water Affairs of the Commission of Plastics' of the Federal

Health Office (BGA). Leaching tests are based on three 72-hours stagnation periods and use the same S/V ratio for all products, i.e. 1 cm^2 ml^{-1}.

The concentration measured during the last stagnation period is expressed as the migration rate in mg m^{-2} 24 $hours^{-1}$ and compared with the appropriate maximum acceptable migration rate (MAMR) given in the KTW Recommendation.

Different MAMRs are specified for five categories of products. The products and their corresponding factors for MAMRs are as follows (Table 2.2):

Table 2.2 Categories of products in Germany

Category	Products	Factor
A	Pipes and pipe coatings	1
B	Reservoirs and reservoir coatings, filter tanks	4
C	Fittings, armatures, etc.	6
D1	Large-surface gaskets, membranes, jointing materials	25
D2	Other gaskets, adhesives, lubricants	50

The above MAMRs take into account the differences in S/V ratios in the actual use of the product and also the contact time, e.g. for reservoirs, but the exact basis for calculations of the factors is not available.

2.4 Approval scheme in the Netherlands

The approach to the assessment of leaching is described in details in the 'Guideline quality of materials and chemicals for drinking water supplies' Issued by the Inspectorate of Public Health and Environmental Protection, Publication 86-01 (updated Dutch version - Publication 92-04).

The leaching test is similar to that in Germany, i.e. the results from the last of the three successive 72-hours stagnation periods are expressed as the specific migration (mg dm^{-1}) during the 72 hours.

Conversion factors, depending on the product, are then applied to calculate the estimated concentration in water (mg l^{-1}). This estimate is then compared with a maximum tolerable concentration (MTC) given in the appropriate positive list (depending on material).

There are two conversion factors, **F1** and **F2. F1** corrects for assumed decrease in migration rates from the material with time, where thought appropriate, and the factor **F2** takes into account the S/V ratio of the product and the estimated contact time. The estimated concentration in water, **C**, is calculated from the following equation:

$$\mathbf{C = F1 \times F2 \times M\ (mg\ l^{-1})}$$

where **M** is migration per unit of surface area (mg dm^{-2}) over 72 hours of the last stagnation period.

The same value of 0.1 for **F1** has been used, regardless of the material and the product. For pipes the value of **F2** is taken to be 3, and for tanks and reservoirs to be 0.1. Separate calculations are given for products with small areas with a general conclusion that each case will have to be assessed individually.

NOTE: These factors are not applied rigidly, i.e. when the assumptions, on which their calculations were made, are not valid, different values may be used. For example, when the contents of the reservoir are changed less frequently than once a day, the **F2** value would be higher then 0.1.

The MTC either equals the MAC in the EC Directive or, for unregulated contaminants, is calculated from toxicological data in accordance with defined general rules. (The calculation is based on no effect level (NEL) assuming a body-weight of 60 kg, daily intake of 2 litres of water and a 10% contribution from drinking water to the maximum permissible intake, and includes a safety factor **f** (minimum 100).

2.5 Approval scheme in the USA

The approach is set out in the ANSI/NSF Standard 61. Both, the conditions of the leaching test, such as the S/V ratio, sample preconditioning and exposure time and temperature, and the conversion factors applied, depend on the product under test. The products are divided into the five following groups:

- Pipes and related products (including pipes, tubings and fittings)
- Protective (barrier) materials (including coatings and linings, rubbers, concrete admixtures, etc.).
- Joining and sealing materials (adhesives, gaskets, lubricants, etc.).
- Process media (adsorption media, filtration media, ion exchange resins, sand, etc.).
- Mechanical devices (chemical feeders, disinfectant generators, pumps, water treatment devices, etc.).

For pipes for cold water application the leaching is carried out inside the pipe of the smallest diameter, the exposure time is 16 hour at 30 °C, after preconditioning the test sample for two weeks, with at least 10 changes of the test water.

For other products, different S/V ratios, sample preparation and product exposure are specified and tabulated in the Standard. For example, coatings containing solvent are tested at 50 cm^2 l^{-1} for 37 days.

A complex system of normalisation factors is then applied to the concentration detected in the leachate to estimate the level of contaminants 'at the tap'. For most products the normalisation factor **NF** is calculated from:

NF = N1 x N2

where **N1** is applied to account for the differences in S/V ratios between laboratory and actual field conditions and **N2** to reflect differences between laboratory and field exposures under flowing conditions. For different categories of pipes the calculations of the **N2** values are based on the following assumptions (Table 2.3):

Table 2.3 Categories of products in the USA

Category	Internal diameter	Assumption	N2
Water main	>4"	The same material from the treatment plant to the point of use.	1.0
Multiple user service line	=4"	72 feet from water mains to the residential connection, 2 connections per length	0.21
Service line	<4" but >1"	100 feet from street to the meter, 1 connection per length, 120 gallons per length	0.034
Residential	<1" but >½"	280 feet of pipes per residence, 120 gallons per 16 hours, 2.86 gallons static volume (for each ½ for cold and the other for hot)	0.024

The normalised concentrations are then compared with set values, i.e.:

- MCL - Maximum Contaminant Level for contaminants regulated by the EPA,
- MDWL - Maximum Drinking Water Level , for contaminants not regulated by the EPA, which is calculated from toxicological data, as set out in the Standard 61,
- MAL - Maximum Allowable Level, which is 10% of the MCL or MDWL.

The normalised concentration calculated for static condition must be less then or equal to the EPA MCL or the calculated MDWL, while that for flowing conditions must be less then or equal to the appropriate MAL.

2.6 Comparison of the different approaches

In respect of acceptable migration rates/concentrations in different countries, it is difficult to make direct comparisons between the approval schemes, because of their basic differences and because some of the steps in the individual approaches are not sufficiently defined. Though the objective of the leaching test is the same, i.e. to provide an estimates of the level of the contaminant in drinking water, which could be compared with a maximum acceptable value, there are differences in every stage of the assessment process.

For illustration, it is possible to make an approximate projection of what would be the likely outcome of the assessment of the leaching of lead from pipes having the same profile of migration rates when tested under the different systems.

Assuming a profile of daily migration rates as shown in Figure 2.1 (based on test results in the interlaboratory study on PVC pipes for TC 164/WG3/AHG2), it is possible to calculate the concentration of lead in the final leaching period on the basis of the appropriate S/V ratio in the test, estimated daily migration rate and duration of the period, and convert it, where appropriate, to a value comparable to a set maximum acceptable level. The results of the calculations and their comparisons with the set values are given in Table 2.4.

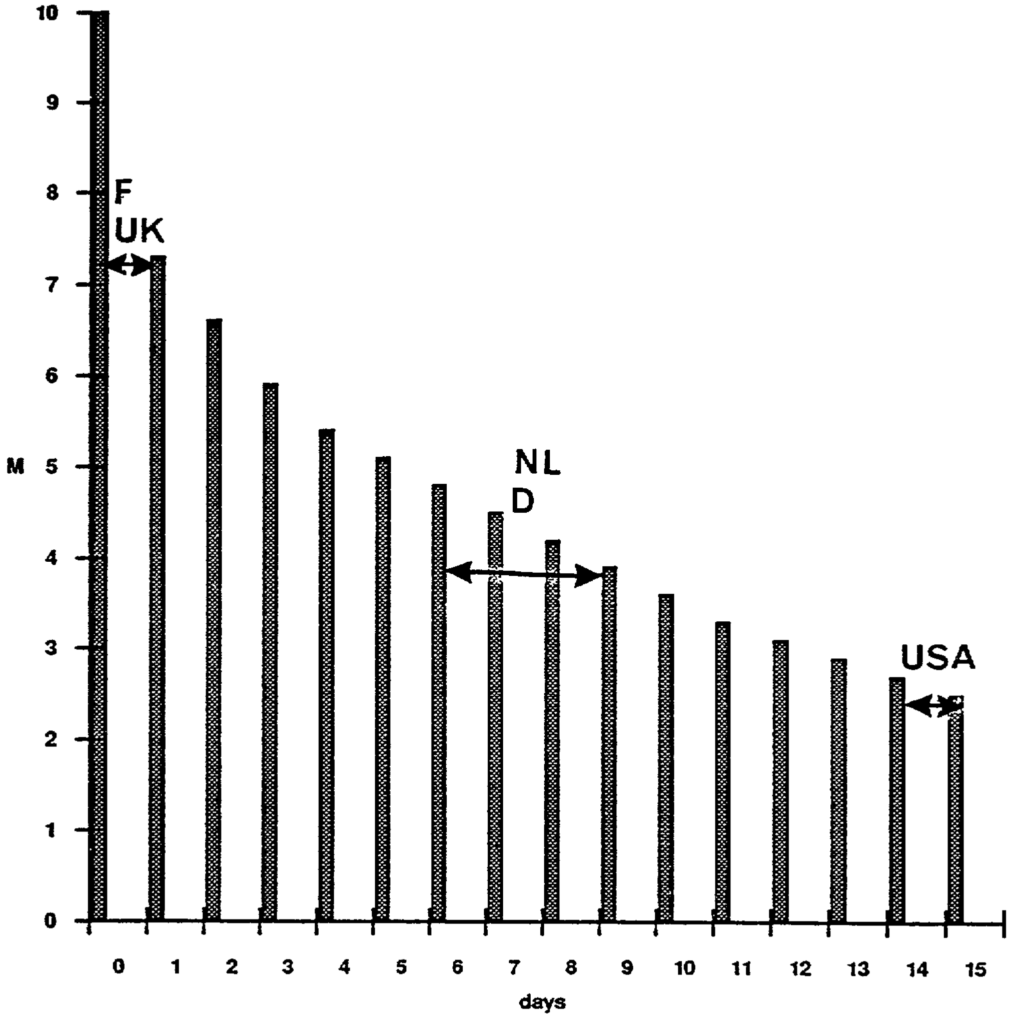

Figure 2.1 Projected daily migration rates, M (μg dm^{-2} day^{-1})

Table 2.4 Projected results of leaching of lead from the same PVC pipe tested under different approval systems

Pipe diameter (o.d. mm)	S/V in test ($dm^2 l^{-1}$)	Main test period - day/duration	Assumed M ($\mu g\ dm^{-2}\ day^{-1}$)	Concn. in test ($\mu g\ l^{-1}$)	Reported result	Permitted value	Pass/Fail
France							
32	2.4	day 1 - 24 h	7.3	17.5	17.5 $\mu g\ l^{-1}$	10 $\mu g\ l^{-1}$	**F**
75	0.6	day 1 - 24 h	7.3	4.4	4.4 $\mu g\ l^{-1}$	10 $\mu g\ l^{-1}$	**P**
Germany							
32+75	10	day 9 - 72 h	Av. 4.2	126	0.42 $mg\ m^{-2}$ per day	0.3 $mg\ m^{-2}$ per day	**F**
KIWA (NL)							
32	14.7	day 9 - 72 h	Av 4.2	185	M=0.0126 $mg\ dm^{-2}$, C= 0.1x3xM		**P**
75	5.9	dtto	dtto	74	= 0.004 $mg\ l^{-1}$	0.05 $mg\ l^{-1}$	**P**
UK BS6920							
32 + 75	1.5	day 1 - 24 h	7.3	11.0	11.0 $\mu g\ l^{-1}$	50 $\mu g\ l^{-1}$	**P**
US-NSF							
32	14.7	day 15 - 16 h	2.5*	24.5	Stat.= 24.5 $\mu g\ l^{-1}$	MCL=15 $\mu g\ l^{-1}$	**F**
					Flow.= 0.83 $\mu g\ l^{-1}$	MAL=1.5 $\mu g\ l^{-1}$	**P**
75	5.9	day 15 - 16 h	2.5*	9.8	Stat.= 9.8 $\mu g\ l^{-1}$ Flow.= 0.33 $\mu g\ l^{-1}$	dtto	**P** **P**

* - leaching rates at the higher temperature used (30 deg C) could be higher

3. PROPOSED CONVERSION FACTORS FOR CEN MIGRATION TESTS

3.1 Scope of the proposals

The existing proposals have been originally prepared for, and discussed by the CEN TC 155/WG2 - Plastic pipes. They concern, therefore, mainly conversion factors for pipes, i.e. service pipes, distribution lines and water supply mains. Some of the proposals include conversion factors for reservoirs, tanks, fittings, valves, etc., but these have not yet been discussed to any extent. This review will, therefore, also focus on the proposals for plastic pipes. Proposed conversion factors for other products will be listed towards the end.

All the proposed conversion factors relate to results from leaching tests consisting of three consecutive stagnation periods, which are common to both prEN Drafts, i.e. prEN 852-1 for plastic pipes and the Draft prEN Standard for migration tests for factory-made products (TC 164/WG3/AHG2). The results are expressed as the **daily migration rates M,** calculated from concentrations determined after each stagnation period:

$$\mathbf{M_{24} = C \times S_T/V_T \times 1/t \ (mg\ dm^{-2}\ 24\ h^{-1})}$$

where **C** is concentration determined in the leachate (mg dm^{-3} or mg l^{-1}) $\mathbf{S_T}$ is the surface area of the test sample exposed to the test water (dm^{-2}), $\mathbf{V_T}$ is volume of the test water (dm^3), and **t** is duration of the stagnation period (hours), usually 72 hours.

It is assumed that an appropriate conversion of the results would give estimated concentrations of the contaminants at the tap under conditions of use, although the meaning of the converted result may eventually depend on the principle on which the maximum acceptable values, which are to be compared with the estimates, are set.

3.2 Conversion factors for pipes

In January 1991 TC 155/WG2 drafted a standard (Document CEN/TC155/WG2 N88) based on the KIWA approach (Section 2.4), i.e. the corrected value **CV** was calculated from the determined migration **M**:

$$\mathbf{CV = M_{72} \times CF \ (mg\ l^{-1})}$$

where **CF = F1 x F2.**

$\mathbf{M_{72}}$ is the migration from a unit of surface area over the stagnation period (mg dm^{-2}) and **CF** is the conversion factor (dm^2). Factor **F1** would correct for assumed decrease in migration rates from the material with time, where thought appropriate, and **F2** would take into account the S/V ratio of the product and the estimated contact time.

The proposed values for pipes were 0.1 or 1.0 for **F1** and 3 for **F2.** (The value for **F2** would be 9 when using $\mathbf{M_{24}}$ (accepted in the Draft Standards as the result to be reported) instead of $\mathbf{M_{72}}$).

The proposed values for both the **F1** and **F2** factors were challenged and modified proposals have been put forward, where the calculations were based on different assumptions. The main proposals are summarised below.

3.2.1 Factor F2

When calculating **F2** factors, the following aspects are taken into consideration:

- S/V ratio under conditions of use,
- periods of stagnation in the pipe,
- residence time in a flowing pipe, which depends on the length of the pipe and the flow, and
- domestic water consumption.

While the S/V ratio is determined by the diameter of the pipe it is much more difficult to estimate the overall contact time, which depends on the combination of the other three factors, each of them may vary significantly. In addition, consideration needs to be given whether the conversion factor should be valid for a typical situation or should be based on a 'worst case' situation and, if the latter, how to deal with this. Should any extreme case be included or, alternately, should products for such cases, such as exceptionally long trunk mains lines or long narrow pipes for remote dwellings be treated separately.

The main alternative proposals for the calculation of **F2** are as follows:

(a) Modified proposal from KIWA, Netherlands, Document CEN TC/155/WG2 N139

(b) Proposal from E. Villquist, VBB VIAK, Sweden, Document CEN TC155/WG2 N138)

(c) Proposal from M. Fielding, WRc, UK, Document CEN TC155/WG2 N143

(d) Proposal from J. Aeyelts Avering, Netherlands, Document CEN TC155/WG2 N194

(e) Proposal from U. Schlosser, WaBoLu, Germany, Document CEN TC164/WG3/AHG2 N80

The proposed values of the factor **F2,** together with the S/V ratios and estimated real contact times used for calculating the **F2** are given in Table 3.1. Basis of each proposal, assumptions on which the calculations were based and some additional calculations are given in Appendix A. Table 3.2 then compares the resulting **F2** values for a range of pipes of different diameter.

Table 3.1 Proposed calculations of the conversion factor F2

F2 = S/V x t/24 (for M24)

Proposal	Pipe diameter (dm)	S/V (dm^{-1})*	Estimated contact time t (h)	F2 ($l\ dm^{-2}$)
KIWA	≤ 1.34	≥ 3	see Appendix A	9
(N139)	>1.34	<0.3		0.9
E. Villquist	≤ 1.5	2.7	80	9
(N138)	>1.5 but ≤ 4	1.0	72	0.9
	>4 but ≤ 10	1.0	24	1
	>10	0.4	18	0.3
M. Fielding	All	As given	72	3 x S/V
(N143)	e.g.: 0.4	10		30
	1.34	3.0		9
	4	1.0		3
	10	0.4		1.2
J. Aeijeltes Averink	0.12 - 0.25	25 (F_G)	12 (F_O = 0.5)	12.5 (F_G x F_O)
(N194)	0.32 - 1.25	10	2 (F_O = 1/12)	1
	1.60 - 5	2.5	24 (F_O = 1/)	2.5
			or 36 (F_O = 1.5)	3.8
	>5	0.8	24 (F_O = 1)	0.8
			or 36 (F_O = 1.5)	1.2
U. Schlosser	≤0.25	>16	8	1/3 x SV
(AHG2 N80)	>0.25 but ≤0.6	<16 but ≥ 6.2	12	0.5 x SV
	>0.6 but ≤ 2	<6.2 but ≥ 2	24	1 x S/V
	>2	<2	24	1 x S/V

* - approximate. Stated pipe diameters usually refer to outside diameters

Table 3.2 Comparison of proposed F2 values for a range of pipe diameters

	F2 ($l\ dm^{-2}$ for M_{24})				
Pipe diameter (mm)	N139	N138	N143	N194	AHG2 N80
16	9	9	75	12.5	8.3
40	9	9	30	1	5.0
160	0.9	3	7.5	2.5 or 3.8	2.5
400	0.9	1	3.0	2.5 or 3.8	1.0
1600	0.9	0.3	0.75	0.8 or 1.2	0.16

3.2.2 Factor F1

Results from various leaching tests over time have provided evidence that the migration rate from plastic materials into water decreases with time. Since both the proposed standard CEN migration tests are carried out, after only a short period of flushing, for nine days after the material first comes into contact with water, the migration is therefore likely to be at its maximum. It can be reasonably expected, that over the life time of the product any leaching of contaminants will virtually stop, sooner or later (this may not be so in case of leaching metals from metallic pipes or for increased pH from cementitious products, where the leaching might continue over the lifetime of the pipe, depending on the characteristics of the water in contact). However, at present, there is no guidance on how long could be elevated leaching tolerated, what would be the acceptable levels, and how would this depend on the nature of the contaminant. In addition, it is not clear, whether it is permissible to approve a product which may exceed the MAC for any contaminant regulated by the EC Directive on Drinking Water Quality, even for a very short period of time after installation.

There are widely different views whether the fact of decreasing migration with time should be taken into consideration when assessing the acceptability of a product for use in contact with drinking water, and if so, how.

Both the initial and the modified KIWA proposals employ the use of the factor **F1,** having an arbitrary value of 0.1 (unless the migration rate does not decrease during the three stagnation periods; **F1** is then 1.0). This arbitrary factor was found generally unacceptable, because it was based on the only available long-term leaching data, i.e. for lead from PVC, but the leaching characteristics differ for individual contaminants.

The TC 155/WG2 therefore proposed to include extended testing of up to ten 72-hours stagnation periods for products, that would show, after the third period, levels of contaminants above the set maximum acceptable value. Several proposals on how to use the additional data have been made:

- When the migration values decrease from stagnation period 8 to period 10 by a certain value (15% was suggested), then **F1** would be 0.1. (CEN TC155/WG2 N99 and N100)

- The product would be approved if the level of the contaminants in the 10th period of the extended testing was below the set maximum acceptable value. (French proposal, CEN TC155/WG2 N140)

- Different **F1** values would be established, as in the case of lead in PVC, for other contaminants, in line with data obtained from the extended testing. (UK proposal, CEN TC155/WG2 N 143). These could then be applied when testing similar products or for audit testing of the same product. NOTE: The modified KIWA proposal (N 139) suggests regression analysis of the results obtained from the subsequent stagnation periods as a useful measure for the correction factor **F1**.

There are other possible approaches how to take into account the decrease in migration with time, e.g.:

- If, as in the French proposal, simple confirmation with the set maximum acceptable value is sufficient for an approval, then all products could be tested only in the extended test, analysing the extract after the 10th stagnation period. This would save high analytical costs for the first three periods and avoid having to restart the test when the results are not available in time just to extend the standard test after the third period. (See also the US NSF approach for pipes, Section 2.5).

- Setting up different short-term and long-term maximum acceptable levels for individual contaminants, both for contaminants for which MACs are set in the EC Directive and for those for which the values would be based on toxicological data.

However, there are also views, that the decrease in migration with time should not be taken into account, i.e. **F1** should always be 1.

3.2.3 Situation at present

At present the proposal by J Ayelts Avering (which does not include any correction for the decrease of migration with time) is being discussed by TC 164/WG3/AHG2 as the possible basis for conversion factors for pipes. The main point of discussion is the maximum contact time for different types of pipes which should be used calculating the factor, i.e. the problem of a typical/worst case situation assumption. The question of the decrease of migration with time has been shelved for the time being.

3.3 Conversion factors for factory-made products other then pipes

The modified KIWA proposal (N139) covers a range of different products which are divided into three categories as given in Table 3.3.

Table 3.3 Proposed values of factor F2 for different categories of products

Category	S/V ($dm^2\ l^{-1}$)	Products	Factor F2 ($l\ dm^{-2}$) (for M_{24})
C1	≥3	pipes, factory- and site-applied pipe coatings and linings, etc.	9
C2	<3 but ≥0.03	large diameter pipes (>1.34 dm), large valves, gaskets, reservoirs, tanks and their coatings, filter material, etc.	0.9
C3	<0.03	fittings, small valves, elastomeric products, greases, adhesives, sealing and jointing compounds, etc.	0.09

In this proposal the suggested values for **F1** factor are the same for all three categories, i.e. **F1** = 0.1 or 1.0.

4. CONCLUSIONS

- Conversion factors need to be applied to the results from standard laboratory leaching tests in order to estimate possible concentrations of the contaminants in water supplies. Different factors should be used for different products, different conditions of field use, and for different conditions of the leaching tests.

- Most progress has been achieved in defining the factor **F2** for plastic pipes and factory-applied pipe coatings and linings, but a number of differences still exists. This factor should correct for differences between laboratory and field use conditions in surface area to volume ratio and contact time of water with the product.

- Decisions are needed concerning adjustments due to decreasing migration with time (**F1**, extended leaching), and whether a typical or 'worst-case' situation should be used when calculating the **F2** factor. Any solution to these questions need to satisfy regulations on water quality and should be based on expert toxicological advice.

- Conversion factors for products other than pipes have not yet been discussed by the CEN TC164/WG3/AHG2.

REFERENCES

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APPENDIX A PROPOSALS FOR CONVERSION FACTORS F2 TO BE APPLIED TO THE RESULTS OF CEN STANDARD MIGRATION TESTS ON PLASTIC PIPES

Modified proposal from KIWA, Netherlands
Document CEN TC/155/WG2 N139

Basis of the proposal: For all pipes with diameter of ≤ 3 dm^2 l^{-1} a single value of **F2**, i.e. 3 (dm^2 l^{-1}) should be applied (when using M_{72}).

For large diameter pipes (>1.34 dm) the factor should be 0.3.

Validity of the proposal was illustrated on three typical examples using the following main assumptions:

- The concentration at the tap is a combination of contributions from the main, service and domestic pipes, all made from the same material (i.e. all having the same M_{72}).
- The contact time for main pipes (S/V 1.6-3 dm^2 l^{-1}) is 24 hours.
- The maximum standstill period in a domestic installation is 24 hours.
- The length of the service pipe (S/V 8-20 dm^2 l^{-1}) does not exceed 150 dm.
- The average length of domestic pipes (S/V 16-33 dm^2 l^{-1}) is between 50 and 75 dm per tap and the domestic installation consists of 5 taps.
- The daily use of water per person is 100 l.

Then it can be calculated from the equation:

$$C = \text{contact time}/72 \times S/V \times M_{72} \ (\text{mg l}^{-1})$$

that the concentration C does not exceed $3M_{72}$.

Proposal from E. Villquist, VBB Viak, Sweden
Documents CEN TC 155/WG2 N 132 and N138

Basis of the proposal: Values of the **F2** factor are proposed for four rather than the two above categories of pipe diameters, i.e. for:

<1.5 dm **F2** = 9
≥ 1.5 to <4.0 dm **F2** = 3
≥4.0 to <10.0 dm **F2** = 1
≥ 10.0 dm **F2** = 0.3

Proposal from M. Fielding, WRc, UK
Document CEN TC155/WG2 N143

Basis of the proposal: Assumed contact time of 72 hour for domestic, service and mains pipes would give better protection against 'worst case' situations, such as stagnation periods over weekends, long connections to isolated buildings or trunk mains over 100 km long.

The estimated concentration can be therefore calculated from:

$C = S/V \times M_{72}$
(or **F2** = $S/V \times 3$ for M_{24})

Proposal from J. Aeyelts Avering, Netherlands
Document CEN TC155/WG2 N194

Basis of the proposal: The two components of the **F2** factor, i.e. S/V and contact time, should be treated separately. The estimated concentration C would then be calculated from:

$C = \mathbf{F_G} \times \mathbf{F_O} \times M_{24}$ (mg l^{-1})

(**F2** = $\mathbf{F_G} \times \mathbf{F_O}$, and assuming **F1** = 1)

where $\mathbf{F_G}$ is determined by geometrical dimensions of the pipe, i.e. $\mathbf{F_G} = S/V$ ($dm^2\ l^{-1}$),

and $\mathbf{F_O}$ depends on operating conditions (i.e. contact time). In practice $\mathbf{F_O}$ = t/24h, where t is the estimated contact time (stagnation or retention).

Values of $\mathbf{F_G}$ and $\mathbf{F_O}$ and the resulting **F2** values are proposed for four categories of pipes, i.e. pipes inside buildings (domestic), service pipes, distribution lines and trunk mains. The values are given in Table 3.1 in the main text.

The values for F_O are based on the following main assumptions:

Domestic pipes - average overnight stagnation of 12 hours,

$\mathbf{F_O}$ = 12/24 = 0.5 - volume of water in pipes within a building is small compared to the assumed usage of water of 200 l per person per day, and therefore migration during the day, under flowing conditions is negligible.

Service pipes - average overnight stagnation is small - assumed 2 hours,

$\mathbf{F_O}$ = 2/24 = 1/12 - migration under flowing conditions is negligible

Distribution lines and trunk mains - stagnation does not occur,

$\mathbf{F_O}$ (24h) = 24/24 = 1 - migration M is the same under static and flowing conditions,

$\mathbf{F_O}$ (36h) = 36/24 = 1.5 - contact time (residence) is either 24 hours or 36 hours.

Proposal from U. Schlosser, WaBoLu, Germany
Document CEN TC164/WG3/AHG2 N80

Basis of the proposal: The calculations use the same basic equation, i.e.:

$C = \mathbf{F2} \times M_{24} = t/24 \times S/V \times M_{24}$,

but the recommendations are made for permissible M_{24} values rather then for values of conversion factors. Recommended M_{24} values for TOC are proposed for four categories of pipes, i.e. the same value of 0.025 mg dm^{-2} day^{-1} for domestic, service and distribution pipes, and 0.1 mg dm^{-2} day^{-1} for trunk mains.

The calculations of the proposed values are based on the following main assumptions:

- an increase of 0.1 mg l^{-1} TOC is acceptable for each category of pipes,
- an increase of 0.4 mg l^{-1} TOC at the tap is acceptable in a system consisting of all four categories of pipes,
- contact time in domestic pipes is 8 hours,
- contact time in service pipes is 12 hours,
- contact time in distribution lines is 24 hours, and
- contact time in trunk mains vary between 10 to 24 hours.