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Plastics piping systems for the transport of water intended for human consumption — Migration assessment — Guidance on the interpretation of laboratory derived migration values

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National foreword

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Plastics piping systems for the transport of water intended for human consumption - Migration assessment - Guidance on the interpretation of laboratory derived migration values

Systèmes de canalisations plastiques pour le transport d'eau destinée à la consommation humaine - Évaluation de la migration - Guide d'interprétation des valeurs de migration déterminées en laboratoire

Kunststoff-Rohrleitungssysteme für den Transport von Trinkwasser für den menschlichen Verzehr - Bewertung der Migration - Anleitung für die Beurteilung von aus Laborversuchen abgeleiteten Migrationswerten

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Foreword

This document (CEN/TR 852:2010) has been prepared by Technical Committee CEN/TC 155 “Plastics piping systems and ducting systems”, the secretariat of which is held by NEN.

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This document supersedes ENV 852:2001.

Introduction

This document was originally issued by CEN/TC 155/WG 2 as an ENV. Because of the current developments relating to contact with water intended for human consumption, CEN/TC 155 has decided not to ask for a revision of this document as a standard, but to propose instead to keep it as a Technical Report. The main objective of this is to make the information available as quickly as possible to interested groups, particularly those involved in designing the regulatory framework of harmonised standards, such as a European acceptance scheme.

EN ISO 8795 provides instructions on how to produce a migration liquid and how to calculate a migration value (M) after analysis of a migrating substance. However, EN ISO 8795 does not give information on:

a) the number of successive migration periods to be carried out;

b) how to interpret *M* values calculated from successive migration periods;

c) a method for converting the calculated *M* values into values that reflect field use conditions;

d) acceptance criteria for the duplicate *M* values obtained by testing in accordance with EN ISO 8795.

This information is included in this document (CEN/TR 852:2010). In the case of the conversion of *M* values (point c), two factors have been considered:

— a geometrical factor F_g , which is a property of the product;

— an operational factor F_o, which is calculated from the residence time of the water in contact with the product. The values of F_o quoted in this document are based on certain assumptions and/or risk analysis. These are explained in the document.

1 Scope

This Technical Report is applicable to plastics pipes, joints and fittings to be used for the transport of water intended for human consumption and raw water used for the manufacture of water intended for human consumption.

It gives guidance on:

a) the number of successive migration periods to be carried out;

b) how to interpret *M* values calculated from successive migration periods;

c) a method for converting *M* values into values that reflect field use conditions;

d) acceptance criteria for the duplicate *M* values obtained by testing in accordance with EN ISO 8795.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 8795, *Plastics piping systems for the transport of water intended for human consumption — Migration assessment — Determination of migration values of plastics pipes and fittings and their joints (ISO 8795:2001)*

3 Terms, definitions and symbols

For the purposes of this document, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1 Terms and definitions related to acceptance limits

3.1.1.1
concentration acceptance limit (C_{al})
concentration of a constituent which shall not be exceeded

NOTE 1 It is expressed in milligrams per litre (mg/l).

NOTE 2 The limit is specified elsewhere, e.g. in national regulations.

3.1.1.2
migration acceptance limit (M_{al})
migration value for a constituent which shall not be exceeded

NOTE 1 It is expressed in milligrams per square decimetres per 24 h [mg/($dm^2 \times 24$ h)].

NOTE 2 The value is either specified elsewhere e.g. in national regulations or calculated from a concentration acceptance limit C_{al} (see 3.1.1.1) and a conversion factor *F* (see 3.1.3.1).

3.1.2 Terms and definitions related to categorisation of pipe lines

3.1.2.1
domestic pipe line
pipe line between the service pipe line (see 3.1.2.2) and the tap

NOTE It is assumed to have a nominal size in the range 12 to 25 inclusive.

3.1.2.2
service pipe line
pipe line between the distribution pipe line (see 3.1.2.3) and the domestic pipe line (see 3.1.2.1)

NOTE It is assumed to have a nominal size in the range 32 and 90 inclusive.

3.1.2.3
distribution pipe line
pipe line between a trunk main (see 3.1.2.4) and several service pipe lines (see 3.1.2.2)

NOTE It is assumed to have a nominal size in the range 100 to 280 inclusive.

3.1.2.4
trunk main
pipe line which transports water from the water works to the distribution pipe line (see 3.1.2.3)

NOTE It is assumed to have a nominal size of 300 and larger.

3.1.3 Terms and definitions related to conversion factors

3.1.3.1
conversion factor (*F*)
factor used to convert an experimentally derived migration value $\overline{M}^{T}_{24;n}$ (see 3.2) to $C_{f;n}$ (see 3.1.3.2)

NOTE It is expressed in days and decimetres to power minus one (day/dm).

3.1.3.2
field concentration ($C_{f;n}$)
calculated concentration of a particular constituent under assumed conditions of field use for migration period *n*

NOTE It is expressed in milligrams per litre (mg/l).

3.1.3.3
geometrical factor (F_g)
relationship between the surface area of a component of a pipe line in contact with the water and the volume of the water contained by that component (see 5.2.2)

NOTE It is expressed in decimetres to the power minus one (dm^{-1}).

3.1.3.4
operational factor (F_o)
time the water is assumed to be in contact with the component in practice (see 5.2.3)

NOTE It is expressed in days.

3.1.4 Terms and definitions related to products

3.1.4.1
fitting
component other than a pipe which is used in a pipe line (e.g. bends, tees, end caps, valves)

[EN ISO 8795:2001]

3.1.4.2
joint
connection between the ends of two components, which includes the method of sealing

[EN 1444:2000]

3.1.4.3
nominal size (DN)
numerical designation of the size of the pipe, fitting or joint, which is whole number approximately equal to the actual dimensions in millimetres (mm) as specified in the relevant System Standard

3.1.5
water
water intended for human consumption or raw water used for the manufacture of water intended for human consumption

3.2 Symbols

n : The sequence number of the migration period (see Clause 5);

$M^{T}_{24;n}$: Migration value M at the temperature T in degrees Celsius, for the migration time 24 h and the migration period n. It is expressed in milligrams per square decimetres per 24 h [mg/(dm$^2 \times$ 24 h)];

$\overline{M}^{T}_{24;n}$: The arithmetic mean value of the results of the duplicate test pieces $M^{T}_{24;n}$.

4 Principle

A maximum of ten migrations is specified.

For assessment purposes the first three and the last three migrations are used.

A procedure for the interpretation of successive migrations is provided.

Procedures are given for the conversion of laboratory derived migration values to values based on assumed conditions of field use. These values can be compared with either a concentration acceptance limit or with a migration acceptance limit.

5 Field use

5.1 General

The concentration $C_{f;n}$ shall be calculated using Equation (1):

$$C_{f,n} = F \times \overline{M}^{T}_{24;n} \quad (1)$$

where:

$C_{f;n}$ is the calculated concentration of a particular constituent under assumed conditions of field use in milligrams per litre for migration period n;

F is the conversion factor in decimetres power minus one and days;

$\overline{M}^{T}_{24;n}$ is the arithmetic mean $M^{T}_{24;n}$ values in milligrams per square decimetre per 24 h (day), obtained by application of the relevant test methods and the assessment in accordance with 6.2.2.

5.2 Factors

5.2.1 Conversion factor

The conversion factor F shall be calculated using Equation (2):

$$F = F_g \times F_o \quad (2)$$

where:

F is the conversion factor (see 3.1.3.1);

F_g is the geometrical factor (see 3.1.3.3);

F_o is the operational factor (see 3.1.3.4).

5.2.2 Geometrical factor

The geometrical factor F_g is defined by Equation (3):

$$F_g = \frac{S}{V} \quad (3)$$

where:

F_g is the geometrical factor (see 3.1.3.3);

S is the inner surface of the pipe, fitting or joint exposed to the water, in square decimetres (dm^2);

V is the volume of the water in the pipe, fitting or joint, in cubic decimetres (dm^3).

For practical purposes F_g shall be calculated using Equation (4):

$$F_g = \frac{400}{DN} \quad (4)$$

where:

F_g is the geometrical factor (see 3.1.3.3);

DN is the nominal size of the pipe, fitting or joint (see 3.1.4.3), in millimetres (mm).

5.2.3 Operational factor

The operational factor F_o for pipes shall be as in Table 1.

The operational factor for fittings and joints for all categories shall be 0,05.

NOTE In Annex B an explanation is given for the determination of F_o.

Table 1 — Operational factor F_o for pipes

Category of pipe line	F_o in days
Domestic pipe line (3.1.2.1)	0,5
Service pipe line (3.1.2.2)	0,5
Distribution pipe line (3.1.2.3)	1,5
Trunk main (3.1.2.4)	1,5

5.3 Determination of the conversion factor, *F*, for pipes, fittings and joints

From the range of products being assessed, the following shall be established:

a) for each product i.e. pipe, fitting or joint the minimum and maximum nominal sizes produced;

b) using 5.2.2 as appropriate, determine the categories and then the applicable F_o;

c) for each category take either:

   1) the smallest nominal size produced, or

   2) the smallest nominal size defined for that particular category (see 3.1.2) whichever is the larger, and use equation (4) to calculate F_g;

d) from the values obtained for F_o and F_g for each category calculate *F* using Equation (2).

NOTE In Annex C an example of an assessment of *F* for pipes, fittings and joints is given.

6 Number of migration periods and assessment procedure

6.1 Number of migrations

Migration tests shall be performed in accordance with EN ISO 8795.

For each of the first three migration periods determine $\overline{M}^{T}_{24;n}$ in accordance with 6.2.2 and assess the results in accordance with 6.2.1.

When using procedure A or B in 6.2.1 if the conditions a) and b) are satisfied then no further migration periods are necessary.

If, however, they are not satisfied, then either:

a) continue without interruption for a further seven migration periods or,

b) start a new series with fresh test pieces and perform ten migration periods.

NOTE For practical reasons the decision to continue will often be made prior to results from the first three migration periods being available.

In case a) the extracts of the fourth to the seventh migration periods inclusive shall be discarded without analysis.

In case b) the extracts of the first to the seventh migration periods inclusive shall be discarded without analysis.

For the migration periods 8, 9 and 10 determine $\overline{M}^{T}_{24;n}$.

In EN ISO 8795 the duration of the migration period is defined as 72 h for cold water applications and 24 h for hot and warm water applications. For migration periods four to seven inclusive, it is permissible to adjust the times as described in Annex A.

6.2 Assessment procedure

6.2.1 Acceptance criteria

A pipe, fitting or joint shall be assessed either by Procedure A or Procedure B as follows.

Procedure A:

a) the results of the values of the field concentration C_f of the first three migrations show a progressive decrease between each value and the last value expressed as $C_{f;3}$ is below the acceptance concentration limit, C_{al}, or

b) the values of the first three field concentrations ($C_{f;1}$, $C_{f;2}$ and $C_{f;3}$) show no increase between each value and all the values are below the acceptance concentration limit, C_{al}, or

c) a further seven migrations are performed in accordance with 6.1 and the values of the last three field concentrations ($C_{f;8}$, $C_{f;9}$ and $C_{f;10}$) are all below the acceptance concentration limit, C_{al}.

Procedure B:

a) the results of the first three migrations show a progressive decrease between each result and the last result expressed as $\overline{M}^{T}_{24;n}$ is below the acceptance migration limit (M_{al}), or

b) the results of the first three migrations ($\overline{M}^{T}_{24;1}$, $\overline{M}^{T}_{24;2}$ and $\overline{M}^{T}_{24;3}$) show no increase between each result and all the results are below the acceptance migration limit M_{al}, or

c) a further seven migrations are performed in accordance with 6.1 and the results of the last three migrations 8, 9 and 10 ($\overline{M}^{T}_{24;8}$, $\overline{M}^{T}_{24;9}$ and $\overline{M}^{T}_{24;10}$) are all below the acceptance migration limit M_{al} and the criteria in 6.2.2 are fulfilled.

6.2.2 Criteria for accepting the duplicate values of $M^{T}_{24;n}$

The procedure given in EN ISO 8795 results in two values of M^{T}_{24} for each migration period which are used to calculate $\overline{M}^{T}_{24}$ (see 3.2).The following procedure allows the rejection of the duplicate values when the difference between them is unacceptable:

The difference between the duplicate values of M_{24}^{T} for each migration period shall not be:

a) greater than 30 % of the higher M_{24}^{T}, or

b) greater than 30 % of the corresponding M_{al},

whichever is the greater.

NOTE Condition b) is deployed to prevent duplicate values much less than the M_{al} value being rejected. For example, in a case where the M_{al} value is 100 mg/(dm^2 × 24 h), values for M^{T}_{24} of 1 mg/(dm^2 × 24 h) and 10 mg/(dm^2 × 24 h) would be rejected by condition a), even though both values, and the difference between them are acceptable with respect to M_{al}.

7 Calculation of the field concentration, $C_{f;n}$ and the acceptance migration limit, M_{al}

7.1 Calculation of the field concentration, $C_{f;n}$

Calculate for a constituent the field concentration, $C_{f;n}$ (see 3.1.3.2) from the arithmetic mean migration value $\overline{M}_{24;n}^{T}$ (see 3.2) using Equation (1).

NOTE $C_{f;n}$ can be used for assessment purposes by comparing it to the acceptance concentration limit (see 3.1.1.1).

7.2 Calculation of the acceptance migration limit, M_{al}

Calculate the acceptance migration limit, M_{al}, for a constituent using Equation (5).

$$M_{al} = \frac{C_{al}}{F} \tag{5}$$

where:

M_{al} is the calculated acceptance migration limit (see 3.1.1.2) for a constituent, in milligrams per square decimetre per 24 h;

C_{al} is the acceptance concentration limit (see 3.1.1.1) for the constituent, in milligrams per litre;

F is the conversion factor in decimetres power minus one and days.

NOTE The $\overline{M}_{24;n}^{T}$ (see 3.2) can be used for assessment purposes by comparing to the acceptance migration limit.

8 Assessment report

The assessment report shall include the following information:

a) a reference to this Technical Report;

b) the test report specified in EN ISO 8795;

c) the acceptance concentration limit, C_{al}, in milligrams per litre (mg/l), or the acceptance migration limit, M_{al}, in milligrams per square decimetres per 24 h [mg/(dm$^2 \times$ 24 h)] for each constituent and the reference for the source of C_{al} or M_{al};

d) results of carrying out the assessment procedure 6.2.2 on each duplicate M_{24}^{T} values;

e) the categories (Table 1), used in the assessments and calculations and the calculated values F_g, F_o and F;

f) results of carrying out either procedure A or B according to 6.2.1.

Annex A
(informative)

Alternative schedules for successive migration periods

Tables A.1 and A.2 provide schedules of successive migration periods in order to achieve practical test laboratory working to avoid working on Saturdays and Sundays.

Table A.1 — Example of a scheme of migration periods for the cold water applications

Migration period	Days	Comment
1	Tuesday to Friday	72 h
2	Friday to Monday	72 h
3	Monday to Thursday	72 h
4	Thursday to Monday	96 h - not analysed
5	Monday to Wednesday	48 h - not analysed
6	Wednesday to Friday	48 h - not analysed
7	Friday to Tuesday	96 h - not analysed
8	Tuesday to Friday	72 h
9	Friday to Monday	72 h
10	Monday to Thursday	72 h

Table A.2 — Example of a scheme of migration periods for the warm and hot water applications

Migration period(s)	Days	Comment
1	Tuesday to Wednesday	24 h
2	Wednesday to Thursday	24 h
3	Thursday to Friday	24 h
4, 5 and 6	Friday to Monday	72 h - not analysed
7	Monday to Tuesday	24 h - not analysed
8	Tuesday to Wednesday	24 h
9	Wednesday to Thursday	24 h
10	Thursday to Friday	24 h

NOTE Before the migration periods start, the cold water pretreatment (stagnation of 24 h and prewashing) has to be performed on Thursday/Friday before the migration periods. The pretreatment at test temperature (7,5 h and 16 h) has to be performed on the Monday to Tuesday, direct before on Tuesday the migration periods start in accordance with Table A.2.

Annex B
(informative)

Determination of the operational factor

B.1 General

The operational factor F_o is based on the operating conditions in raw and treated water supply systems and expressed in days.

The relevant operating condition is the residence time, which is the time water is in contact with the inner surface of the pipe line.

In order to define F_o the following categories of pipe lines are used:

a) trunk mains (see 3.1.2.4);

b) distribution pipe lines (see 3.1.2.3);

c) service pipe lines (see 3.1.2.2);

d) domestic pipe lines (see 3.1.2.1).

The assumptions contained in the following clauses have been derived from information provided from various countries represented on the working group that drafted this Technical Report. The values quoted are not the extremes of the values considered, but are felt to be typical for the application.

B.2 Pipes

B.2.1 Trunk mains

Experience has shown that the length of a trunk main can be assumed to be 10 km to 60 km and the velocity of the water can be between 0,5 m/s and 1,5 m/s (1,8 km/h to 5,4 km/h).

From these values residence times between 2 h and 33 h are derived, which leads to a value for F_o between 0,1 days and 1,5 days.

For trunk mains F_o = 1,5 days is adopted, since this covers the majority of practical cases.

B.2.2 Distribution pipe lines

The flow pattern in a distribution system is complex.

Typical residence times in a distribution system are extremely variable, ranging from a few hours to 1,5 days.

A value of F_o = 1,5 days is adopted because this covers most practical situations.

B.2.3 Service pipe lines

The length of a pipe in a service pipe line is assumed to be between 5 m and 20 m. The corresponding maximum volume is about 130 l.

The residence time of water in service pipe lines is directly related to water use in a domestic pipe line system. Residence times in both systems can be long, up to 12 h in the case of overnight stagnation, and up to 72 h in the case of stagnation over a weekend.

Some people consume mainly, as first draw water, drinking water related to such residence times. An analysis of consumption in a one person household with regular consumption of overnight and weekend first draw water shows that the average residence time of the water consumed over seven days is about 5 h.

This represents a worst case situation. However since residence time in service pipe lines is complex and variable an additional safety factor is included such that a residence time of 12 h is adopted. This corresponds to a value of F_o = 0,5 days.

B.2.4 Domestic pipe lines

Pipes in a domestic pipe line have an average length of 40 m and an average nominal size of 20. The total volume of water in such a pipe line is about 12 l.

Using a daily water usage of 400 l for a typical household (an occupancy of two to three persons) leads to a residence time of 8 h and which corresponds to a value F_o = 0,3 days.

For the reasons given in B.2.3 an additional factor is included, such that a residence time F = 0,5 days is adopted.

B.3 Fittings and joints

B.3.1 Trunk mains

For trunk mains it is assumed that for every 60 m of pipe line there is one fitting and ten joints.

For a size DN 300 the fitting length in contact with water is taken as 0,6 m and the joint length as 0,02 m.

The ratio of fitting to pipe is $\frac{0,6}{60}$ = 0,01 and the ratio of joint to pipe is $\frac{0,02}{6}$ = 0,003.

Consequently the value of F_o for fittings is $(0,01 \times 1,5)$ days = 0,015 days and for joints $(0,003 \times 1,5)$ days = 0,0045 days.

B.3.2 Distribution pipe lines

For distribution pipe lines it is assumed that for every 6 m of pipe line there is one fitting or joint included.

For a size DN 100 and using a T-piece as a fitting, which include also the three joints, the fitting length in contact with water is estimated at $0,10 + (3 \times 0,02)$ = 0,16 m.

The ratio fitting to pipe is $\frac{0,16}{6}$ = 0,027.

Consequently the value for F_o for fittings is $(0,027 \times 1,5)$ days = 0,04 days.

B.3.3 Service pipe lines

For service pipe lines it is assumed that for every 5 m of pipe line there are two fittings (bends and/or tees).

For a size DN 32 the fitting length in contact with water is estimated at $2 \times 0,05 = 0,1$ m.

The ratio fitting to pipe is $\frac{0,1}{5} = 0,02$.

Consequently the value for F_o for fittings is $(0,02 \times 0,5)$ days = 0,01 days.

B.3.4 Domestic pipe line

For domestic pipe lines it is assumed that for every 4 m of pipe line there are eight fittings.

For a size DN 12 using bends as a fitting, the fitting length in contact with water is estimated at $8 \times 0,015 = 0,12$ m.

The ratio fitting to pipe is $\frac{0,12}{4} = 0,03$.

Consequently the value for F_o for fittings is $(0,03 \times 0,5)$ days = 0,015 days.

B.3.5 Operational factor, F_o, for fittings/joints

Taking into consideration the values of F_o for pipes given above, and because fittings and joints are of such variable geometry and cover many different applications, for practical purposes a value for $F_o = 0,05$ days is adopted for all categories.

Annex C
(informative)

Example of the determination of the conversion factor, *F*, for pipes, fittings and joints

A manufacturer produces pipes, fittings and joints in the range 40 mm – 600 mm and asks for assessment for approval for a range of applications. The values for *F* are determined for each category of application as detailed in Table C.1 and C.2 using F_g from Equation (4) and F_o from Table 1 or from 5.2.2.

Table C.1 — Determination of *F* for pipes

Dimensions in millimetres

Category of pipe line	Smallest size	F_g	F_o	*F*
Service pipe line	40	10	0,5	5
Distribution pipe line	100	4	1,5	6
Trunk main	300	1,33	1,5	2

Table C.2 — Determination of *F* for fittings and joints

Dimensions in millimetres

Category of pipe line	Smallest size	F_g	F_o	*F*
Service pipe line	40	10	0,05	0,5
Distribution pipe line	100	4	0,05	0,2
Trunk main	300	1,33	0,05	0,065

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[1] EN 1444:2000, *Fibre-cement pipelines – Guide for laying and on-site work practices.*

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