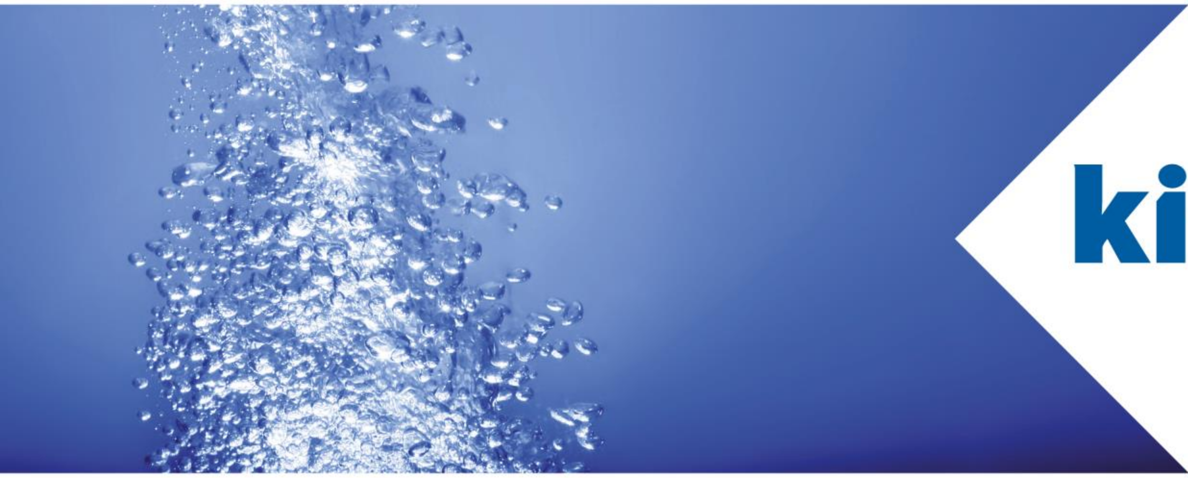
BRL K-17102
2017-12-12

Evaluation guideline

for the Kiwa technical approval with product certificate for class II and class III polyethylene piping systems with a plastic barrier layer for the transport of drinking water in polluted soil



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Preface Kiwa

This evaluation guideline has been prepared by the Kiwa Board of Experts Water Cycle (CWK), wherein all the relevant parties in the field of class II and class III polyethylene piping systems with an plastic barrier layer for the transport of drinking water in polluted soil are represented. These Boards of Experts also supervises the certification activities and where necessary require the evaluation guideline to be revised. All references to Board of Experts in this evaluation guideline pertain to the above mentioned Boards of Experts. This Board of Experts also guides the performance of certification and updates this evaluation guideline in case necessary. Wherever the term "Board of Experts" is written in this evaluation guideline, the above- mentioned Board of Experts is meant.

This evaluation guideline will be used by Kiwa in conjunction with the Kiwa Regulations for Product certification. This regulation details the method employed by Kiwa for conducting the necessary investigations prior to issuing the product certificate and the method of external control.

The product requirements and test methods for the inner pipe in this evaluation guideline are based on the product requirements and test methods listed in BRL-K17105.

The motivation to make this evaluation guideline is originated in the seventies. It turned out that methyl bromide (applied as a soil disinfectant in horticulture) had polluted the drinking water in Westland (part of the Netherlands). The cause was to be found in the permeation behaviour of the used PE piping systems. There were also complaints concerning the odour and flavour of drinking water from pipes near petrol stations. As a result Kiwa carried out a large-scale investigation. Hereby it was concluded that the phenomenon 'permeation' (and as a result the pollution of drinking water) depends among other thing on the type of plastics used for the piping system. Background information for the development of this evaluation guideline can be found in annex III.

The objective of this guideline is to guarantee the drinking water quality by specific relevant additional testing and criteria on the barrier properties of the piping system for an operation period of 50 years in polluted soil.

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Validation
This evaluation guideline has been validated by the Director Certification and Inspection of Kiwa on 2017-12-12.

Contents

1 Introduction

1.1 General

This evaluation guideline includes all relevant requirements which Kiwa uses as the basis for the issue and maintenance of a certificate for the Kiwa technical approval with product certificate for class II and class III polyethylene piping systems with a plastic barrier layer for the transport of drinking water in polluted soil.

For the performance of its certification work, Kiwa is bond to the requirements as included in NEN-EN-ISO/IEC 17065 “Conformity assessment – Requirements for bodies certifying products, processes and services”.

1.2 Field of application / scope

The products are intended to be applied in piping systems for the conveyance of water for human consumption (drinking water), and raw water under pressure in polluted soil.

The evaluation guideline determines the permeation resistance of piping systems with barrier properties (fitness for purpose) and cannot be used to determine health risks. In the Netherlands, health risks are based on exceeding the Maximum permissible risk level (MTR_{human}: Maximum Toelaatbaar Risiconiveau) through all possible exposure routes, among others consumption and use of drinking water after permeation of contaminants through drinking water pipelines. Details can be found in the public RIVM-report 2016-0107[1] . Another issue is that drinking water regulations differ per country which favours the approach to determine the permeation properties of the piping system.

A classification system is applicable for piping systems and is listed in table 1.

[1] RIVM-rapport - Permeatie van contaminanten vanuit grondwater door polyethyleen-drinkwaterleidingen Methodiek voor de beoordeling van risico’s voor de drinkwaterkwaliteit

Table 1 – Classification of the fields of application

Designation	Field of application
Class 0	Class 0 piping systems are allowed to be installed in areas where the concentration of pollutants not exceed the *target values*. Basically this means that the soil is clean [1].
Class I	Class I piping systems are resistant to a low level of concentration of pollutants and may only be installed in areas where no ground pollution higher than the *intervention values* is observed [2].
Class II	Class II piping systems are installed in areas where the pollution of the ground is most likely higher than the *intervention values*. In this case there is a serious pollution. Average concentrations of the contaminants higher than 15 % of the saturation value are seldom found in practice. However because the contaminants in the soil are not homogeneously divided, the pipe systems are being tested for their permeation behaviour at a concentration of 60 % of the saturation value of the model substances. Thus, the most common contaminants are covered adequately because 15 % is a value that is much higher than the values measured in practice.
Class III	Class III piping systems are installed in areas with an increased risk, for example where extreme pollution of the ground can occur due to calamities. The applied piping system must be completely resistant to any pollution (such as toluene, aromatic mixtures and chlorinated substances). Test will be performed with a concentration of 100 % of the saturation value of the model substances.
1) All piping systems provided with the Kiwa mark fulfil the classification Class 0 and therefore it is not necessary to mark the pipes and fittings with an indication of this classification with respect to the resistance to permeation. 2) Class I piping systems are not part of this evaluation guideline.	

This evaluation guideline specifies the product requirements for class II and class III piping systems.

1.3 Acceptance of test reports provided by the supplier

If the supplier provides reports from test institutions or laboratories to prove that the products meet the requirements of this evaluation guideline, the supplier shall prove that these reports have been drawn up by an institution that complies with the applicable accreditation standards, namely:

- NEN-EN-ISO/IEC 17020 for inspection bodies;
- NEN-EN-ISO/IEC 17021-1 for certification bodies certifying systems;
- NEN-EN-ISO/IEC 17024 for certification bodies certifying persons;
- NEN-EN-ISO/IEC 17025 for laboratories;
- NEN-EN-ISO/IEC 17065 for certification bodies certifying products.

This requirement is considered to be fulfilled when a certificate of accreditation can be shown, issued either by the Board of Accreditation (RvA) or by one of the institutions with which an agreement of mutual acceptance has been concluded by the RvA. The accreditation shall refer to the examinations as required in this evaluation guideline. When no certificate of accreditation can be shown, Kiwa shall verify whether the accreditation standard is fulfilled.

1.4 Quality declaration

The quality declarations to be issued by Kiwa is described as Kiwa technical approval with product certificate.
A model of the certificate to be issued on the basis of this Evaluation guideline has been included for information as annex I.

2 Terminology

In this evaluation guideline the following terminology applies:

2.1 Definitions

2.1.1 General

2.1.1.1 Board of Experts
The Board of Experts "CWK".

2.1.1.2 Drinking water
Water intended or partly intended for drinking, cooking or food preparation or other domestic purposes, but does not include hot water, and is made available by pipeline to consumers or other customers.

2.1.1.3 Evaluation guideline (BRL)
Evaluation guideline with the agreements made within the Board of Experts on the subject of certification.

2.1.1.4 IQC scheme
Internal quality control scheme, a description of the quality inspections carried out by the supplier as part of his quality system.

2.1.1.5 Inspection tests
Tests carried out after the certificate has been granted in order to ascertain whether the certified products continue to meet the requirements recorded in the Evaluation guideline.

2.1.1.6 Pre certification tests
Tests in order to ascertain that all the requirements recorded in the Evaluation guideline are met.

2.1.1.7 Piping system
The piping system for in polluted soil can consist of (coiled) pipes and fittings.

2.1.1.8 Product requirements
Requirements made specific by means of measures or figures, focusing on (identifiable) characteristics of products and containing a limiting value to be achieved, which limiting value can be calculated or measured in an unequivocal manner.

2.1.1.9 Raw water
Water that is used for the production of tap water (drinking water).

2.1.1.10 Supplier
The party that is responsible for ensuring that the products meet and continue to meet the requirements on which the certification is based.

2.1.1.11 Technical approval-with-product certificate
A document, in which Kiwa declares that a product may, on delivery, be deemed to comply with the product specification as recorded in the certificate.

2.1.2 Construction

2.1.2.1 Adhesive layer

The layer which provides sufficient adhesion between the different layers of the pipe.

2.1.2.2 Barrier layer

The layer in the multilayer B pipe which is meant to provide high resistance against permeation of contaminations.

2.1.2.3 Inner-pipe

The layer in the multilayer B pipe which is in direct contact with the transported liquid, e.g. a polyethylene pipe conforming to NEN-EN 12201-2.

2.1.2.4 Multilayer B pipe

This term only applies to this evaluation guideline and describes the end product, the multilayer B pipe, as composed of an inner pipe, a barrier layer and a protection layer. Adhesive layers may be used. Only the inner pipe contains stress bearing designed layer(s).

2.1.2.5 Protection layer

The layer which is in contact with the surrounding area of the piping system.

It is allowed to make the protection layer of the same material as the barrier layer as long as the thickness of the layer for both functionalities is very well described.

For the function of such a protective layer see clause 5.6.

2.1.2.6 Test group

A test group consists of a range or family of products made such that the results of the leaktightness test (clause 9.2) and the bottle method (clause 8.4) are applicable to all products in the group. A test group shall be made of products:

- manufactured by the same process;
- with the same material specification;
- with the same pipe wall construction (i.e. the sequence of layers, layer composition, material properties and design method);
- when applicable, the same joint construction (i.e. the sequence of layers, layer composition, material properties and design method);
- tested to the same load stresses.

2.1.2.7 Test group representative

Component that is taken to be representative of that particular test group.

Remark: Due to the area / volume ratio of a pipe ($F_g = 4/d_i$) the smallest diameter in the test group is usually the test group representative of this test group.

2.1.3 Permeation

2.1.3.1 Break through time

Break through time refers to the time between the moment the outer side of the test piece (pipe) is into contact with the fluid and the moment the fluid reach the inner side of the test piece (pipe). See figure 1.

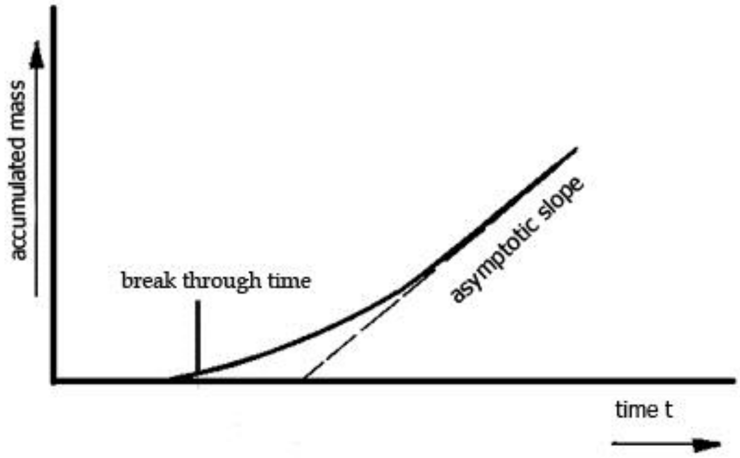

Figure 1 – The intercept of the dotted line with the x-as is called time-lag.

2.1.3.2 Diffusion Coefficient (D)

Diffusion is the process by which an net transport of the penetrant moves from one side of the polymer film to the other side. The diffusion coefficient is the parameter that is proportional to the rate of transfer of penetrant through the polymer film at steady state. This can express as:

$$J = D \times \frac{C_1 - C_2}{e}$$

Where:

- J is the flux which gives the quantity of penetrant diffusing across unit area of film per unit time;
- D the diffusion coefficient;
- $(C_1 - C_2)/l$ is called the gradient of the concentration along the thickness of polymer layer.

The diffusion coefficient D is function of type of polymer and penetrant and is expressed in m^2/day.

2.1.3.3 Half-time ($t_{1/2}$)

The **half-time** is the time required to achieve an increase in mass by absorption which is half of the increase in mass relative the maximum increase of mass during an immersion experiment according to clause 8.3.

2.1.3.4 *Intervention value*

Intervention values [1] indicate when the functional properties of the soil for humans, animals and plants are severely reduced or threaten to reduced. They are representative for the contamination levels above which there is a case of severe (soil) contamination.

2.1.3.5 *Model substances*

The substances that are used in the test liquid.
The concentrations applying to class II piping systems are chosen at a level of 60 % of the expected saturation value in water and are listed in table 2, second column.
The concentrations applying to class III piping systems are chosen at a level of 100 % of the expected saturation value in water and are listed in table 2, third column.

Table 2 – Model liquid for the benefit of class II and class III piping systems

Substance / CAS nr	**Density (g/cm^3)**	**Concentration level in water (mg/l) Class II**	**Concentration level in water (mg/l) Class III**
Toluene / 108-88-3	0.866	309	515
Trichloroethylene / 79-01-6	1.463	660	1100
P-dichlorobenzene / 106-46-7	1.458	29.4	49

2.1.3.6 *Permeation coefficient*

It is the rate at which penetrants moves through the polymer films at equilibrium state. In this evaluation guideline it is assumed that it is the product of solubility coefficient and diffusion coefficient, thus the next formula shows the relation:

$P = S * D$

2.1.3.7 *Saturation value*

The saturation value is the maximum solubility of a chemical substance in pipe materials and water.

2.1.3.8 *Solubility Coefficient ($C_{p,a}$ or $C_{p,a,max}$)*

Solubility coefficient of the polymer is defined as the maximum concentration of the penetrant that can be adsorbed in the polymer at equilibrium and is expressed in kg/m^3.

2.1.3.9 *Target value*

Target values [1] for contaminations in the soil which are the benchmark for environmental quality on the long term, assuming negligible risks to the ecosystem.

2.1.3.10 *Time-lag (t_L)*

The mass of the substance which is transported by permeation through e.g. a pipe wall is represented in figure 1 and is a typical result of an experiment carried out according to clause 8.4. The intercept of the dotted line with the x-axis is called the **time-lag**. Steady state conditions apply when the line in figure 1 becomes straight approximately after a time of 3 x time-lag.

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[1] See intervention values (interventiewaarden) target values (streefwaarden), Staatscourant nr 16675 of 27 june 2013 "Circulaire bodemsanering per 1 juli 2013" and annex VI

2.1.3.11 Ultrapure water

In this document with ‘ultrapure water’ is meant: water with a conductivity < 2 mS/m and a TOC < 0,2 ppm C. Ultrapure water can be reached by, for example, reversed osmosis, de-ionization or distillation, followed by active carbon filtration.

2.1.4 Dimensions

d_{em} mean outside diameter of the multilayer B pipe.

e wall thickness of the inner pipe.

d_{ei} outside diameter of the inner pipe.

d_{eb} outside diameter of the barrier layer.

d_{ip} inside diameter of the protection layer.

e_{pl} thickness of the plastic barrier layer.

e_p thickness of protection layer.

$e_{ad,x}$ thickness of the adhesive layer where x refers to the position of the adhesive layer in the multilayer B pipe.

SDR Standard Dimension Ratio according to BRL-K17105.

3 Procedure for granting the quality declaration

3.1 Feasibility study

Assessment to be performed based on the product specifications in order to evaluate the long term properties of the piping system and in particular of the barrier layer against influences during life-time. The feasibility of the piping system concept shall be proven and recorded in the quality system of the supplier after approval of Kiwa.

To determine the permeation resistance of the piping system with barrier properties three model substances and two test principles were selected. The model substances are: toluene, trichloroethylene, and p-dichlorobenzene, substances that were selected to cover permeation hazards that could occur in practice. The test principles are used in an immersion test and a so-called bottle test.
In the immersion test the material responsible for the barrier function is immersion in a saturated solution of water and one of the model substances. By measuring the mass increase of the test piece the solubility coefficient and the diffusion coefficient of the model substance in the barrier material are determined. By using this material properties and the geometry of the pipes and fittings, calculations can be made to determine if the parts of the piping system fulfil the BRL requirements.
The bottle test mentioned in de BRL's is performed on pipes and assemblies (pipe and fitting) by exposing the outside of the test piece to a solution of water and all three model substances. The concentration of the model substances on the inside is kept practically zero to maximize the driving force of permeation of the model substances. When the test is performed on pipes and assemblies (pipe and fitting) the result of the test is a concentration, C_{24h}, which is also the required property listed in the BRL. In this configuration the bottle test is used as a verification test.
The same test principle can also be used to determine the barrier properties of sheet shaped test pieces (containing only the barrier material). In this test set-up it is also possible to determine the solubility coefficient and the diffusion coefficient of the model substance(s) of the barrier material.

Diffusion coefficient and solubility coefficient of the model substances may be used together with a typical wall construction of the products to calculated the concentrations after the required standstill time. See table 3.

3.2 Pre certification

The pre certification tests to be performed are based on the (product) requirements as included in this evaluation guideline including the test methods and contain, depending on the nature of the product to be certified:

- type testing to determine whether the products comply with the product and/or functional requirements;
- assessment of the production process;
- assessment of the quality system and the IQC-scheme;
- assessment of the presence and functioning of the remaining procedure.

3.3 Granting the quality declaration

After finishing the pre certification tests the results are presented to the person deciding on granting of certificate. This person evaluates the results and decides whether the certificate can be granted or additional data and/or tests are necessary.

4 Requirements and test methods for the piping system

This chapter contains test methods and public law requirements and private requirements, which class II and class III piping systems have to fulfil. The requirements are part of the technical specification of the product, which is included in the certificate.

4.1 Public regulation – requirements to avoid deterioration of the quality of the drinking water

The requirements in this clause are public law requirements.

To prevent harmful effects on the quality of drinking water, the following government imposed provisions apply.
Products and materials which (may) come into contact with drinking water or warm tap water, shall not release substances in quantities which can be harmful to the health of the consumer, or negatively affect the quality of the drinking water. Therefore, the products or materials shall meet toxicological, microbiological and organoleptic requirements as laid down in the currently applicable "Ministerial Regulation materials and chemicals drinking water and warm tap water supply", (published in the Government Gazette). Consequently, the procedure for obtaining a recognised quality declaration, as specified in the currently effective Regulation, has to be concluded with positive results.
Products and materials with a quality declaration, e.g. issued by a foreign certification institute, are allowed to be used in the Netherlands, provided that the Minister has declared this quality declaration equivalent to the quality declaration as meant in the Regulation.

These requirements are considered to be fulfilled in case evaluation according Kiwa Protocol K15010 has been finished with positive result.

4.2 Resistance to permeation

The complete piping system must give sufficient protection against pollution of the drinking water from the soil during a period of 50 years. It is assumed that compliance with this requirement is satisfied when all components of the piping system meet the requirements listed in chapter 8.

Remark:
The calculations of the C_{24h} may be based on non-steady-state conditions (see chapter 8).

4.3 Life expectancy of the piping system

The complete piping system must be designed in such a way that, at a water pressure equal to the design pressure, the piping system maintains its function for 50 years. It is assumed that this requirement is fulfilled when the piping system and its components meets the requirements of this evaluation guideline.

4.4 Type test groups

In order to keep the total test effort within acceptable limits but at the same time to control the use of test data beyond their limits, the concept of type test groups is used in this evaluation guideline. The definition of a type test group is given in clause 2.1.2.6. The supplier shall document and record the various type test groups that cover the product range listed on his certificate after approval of the certification body.

4.5 Installaton instructions

The manufacturer must provide installation instructions in the native language. These instructions must contain specific information with regard to the welding of the joints (in case fusion joints are used in the system) and procedures concerning the installation of the barrier layer and protection layer for joints. Furthermore, instructions must be available for the storage and transport, processing temperature etc.

4.6 Prevention of contamination during transport and storage of new products

For the purpose of hygienic work, products shall be protected during storage and transportation to prevent contamination of all product parts intended to be in contact with drinking water. Requirements regarding the prevention of contamination during transport and storage are given in Annex IV.

4.7 Rubber sealing elements

Rubber sealing elements are not allowed when they are used for barrier purposes.

4.8 Greases and lubricants

Where greases and/or lubricants are used in the making of a joint, these products shall meet the requirements of BRL-K535.

4.9 Markings

4.9.1 Markings of pipes

After entering into the Kiwa certification agreement the Kiwa®-mark and the Kiwa®-water mark or the simplified Kiwa®-water mark must be printed or formed on the pipe at intervals of not more than 2 m, with the following clearly legible and indelible markings:

- the manufacturer's name or registered trademark;
- PE 80 or PE 100 , depending on the material of the inner-pipe;
- designation: "BRL-K17102";
- designation: class II or class III;
- reference to the certificate number of the system;
- pressure class (PN);
- the nominal diameter of the inner pipe;
- the wall thickness of the multilayer pipe;
- production code.

The simplified Kiwa®-watermark is allowed for small diameters after permission of Kiwa.

4.9.2 Markings on fittings

Fittings shall be marked in accordance with the requirements listed in BRL K 17105. Further on the fitting or package of the fitting reference is made to the number of the system.

5 Requirements and test methods for the multilayer B pipe and its components

5.1 Multilayer B pipe

5.1.1 General

The pipe shall be composed of at least an inner pipe, a barrier layer and a protection layer. Adhesive layer(s) may be used to provide adhesion between the different layers.

5.1.2 Dimensions of the multilayer B pipe

The nominal dimensions and permissible tolerances of the inner pipe shall be in accordance with BRL-K17105.

The outside diameter of the multilayer B pipe deviates from the outside diameter of pipes that meet the requirements of product standards of piping systems e.g. BRL-K17105 and therefore a technical approval with product certificate is issued for the complete system, the dimensions of the pipe and other parts (e.g. fittings, valves) of the piping system are matched to each other.

The dimensions of the multilayer B pipe shall be determined according clause 9.1. The nominal size shall be classified as the nominal outside diameter of the inner pipe.

All relevant dimensions with permissible tolerances shall be documented for each nominal size, e.g.:

- outside diameter of the multilayer B pipe (d_{em});
- outside diameter of the barrier layer (d_{eb});
- inside diameter of the protection layer (d_{ip});
- thickness of plastic barrier layer (e_b);
- thickness of protection layer (e_p) ;
- thickness of adhesive layers ($e_{ad,x}$), where x refers to the position of the adhesive layer in the multilayer B pipe;
- wall thickness of the inner pipe (e);

Pipes shall fulfil the by the supplier documented dimensional requirements.

5.1.3 Permeability of the multilayer B pipe: bottle method

The bottle method shall be carried out according to clause 8.4. and shall comply to the requirement listed in clause 8.1 for every test group (see clause 2.1.2.6) specified and recorded in the quality system of the supplier.

Alternatively, the immersion method may be carried out according to clause 8.3 and the diffusion coefficient and the solubility coefficient shall be determined. With the use of the dimensions of the multilayer B pipe and the determined diffusion coefficient and solubility coefficient the concentration C_{24h} is calculated. The concentration C_{24h} shall comply to clause 8.1.

The bottle method is considered the reference method. However the bottle method and immersion test have equal validity.

5.1.4 Leaktightness of the multilayer B pipe

The test shall be carried out according to clause 9.2.
The required concentration, C_{24h}, shall be in accordance with clause 8.1.

5.2 Inner pipe

The inner-pipe shall be made of PE80 and PE100 and shall meet the requirements specified in BRL-K17105. This means that the PE material used for the production of the inner pipe shall be in accordance with EN 12201-1 and the inner pipe shall fulfil all requirements of EN 12201-2, after removal of the layer(s) containing the protection functionalities and the barrier functionalities.

Remark: For calculations it is assumed that the protection layer and the barrier layer are not contributing to the mechanical strength and stability of the multilayer B pipe.

5.3 Barrier layer

The barrier layer shall be composed of a plastic layer. The barrier layer is applied to the inner pipe with adhesive layers if necessary.

5.3.1 Material

The specifications of the material of the barrier layer shall be documented and recorded in the internal quality control scheme of the supplier after approval by the certification body.

5.4 Adhesive

The adhesive must sufficiently adhere to the connecting layers of the multilayer B pipe.
It is expected that the adhesion is sufficient when the multilayer B pipe complies to this evaluation guideline.

5.5 Protection layer

5.5.1 Function

The function of the protection layer is to protect the barrier layer against damages e.g. during installation or transport. After installation the protective layer has no function.

5.5.2 Material

The specifications of the material of the protection layer shall be documented and recorded in the internal quality control scheme of the supplier after approval by the certification body.

5.5.3 Appearance

The protection layer must be free of irregularities e.g. impurities and pores.

5.5.4 Exposure to sunlight

The protection layer shall be resistant to exposure to direct sunlight and this shall be demonstrated by the supplier.

The outdoor weathering test may be performed according to NEN-EN-ISO 16871 with a solar radiant exposure of 3,5 GJ/m^2 or may be performed according to NEN-EN-ISO 4892-2:2013: table 3, cycle No 1. Using the artificial weathering test according to NEN-EN-ISO 4892-2 the exposure period shall be 650 hours.

Remark: An radiant exposure of 3,5 GJ/m^2 is the annual global irradiance in Western Europe and therefore covers one year outdoor exposure in Western Europe.

The property to determine the effect of the weathering test shall be the change in tensile impact strength. The tensile impact strength is determined according to NEN-

EN-ISO 8256. Prior to the mechanical test the test pieces shall be conditioned for at least 24 hours at a temperature of (23 ± 2) °C.

In total twelve test pieces are required and shall be prepared according to NEN-EN-ISO 8256. The shape and dimensions of the test piece shall confirm to type 3 or type 5. Six test piece are used to determine the average initial tensile impact strength. The average tensile impact strength of the other six test pieces is determined after weathering.

The material is considered weather resistant when the remaining tensile impact strength exceeds 50 %. The remaining tensile impact strength is defined as the ratio between the average impact strength after weathering and the average impact strength before weathering.

The protection layer is considered to be resistant to direct sunlight in Western Europe for a period of one year when the material is polyethylene or polypropylene with a carbon black mass content not lower than 2 % when determined according ISO 6964 and carbon black dispersion grade ≤ 3 when determined according to NEN-ISO 18553.

5.6 Combined layer - barrier and protective layer

When the protective layer and the barrier layer are combined to one layer the protective functionality and the barrier functionality of the combined layer shall be described in the quality system and the installation instructions of the supplier after approval of Kiwa e.g. by declaring the minimum layer thickness of both functionalities for specified methods of installation.

6 Requirements and test methods: Fittings

Fitting e.g.

- plastic or metal mechanical fittings;
- electrofusion socket fittings;
- spigot end fittings;
- socket fusion fittings;

shall meet the requirements as specified in BRL-K17105 and requirements regarding permeation listed in this BRL (see chapter 7: Joints).

7 Requirements and test methods: Joints

7.1 General

Joints e.g.

- mechanical joints;
- pipe - pipe butt fusion joints;
- pipe - spigot end fitting joints;
- socket fusion joints;
- electrofusion joints;

shall meet the requirements as specified in BRL-K17105.

Joints connecting the piping system to other piping systems outside the polluted soil area shall comply to BRL K17105.

7.2 Mechanical joints

7.2.1 General

Plastic and metal fittings may be used with inserts or stiffeners which reinforce the gripping at the sealing regions.

It is assumed that the body of metal fittings is not permeable for the substances in polluted soil. For that reason it is not required to add a barrier layer around the metal fitting body. Sealing the joint shall be sufficient.

Joint performance shall comply to the requirements listed in BRL K17105

Fusion joints and joints with plastic fittings shall be sufficiently sealed to fulfil the requirement of clause 8.1. The work instruction to make the joint shall be recorded in the quality system of the supplier after approval by the certification body.

7.2.2 Leaktightness of mechanical joints

The leak tightness of the joints shall be determined according to clause 9.2 for every type test group preferably on an assembly with a multilayer B pipe with the smallest nominal diameter of the inner pipe of that type test group.

After a test duration of six months the requirements listed in clause 8.1 shall be fulfilled:

- after production;
- after the following pre-treatments:
  - bending the assembly according to clause 9.2.2.1;
  - applying a hydrostatic internal pressure for a duration of 1000 hours and temperature of (20 ± 2) °C according to clause 9.2.2.3.

7.2.3 Permeability mechanical joints: bottle method

The bottle method shall be carried out according to clause 8.4 and shall comply to the requirement listed in clause 8.1 for every test group (see clause 2.1.2.6) specified and recorded in the Quality system of the supplier.

7.3 Fusion joints

7.3.1 General

Fusion joints e.g. electrofusion socket fittings, electrofusion saddle fittings, spigot end fittings, fabricated fittings and butt fusion joints of the piping system shall meet the requirements as specified in BRL-K17105.

7.3.2 Leaktightness of fusion joints

The leaktightness of a butt fusion joint shall be determined according to 9.2 and using a pre-treatment producer according to clause 9.2.2.1 “Bending test” for every type test group.

After a test duration of six months the requirements listed in clause 8.1 shall be fulfilled:

- after production;
- after the following pre-treatments:
  - bending the assembly according to clause 9.2.2.1;
  - applying a hydrostatic internal pressure for a duration of 1000 hours and temperature of (20 ± 2) °C according to clause 9.2.2.3.

No delamination or any other form of damage shall occur in the joint construction.

7.3.3 Permeability of fusion joints: bottle method

The bottle method shall be carried out according to clause 8.4 and shall comply to the requirement listed in clause 4.1 for every test group (see clause 2.1.2.6) specified and recorded in the quality system of the supplier.

8 Requirements and test methods: permeation

8.1 (Revised) Waterworks Decree

On basis of what is mentioned in annex III.4 and on basis of the revision of the standards in the Waterworks Decree, the concentrations of toluene, trichloroethylene and p-dichlorobenzene (of the three model substances) in drinking water shall not be more than 1,0 µg/l at a lifetime of the piping system of 50 years and after a standstill time (Δt) of 24 hours.

In this document the corresponding concentration is indicated as C_{24h}.

Depending on the permeation properties and dimensions of the product steady state conditions may not be reached after 50 years. For this particular situation the flux through the product shall be calculated for a period of 100 years.

8.1.1 Calculation of the contribution of the different parts

Remark:
In the previous BRL the requirement of C_{24h} applies for the whole piping system. It has shown that this requirement led to confusion by the suppliers and the end users. For that reason this clause "calculation of the contribution of the different parts" is added to the BRL.

The concentration after 24 hours standstill in the fitting or joint or combination of the fitting and joint shall be calculated as follows:

$$C_{24h,joint} = \frac{[(C_{24h,ass} \times L) - (C_{24h,pipe} \times L_{pipe})]}{L_{joint}} = \frac{L}{L_{joint}} \times (C_{24h,ass} - C_{24h,pipe}) + C_{24h,pipe}$$

(8.1.1)

where:

$C_{24h,joint}$	calculated concentration for the fitting or joint or fitting/joint;
$C_{24h,pipe}$	calculated concentration for the pipe piece(s);
$C_{24h,ass}$	calculated concentration of the assembly (test piece);
L	total length of the assembly (test piece);
L_{pipe}	length of pipe parts in assembly;
L_{joint}	length of fitting or joint or fitting/joint.

The concentration in a pipeline after 24 hours standstill containing a joint shall be calculated as follows:

$$C_{24h,pipeline} = \frac{1}{L_{pipeline}} \times [C_{24h,pipe} \times (L_{pipeline} - L_{joint}) + C_{24,joint} \times L_{joint}] \quad (8.1.2)$$

where:

$C_{24,pipeline}$	calculated concentration for the pipeline;
$C_{24,pipe}$	calculated concentration for the pipeline;
$C_{24,joint}$	calculated concentration for the pipeline;
$L_{pipeline}$	length of the pipeline;
L_{joint}	length of fitting in the pipeline.

Example

$C_{24h,pipe}$ 0,5 µg/l;

$C_{24h,ass}$	5 µg/l;
L	typical length of a test assembly is 0,4 m;
L_{pipe}	0,3 m;
L_{joint}	0,1 m.

Calculated $C_{24h,joint}$ = 18,5 µg/l.
Calculated $C_{24h,pipeline}$ = 0,68 (for $L_{pipeline}$ = 10 m).

8.2 Product invesigation

There are a number of tests available to determine the permeation behaviour of the chemicals of the test liquid in the piping system. An inventory of possible test methods is given in annex III.5.

The immersion test can be applied on specific component of the piping system e.g. an adhesive and / or barrier layer. The immersion test is very well suited to determine the diffusion coefficient, solubility coefficient and permeation coefficient of a model substance of interest for a specific component. The results of the immersion test can be used to estimate C_{24h} and the exposure time at which steady state conditions apply.

The bottle method is a test method that is close to the circumstance that apply in practice. The test method determines directly the C_{24h} values independent whether the transport of the model substance can be described by e.g.: Fickian diffusion, capillary action, pores in the barrier layer, leaks etc. It is the perfect test for verification purposes and for determining the soundness of the barrier layer of the products.

For pre certification the following route is proposed (see table 3).

Table 3 - Resistance to permeation: Route to fulfil the permeation requirements for the pre certification

Component	Route
Pipe	Immersion test on the material of the barrier layer according to clause 8.3 to determine the diffusion coefficient (D) and the solubility coefficient. Test can be performed for each model substance in water and water.
	Calculation of C_{24h} value for each model substance (toluene, trichloroethylene and p-dichlorobenzene).
	Leaktightness test of the multilayer B pipe according to 5.1.4. (Test duration is six months)
	Bottle method [2] according to clause 5.1.3.
Mechanical joint [1]	When applicable, immersion test on the material of the barrier layer according to clause 8.3 to determine the diffusion coefficient (D) and the solubility. Test shall be performed for each model substance in water and water.
	Calculation of C_{24h} value for: toluene, trichloroethylene and p-dichlorobenzene.
	Leaktightness test according to clause 7.2.2. (Test duration is six months)
	Bottle method [2] according to clause 7.2.3.
Fusion joint [1]	When applicable, immersion test on the material of the barrier layer according to clause 8.3 to determine the diffusion coefficient (D) and the mass increase. Test shall be performed for each model substance in water.
	Calculation of C_{24h} value for: toluene, trichloroethylene and p-dichlorobenzene.
	Leaktightness test according to clause 7.3.2. (Test duration is six months)
	Bottle method [2] according to clause 7.3.3.
1. When the joint is wrapped by an aluminium layer or other kind of barrier construction, calculating the C_{24h} value for: toluene, trichloroethylene and p-dichlorobenzene depends on the design of the joint. Values and the design shall be documented in the quality system of the supplier after approval of Kiwa. 2. The bottle test can be used for checking Fickian diffusion or for checking other kinds of transport. The test duration to determine the soundness of pipes and joints is six months. When the test is used to determine	

the permeation properties steady state conditions shall apply at the end of the test (see 2.1.3.10 – time-lag).

8.3 Immersion method: sorption experiment

The immersion test is based on NEN-EN-ISO 175 and is performed on the barrier layer.

The barrier properties of the foil test pieces shall be similar to the barrier properties of the layer in the multilayer B pipe.

8.3.1 Test pieces

The number of test pieces is four (one for every model substance and water). The preferred dimensions of the test piece are 150 mm long 50 mm wide and a thickness which corresponds to the thickness of the layer in the multilayer B pipe.

The permissible deviation on the test piece thickness is ± 10 %.

Remark: the thinner the test piece the shorter the duration of the test.

8.3.2 Test liquid

The test liquids are:

- water;
- water with toluene;
- water with trichloroethylene
- water with p-dichlorobenzene.

In latter three test liquids in concentrations as listed in table 2 for class II and class III piping systems.

8.3.3 Procedure

8.3.3.1 Immersion test

The test pieces shall be completely immersed in the test liquid.

It is allowed to accelerate the permeation process by performing tests at elevated temperatures to reached steady state conditions within a test duration of 11 months. Test temperatures shall be agreed upon between the supplier and the certification body and shall be recorded in the quality system of the supplier.

Remark:
To be able to extrapolate to the design temperature of the piping system tests shall be performed at a minimum of two higher test temperatures, preferably three higher test temperatures.

The concentration of the test liquid outside the test piece needs to be checked regularly and shall be held constant during the duration of the test within 90 - 100 % of the aimed concentrations.

Alternatively, the experiment may be carried out with an oversaturated mixture in which a water phase and a test liquid phase exists. The mixture shall be stirred calmly to maintain the saturation concentration of the aqueous phase layer in which the polymer is exposed.

Determine the mass (M(t)) of the test piece as a function of the exposure time (in days) with an accuracy of 0,1 mg mass increase /g polymer. The test shall be terminated when the saturation point of the liquid in the test piece is reached (M_∞). The test piece shall be considered as being saturated when the mass reached its maximum value (see figure 2).

The permeation properties of the material depend on e.g. the glass transition temperature of the material. The effect of these properties shall be taken into account when tests are performed at higher test temperatures.

The solubility of the model substance in water is dependent of the (test) temperature. The concentration difference between a test temperature of 20 °C and a higher test temperature shall be taken into account when results are evaluated.

Record the mass of the test piece as a function of the immersion time (M(t)).

8.3.4 Evaluation of the test results

8.3.4.1 Determination of the saturation mass (M_∞)

The mass increase of the model substance as a function of the test duration is determined by subtracting the recorded curve obtained during immersion of the barrier material in water from the curve obtained after immersion of the barrier material in the test liquid (model substance in water).

The saturation mass is calculated as using equation 8.3.1;

$$\Delta M_\infty = M_\infty - M(0) \qquad (8.3.1)$$

$$\Delta M(t) = M(t) - M(0) \qquad (8.3.2)$$

where

- M_∞ is the mass of the test sample at saturation (sorption) corrected for water sorption;
- *M(0)* is the mass of the test sample “as received”;
- *M(t)* is the mass of the test sample after an immersion period of t, corrected for water sorption.

8.3.4.2 Determination of the half-time ($t_{1/2}$) and Diffusion coefficent (D)

Calculate from the determination of the mass of the test piece used in the immersion test:

$$\frac{\Delta M(t)}{\Delta M_\infty} = \frac{M(t)-M(0)}{M_\infty - M(0)} \qquad (8.3.3);$$

and determine $t_{1/2}$ for using the reduced sorption curve in which $\Delta M(t)/\Delta M_\infty$ is plotted as a function of the square root of the immersion time, for the condition $\Delta M(t)/\Delta M_\infty$ = 0,5 (see figure 2);

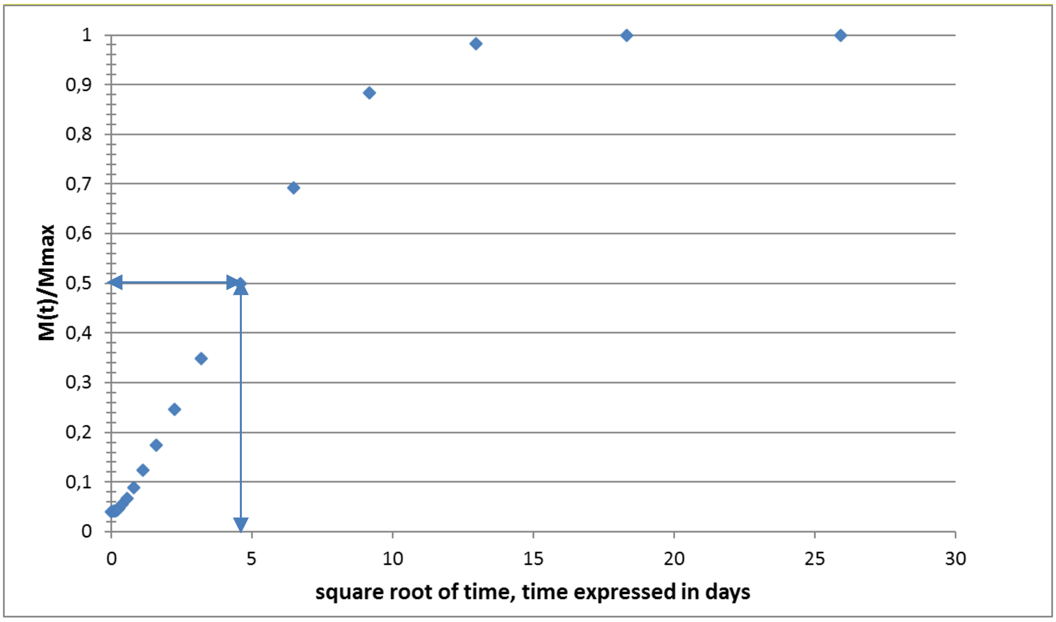


Figure 2 - Graphical method for the determination of $t_{1/2}$ using the reduced absorption curve. D = 2.1 x 10^{-8} m^2/day, e_m = 3 x 10^{-3} m, half-time = 21 days.

Calculate the diffusion coefficient, expressed in (m^2/day) using the derived half-time ($t_{1/2}$) using equation 8.3.4.

$$D = 0.049 \times \frac{e_{im}^2}{t_{1/2}} \qquad (8.3.4)$$

where:

$t_{1/2}$ is the half-time, expressed in (days)

e_{im} is the thickness of test piece used for the immersion tests.

8.3.4.3 *Determination of the absorded concentration ($C_{P.a}$)*

The absorbed concentration ($C_{P,a}$), expressed in (kg/m^3) is calculated using equation 8.3.5

$$C_{P,a} = \frac{(M_\infty - M(0))}{\frac{M(0)}{\rho_{p,a}} + \frac{(M_\infty - M(0)}{\rho_S}} \qquad (8.3.5)$$

M_∞ equilibrium mass of the test piece which is reached after long immersion period in water with a model substance, corrected for water sorption, expressed in (kg);

M(0) mass of the test piece “as received”, expressed in (kg);

$\rho_{p,a}$ density of test piece “as received”, expressed in (kg/m^3);

ρ_s density of model substance which is absorbed expressed in (kg/m^3).

When the immersion test is performed in a class III solution (see table 2) the index of $C_{p,a}$ is to be extended with “max’’; $C_{p,a,max}$.

Remark: $C_{p,a}$ or $C_{p,a,max}$ is identical as the solubility of the model substance in the polymer material. When the concentration difference has no influence on the solubility of the model substance in the polymer $C_{p,a}$ and $C_{p,a,max}$ are the same.

8.3.4.4 *Calculation of the overall permeability*

The flux, (J_b) of a chemical through a barrier layer with thickness (e_b), diffusion coefficient (D_b) and the concentration difference (Δc_b) is given by:

$$J_b = D_b \times \frac{\Delta c_b}{e_b} \times f(t) \qquad (8.3.6)$$

where

J_b	mass transfer rate through the barrier layer expressed in kg/(m² x day);
D_b	diffusion coefficient expressed in (m²/day);
e_b	thickness of barrier layer expressed in (m);
f(t)	time dependent part (see annex V).

For class II piping systems the concentration difference (Δc_b) is:

- 0,6 x $C_{p,a}$ or;
- 0,6 x $C_{p,a,max}$;
- and under the condition that the concentration in the drinking water during a bottle experiment and in practice is practically (kept) to zero.

The concentration difference Δc_b is equal to $C_{p,a,max}$ when a saturated solution of the model substance in water is used (class III) and under the condition that the concentration in the drinking water during a bottle experiment and in practice is practically (kept) to zero.

8.3.4.5 *Calculation of C_{24h}*

The concentration of the model substance after 24 hours of standstill C_{24h} shall be as follows:

$$C_{24h} = J_b \times \frac{A_o}{V_i} \times 10^6 \qquad (8.3.9)$$

where;

C_{24h}	concentration of model substance in drinking water 24 hours standstill expressed in (µg/l);
J_b	mass transfer rate through the barrier layer expressed in kg/(m² x day);
A_o	outside area of the barrier layer expressed in (m²);
V_i	inside volume of the inner pipe expressed in (m³).

An example calculation is given in annex V.

The calculated concentration C_{24h} shall be not more than 1 µg/l for pipes (see clause 8.1).

8.4 Bottle method: permeation experiment

The Bottle method is based on an experimental arrangement where both the concentration of model substance on every place in the pipe wall at the start of the experiment at (t = 0) and the concentration on the inside of the pipe are zero.

The test rig shall be suitable for testing all configurations of pipe and fittings and joint e.g.:

- straight pipe;
- assembly of pipes and a coupling;
- butt fusion weld in pipe assembly;
- pipes and fitting (e.g. bend, tee, reducer).

8.4.1 Test liquid

8.4.1.1 Class II piping systems

For a class II piping system the test liquid consists of water with the following model substances:

- trichloroethylene;
- toluene;
- P-dichlorobenzene;

to a concentration of 60 % of the saturation level of the model substances (see table 2).

The concentration of the test liquid outside the test piece needs to be checked regularly and shall be held constant during the duration of the test within 90 - 100 % of the aimed concentrations. During experiments the test liquid is stirred calmly to maintain even concentrations in the test liquid at the surface of the test piece.

8.4.1.2 Class III piping systems

For a class III piping system the test liquid consists of water saturated with the following model substances (see table 2):

- trichloroethylene;
- toluene;
- P-dichlorobenzene.

When an oversaturated test liquid is used a floating layer and a bottom layer must be present in the test apparatus. When the test liquid is not oversaturated the concentration of the test liquid needs to be checked regularly and shall be held constant during the test within 90 - 100 % of the aimed concentrations. During experiments the test liquid is stirred calmly to maintain an even concentration in the test liquid at the surface of the test piece.

8.4.2 Principle

Test pieces (multilayer B pipe or assembly) filled with water and airtight sealed are immersed on the outer surface in the test liquid. At prescribed time intervals the concentration of permeating substances is checked and a plot of total amount of diffusing substance (Qt) as a function of the test time (t) is constructed for toluene, trichloroethylene and p-dichlorobenzene.

It is allowed to accelerate the permeation process by performing the bottle method at elevated temperatures to reach steady state conditions within a test duration of e.g. 11 months.

Finally the concentration of toluene, trichloroethylene and p-dichlorobenzene in (µg/l) after a standstill time (Δt) of 24 hours is calculated for the steady state conditions or at an expected life time of the piping system of 100 years.

Remark:
When steady state conditions have been reached before 50 years of use, concentrations after 50 years and 100 years should be the same.

Remark:
When the bottle method is used for the verification of the soundness of the construction of a pipe or an assembly (joint system) the test duration is 6 months.

8.4.3 Test pieces

8.4.3.1 Multilayer B pipe sample

Two test pieces shall be cut from the same piece of multilayer B pipe. One test piece is exposed to the test liquid. The other test piece is exposed to tap water for reference purposes.

8.4.3.2 Assembly (multilayer B pipes and fitting)

Two test assemblies shall be prepared from the same piece of multilayer B pipe and fittings from the same batch.

8.4.3.3 Pre-treatment of the test pieces

The test pieces need to be thoroughly cleaned on the inside, e.g. with a brush and cleansing agent. The cleaning consists of the filling of the test piece with tap water. After one hour the water is refreshed. It is expected that the test pieces are clean when the tap water in the test pieces is refreshed three times.

Prior to the bottle method, the test piece is rinsed with ultrapure water for 2 minutes with the aim of removing the remaining tap water.

8.4.4 Execution of the bottle method

Both sides of the pre-treated test pieces are closed off, e.g. with stainless steel seals, which are provided with stainless steel valves. These seals shall be thoroughly cleaned in advance also. It is not allowed to use rubber stoppers and/or rubber O-rings that can contaminate the water. When necessary, the valves shall have a 'seat' of PTFE (Teflon).

At the outside, the test pieces are exposed to the test liquid at a test temperature X_T °C. The test temperature shall be agreed upon between the supplier and the certification body and shall be recorded in the quality system of the supplier. To reduce the exposure time to reach steady state conditions the test temperature may be increased. In that case the acceleration factor shall be determined experimentally.

When the desired test duration is reached the test pieces are rinsed during 1 hour with ultrapure water. The test piece is filled with ultrapure water and exposed to the test liquid for at least 24 hours at X_T C. Finally the concentration of the model substance(s) in the test pieces shall be measured and C_{24h} shall be calculated.

The concentration of permeate inside the test piece shall be kept low, that is at the most 4 % of the concentration of the substance outside the test piece.

Simultaneously a reference experiment (blank) is carried out also, where tap water is used instead of the test liquid.

The result of the analysis is compared with the requirements listed in clause 8.1. The results of the reference experiments shall be taken into account as a reference.

8.4.5 Determination of the concentration of model substances

The concentrations of model substance in the water samples shall be determined using gas chromatography / mass spectrometry (GC/MS) techniques. The used method shall have a demonstrated and recorded required accuracy of at least 0,05 µg/l for toluene, trichloroethylene and p-dichlorobenzene.

8.4.6 Evaluation of the test results

Figure 3 illustrates the one-dimensional diffusion in a medium bounded by two parallel planes e.g. the planes at x = 0 , x = l. These will apply in practice to diffusion

into a plane sheet of material so thin that effectively all the diffusing substance enters through the plane faces and a negligible amount through the edges.
C0 is the substance concentration outside the plane sheet, C1 is the surface substance concentration at the supply side, C2 is the surface substance concentration at the other water side and C3 is the substance concentration outside the plane sheet at the other side.

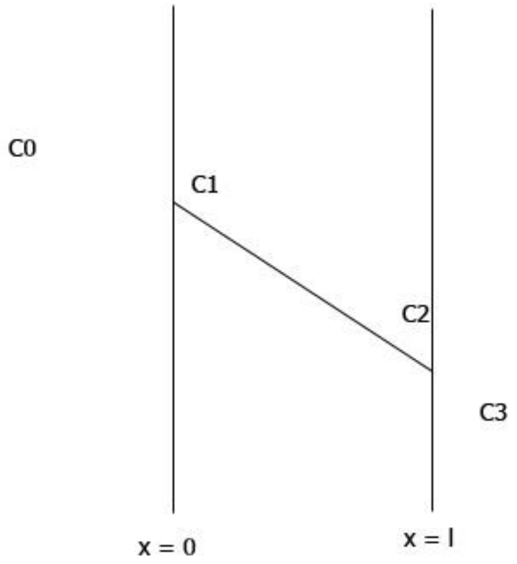


Figure 3 - Illustrates a typical test result for the bottle method.

In the bottle method arrangement the concentration at the plane through which diffusing substance emerges (C3) is maintained effectively at zero concentration. The total amount of diffusing substance which has passed through the barrier layer in time t shall be determined experimentally and can be normalized by calculating to following values for the x-axis and y-axis:

$$x = \frac{D \times t}{l^2} \qquad (8.4.1)$$

and

$$y = \frac{Qt}{l \times C1} \qquad (8.4.2)$$

where:

D is diffusion coefficient;
t is time;
l is plane sheet wall thickness or (L_b) the shortest distance to be travelled by the substance through the adhesive to bridge the part with the high concentration to the low concentration;
C1 is the surface substance concentration at the supply side.

The intercept in the t-axis is referred to as the time-lag. Steady state condition is achieved when Dt/l^2 =0,45 approximately (see figure 4).

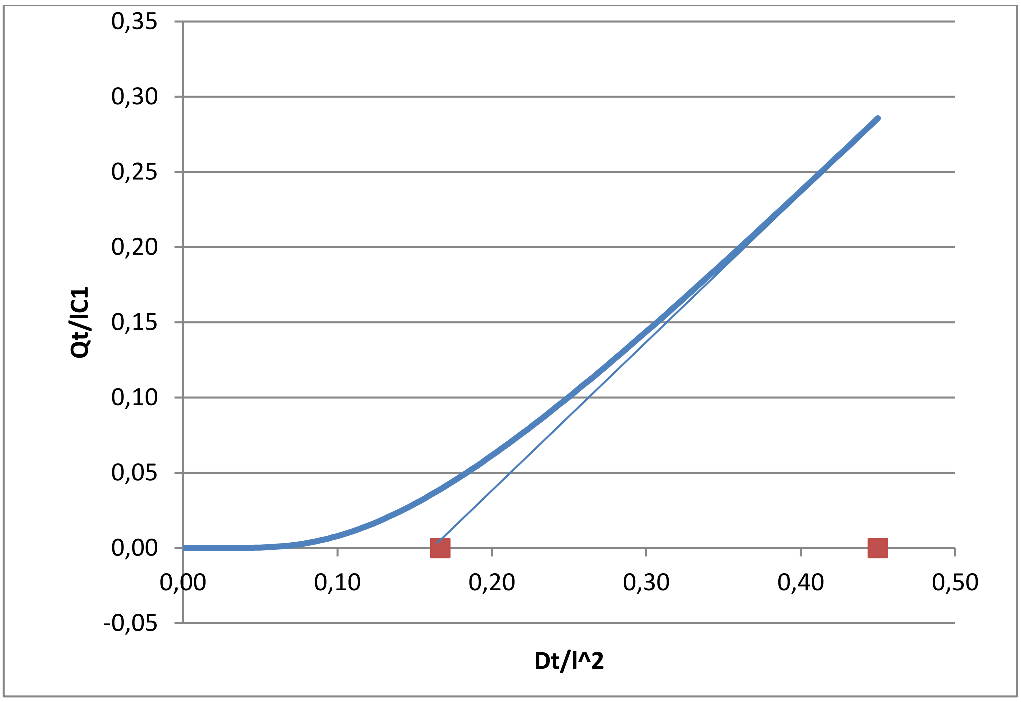


Figure 4 – Normalized test result. Approach to steady state flow through a plane sheet.

8.4.6.1 Pipe and assembly with diameter as tested

The result of the bottle method is the concentration of the model substance after a 24 hours standstill (C_{24h}) for the pipe or the assembly tested and shall be not more than the requirement listed in section 8.1.

9 Test methods

9.1 Determination of dimensions

For the determination of the dimensions of the relative position (e.g. eccentricity, thickness variations in hoop direction etc.), and thickness and tolerances of the various layers at least three test pieces per batch shall be cut. When needed the cuts are finished and the dimensions are measured with a magnification between 5 and 10 times using e.g. a magnifying glass. The dimensions shall be determined according to NEN-EN-ISO 3126.

9.2 Leaktightness test

9.2.1 Test pieces

9.2.1.1 Test pieces from straight pipe

All test pieces shall be cut from the same pipe sample. From every type test group the pipe with the smallest outside diameter d_{ei} shall be tested. For the leaktightness test a test pieces of 1 meter long is required. To perform the bending test (pre-treatment) a longer test piece may be used.

9.2.1.2 Test assembly

The joint shall be made using multilayer pipes and fittings conforming to this evaluation guideline. The protection layer and / or barrier or bifunctional layer of the multilayer B layer pipe shall be removed in the area of the joint prior to making the joint. Assemblies for testing shall be prepared according to the supplier’s instructions.

9.2.2 Pre-treatment for the leaktightness test

The multilayer B pipes samples shall be taken at least 24 hours after extrusion before starting with the pre-treatments. The pre-conditioning time is 24 hours at a temperature of (23 ± 2) °C.

9.2.2.1 Bending test

A straight pipe test piece is bend once over a bending-gauge and hold in the bending position for at least 1 hour.

For pipes the bending radius of the bending-gauge shall be 20 times the nominal diameter of the inner pipe.

For assemblies with a joint the bending radius of the bending-gauge shall be 50 times the nominal diameter of the inner pipe which is part of the assembly.

After the bending test, the test piece is straightened again and tested according to clause 9.2.3.

9.2.2.2 Compression test (only for straigth pipe samples)

A straight pipe test piece is supported horizontally and loaded throughout its length to compress it diametrically to achieve a desired level of relative vertical deflection. The force application surfaces are either bearing plates or beam bars. The relative vertical deflection shall be 12 %. The relative vertical deflection is the ratio of the vertical change in diameter of the multilayer B pipe in a horizontal position to a vertical compressive load and the mean diameter of the multilayer B pipe. The mean diameter is defined as the nominal outside diameter of the multilayer B pipe minus the nominal wall thickness of the multilayer B pipe.

After the compression test, the test piece is straightened again and tested according to clause 9.2.3

9.2.2.3 Resistance to hydrostatic pressure

The multilayer B pipe piece or assembly is subjected to an internal pressure test according to NEN-EN-ISO 1167-1 and NEN-EN-ISO 1167-2. Test conditions are:

- test duration of at least 1000 hours;
- test temperature of (20 ± 2) °C;
- test pressure of 1,43 times the PN of the inner pipe;
- end caps type A.

Afterwards the test piece is straightened again and tested according to clause 9.2.3.

9.2.3 Procedure leaktigthness test

The leaktightness test shall be carried out according to clause 8.4 with a fixed test duration of six months.

10 Requirements in respect of the quality system

This chapter contains the requirements which have to be met by the supplier's quality system.

10.1 Manager of the quality system

Within the supplier's organizational structure, an employee who will be in charge of managing the supplier's quality system must have been appointed.

10.2 Internal quality control/quality plan

The supplier shall have an internal quality control scheme (IQC scheme) which is applied by him.

The following shall have been demonstrably recorded in this IQC scheme:

- what aspects are checked by the producer;
- according to what methods such inspections are carried out;
- how often these inspections are carried out;
- in what way the inspection results are recorded and kept.

This IQC scheme should at least be an equivalent derivative of the model IQC scheme as shown in annex II.

10.3 Control of test and measuring equipment

The supplier shall verify the availability of necessary test and measuring equipment for demonstrating product conformity with the requirements in this evaluation guideline. When required the equipment shall be kept calibrated (e.g recalibration at interval). The status of actual calibration of each equipment shall be demonstrated by traceability through an unique ID. The supplier must keep records of the calibration results. The supplier shall review the validity of measuring data when it is established at calibration that the equipment is not suitable anymore.

10.4 Procedures and working instructions

The supplier shall be able to submit the following:

- procedures for:
    - dealing with products showing deviations;
    - corrective actions to be taken if non-conformities are found;
    - dealing with complaints about products and/or services delivered;
- the working instructions and inspection forms used.

11 Summary of tests and inspections

This chapter contains a summary of the following tests and inspections to be carried out in the event of certification:

- Pre-certification tests;
- Inspection test as to toxicological requirements and product requirements;
- Inspection of the quality system.

The frequency with which Kiwa will carry out inspection tests is also stated in the summary.

11.1 Test matrix

Table 5 - Test matrix.

Description of requirements	Clause BRL	Tests within the scope of:		
		Pre certification	Control after issue of the certificate 1)	
			Inspection	Frequency 3)
Piping system				
Deterioration of the quality of the drinking water	4.1	X	-	1 / year
Resistance to permeation	4.2	X, see also table 3	-	
Life expectancy of the piping system	4.3	X	-	
Type test groups	4.4	X	-	
Installation instructions	4.5	X	-	1 / year
Prevention of contamination during transport and storage of new products		X	X 2)	
Rubber sealing elements	4.6	X	-	
Greases and lubricants	4.7	X	-	
Markings	4.9	X	X 2)	1 / year
Multilayer B pipe				
General	5.1.1	X		
Dimensions of the multi-layer pipe	5.1.2	X	X 2)	1 / year
Permeability of the multilayer B pipe: Bottle method	5.1.3	X		
Leaktightness of the multilayer B pipe:	5.1.4	X	-	1 / year
Inner pipe				
Inner pipe	5.2	X	see BRL-K17105 – test matrix	
Barrier layer				
Barrier layer Barrier layer thickness and material by documentation	5.3	X	-	1 year
Adhesive layer				
Adhesive layer	5.4	X	-	
Protection layer				
Function	5.5.1	X	-	
Material	5.5.2	X	-	
Appearance	5.5.3	X	-	

Exposure to sunlight	5.5.5	X	-	
Fittings				
Fittings	6	X	X [4)]	1 / year
Joints				
General	7.1	X	-	
Mechanical joints - general	7.2.1	X	-	
Mechanical joints - leaktightness	7.2.2	X	-	
Mechanical joints - permeability	7.2.3	X	-	
Fusion joints – general	7.3.1	X	-	
Fusion joints – leaktightness	7.3.2	X		
Fusion joints - permeability	7.3.3	X	-	

1. In case the product or production process changes significantly, it must be determined whether the performance requirements are still met.
2. All product characteristics that can be determined within the visiting time (maximum 1 day) are determined by the inspector or by the supplier in the presence of the inspector. In case this is not possible, an agreement will be made between the certification body and the supplier about how the inspection will take place. The frequency of inspection visits is defined in chapter 12.6 of this evaluation guideline.
3. Once a year the inspector samples for an Audit Test.
4. Leaktightness of the joint according to BRL-K17105 using test parameters 1000 hours and 80 °C.

11.2 Inspection of the quality system

The quality system shall be checked by Kiwa on the basis of the IQC scheme.
The inspection contains at least those aspects mentioned in the Kiwa Regulations for Product certification

12 Agreements on the implementation of certification

12.1 General

Beside the requirements included in these evaluation guidelines, also the general rules for certification as included in the Kiwa Regulations for Product Certification apply.

In particular, these are:

- The general rules for conducting the pre certification tests, to be distinguished in:
    - the way suppliers are to be informed about an application is being handled,
    - how the test are conducted,
    - the decision to be taken as a result of the pre certification tests.
- The general directions for conducting inspections and the aspects to be audited,
- The measurements to be taken by Kiwa in case of Non Conformities,
- Measurements taken by Kiwa in case of improper Use of Certificates, Certification Marks, Pictograms and Logos,
- Terms for termination of the certificate,
- The possibility to lodge an appeal against decisions of measurements taken by Kiwa.

12.2 Certification staff

The staff involved in the certification may be sub-divided into:

- Certification assessor (**CAS**): in charge of carrying out the pre certification tests and assessing the inspectors' reports;
- Site assessor (**SAS**): in charge of carrying out external inspections at the supplier's works;
- Decision maker (**DM**): in charge of taking decisions in connection with the pre certification tests carried out, continuing the certification in connection with the inspections carried out and taking decisions on the need to take corrective actions.

12.2.1Qualification requirements

The following qualification requirements have been set by the Board of Experts for the subject matter of this evaluation guideline (see table 6):

Table 6 – Qualification requirements of certification staff

Basis requirements	Evaluation criteria
Knowledge of company processes Requirements for conducting professional audits on products, processes, services, installations, design and management systems.	*Relevant experience: in the field* **SAS, CAS** : 1 year **DM**: 5 years inclusive 1 year with respect to certification Relevant technical knowledge and experience on the level of: **SAS**: High school (MBO) **CAS, DM** : Bachelor (HBO)
Competence for execution of site assessments. Adequate communication skills (e.g. reports, presentation skills and interviewing technique).	**SAS**: Kiwa Audit training or similar and 4 site assessments including 1 autonomic under review.
Execution of initial examination	**CAS**: 3 initial audits under review.
Conducting review	**CAS**: conducting 3 reviews

	Certification assessor	Site assessor	Decision maker
Education - specific	• BRL-relevant technical education • specific studies and training (know-how and skills)	• BRL-relevant technical education • specific studies and training (know-how and skills)	• not applicable.
Experience - specific	• Detailed knowledge of the BRL and 4 certification tests carried out on the basis of the BRL or similar	• Detailed knowledge of the BRL and 4 inspections carried out on the basis of the BRL or one similar.	• general knowledge of the BRL

The level of education and experience of the certification staff involved should be demonstrably recorded.

Legend:

- Site assessor (**SAS**)
- Certification assessor (**CAS**)
- Decision maker (**DM**)

12.2.2Qualification

The qualification of the Certification staff shall be demonstrated by means of assessing the education and experience to the requirements mentioned before. In case staff is to be qualified on the basis of deflecting criteria, written records shall be kept. The authority to qualify staff is dedicated to:

- decision makers: qualification of certification experts and inspectors,
- Management of Kiwa: qualification of decision makers.

12.3 Report Product invesigation tests

Kiwa records the results of the pre certification tests in a report. This report shall comply with the following requirements:

- completeness: the reports verdicts about all requirements included in the evaluation guideline,
- traceability: the findings on which the verdicts have been based shall be recorded traceable,
- basis for decision: the decision maker shall be able to base his decision on the findings included in the report.

12.4 Decision for granting the certificate

The decision for granting the certificate shall be made by a qualified decision maker which has not been involved in the pre certification tests. The decision shall be recorded traceable.

12.5 Lay out of quality declaration

The product certificate shall be conform the model included as an annex

12.6 Nature and frequency of external inspections

The certification body shall carry out audits on site at the supplier at regular intervals to check whether the supplier complies with his obligations.

At the time this BRL entered into force, the frequency of audits amounts 2 audit(s) on site per year for suppliers with a quality management system (in accordance with ISO 9001) for their production, which has been certified by an acknowledged body (in accordance with ISO/IEC 17021) and where the IQC scheme forms an integral part of the quality management system.
In case the production of the supplier is not certified against ISO 9001, the frequency of the audits on site may be increased to 4 per year.

The audit program on site shall cover at least:

- the product requirements;
- the production process at the place of manufacturing;
- the suppliers IQC scheme and the results obtained from inspections carried out by the supplier;
- the correct way of marking certified products;
- compliance with required procedures;
- handling complaints.

For suppliers with a private label certificate the frequency of audits amounts to 1 audit per two years. These audits are conducted at the site of the private label certificate holder. The audits are focussed on the aspects inserted in the IQC scheme and the results of the control performed by the private label holder with respect to at least

- the correct way of marking certified products;
- compliance with required procedures for receiving and final inspection;
- the storage of products and goods;
- handling complaints.

The results of each audit shall be recorded by Kiwa in a traceable manner in a report.

12.7 Report to the Board of Experts

De certification body shall report annually about the performed certification activities. In this report the following aspects are included:

- mutations in number of issued certificates (granted/withdrawn);
- number of executed audits in relation to the required minimum.

12.8 Non conformities

When the certification requirements are not met, measures are taken by Kiwa in accordance with the sanctions policy what is published on the Kiwa service portal (www.kiwa.nl) at the corresponding BRL.

12.9 Interpretation of requirements

The Board of Experts may record the interpretation of requirements of these evaluation guidelines in one separate interpretation document.

13 Titles of standards

13.1 Public regulation

Standard	Title
Staatscourant van 18 juli 2011, nr. 11911	Regeling Materialen en Chemicaliën drink- en warm tapwatervoorziening
Staatscourant van 27 juni 2013, nr 16675	Circulaire bodemsanering per 1 juli 2013

13.2 Standards / normative documents

Number[1)]	Title
BRL-K17105	evaluation guideline for the Kiwa product certificate for plastics piping systems of polyethylene for the transport of drinking water and raw water
iso 6964	Polyolefin pipes and fittings - Determination of carbon black content by calcination and pyrolysis - Test method and basic specification
K15010	Kiwa protocol for products in contact with drinking water
nen-en 546-2	Aluminium and aluminium alloys - Foil - Part 2: Mechanical properties
nen-en 12201-2	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 2: Pipes
nen-en-iso/iec 17020	Conformity assessment - General criteria for the operation of various types of bodies performing inspection
nen-en-iso/iec 17021-1	Conformity assessment - Requirements for bodies providing audit and certification of management systems
nen-en-iso/iec 17024	Conformity assessment - General requirements for bodies operating certification of persons
nen-en-iso/iec 17025	General requirements for the competence of testing and calibration laboratories
nen-en-iso/iec 17065	Conformity assessment - Requirements for bodies certifying products, processes and services
nen-en-iso 175	Plastics - Methods of test for the determination of the effects of immersion in liquid chemicals
nen-en-iso 527-2	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics
nen-en-iso 1167-1	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure - Part 1: General method
nen-en-iso 1167-2	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure - Part 2: Preparation of pipe test pieces
nen-en-iso 3126	Plastics piping systems - Plastics components - Determination of dimensions
nen-en-iso 8256	Plastics - Determination of tensile-impact strength
nen-en-iso 9001	Quality management systems - Requirements
nen-en-iso 16871	Plastics piping and ducting systems - Plastics pipes and fittings - Method for exposure to direct (natural) weathering
nen-iso 18553	Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds

1. The documents in this table, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the reference document (including any amendments) applies.

Remark: Within the text, references to specific divisions or subdivisions, tables and figures of another document shall always be dated.

I Model certificate (informative)

CERTIFICATE

Product certificate
Kxxxxx

Issued 2017-01-01

Replaces

Page 1 of 2

Name product

STATEMENT BY KIWA
With this product certificate, issued in accordance with the Kiwa Regulations for Product Certification, Kiwa declares that legitimate confidence exists that the products supplied by

Name Supplier

as specified in this product certificate and marked with the Kiwa®-mark in the manner as indicated in this product certificate may, on delivery, be relied upon to comply with Kiwa evaluation guideline BRL-K<number> “<title>” dated [dd-mm-yyyy]

Luc Leroy
Kiwa

Publication of this certificate is allowed.
Advice: consult www.kiwa.nl in order to ensure that this certificate is still valid.

Kiwa Nederland B.V.
Sir Winston Churchilllaan 273
Postbus 70
2280 AB RIJSWIJK
The Netherlands
Tel. +31 88 998 44 00
Fax +31 88 998 44 20
info@kiwa.nl
www.kiwa.nl

Company
xx

Tel.

Certification process consists of initial and regular assessment of:
- quality system
- product

II Model IQC scheme (informative)

(see next page)

<table>
<tr><td colspan="2"><u>IQC-schedule</u>

<u>INTERNAL QUALITY PLAN</u></td><td>Manufacturer / supplier :
Production location address :</td><td>Number of appendices:</td></tr>
<tr><td colspan="4"><u>Field(s) of application</u>

<u>According Evaluation Guideline(s)</u></td></tr>
<tr><td><u>Number of production shifts:</u></td><td colspan="3" rowspan="3"><u>Quality manual, procedures and working instructions</u>
Is the Quality Management System (QMS) certified according to ISO 9001[1)]?
If yes, by which certification body:
If yes, is the certification body accredited for the particular scope of certification?
The following procedure for dealing with <u>complaints</u> applies:

In case the QMS is <u>not</u> certified according to ISO 9001:
• Working instructions, test instructions and procedures are documented as follows:
• The following procedure for <u>nonconformity review</u> applies:</td></tr>
<tr><td><u>Quality Control</u>
Total number of employees in QC department :
Number of QC-operators per shift :

If no QC-inspections are carried out during night shifts, state the QC procedure(s)/instruction(s) to be followed: , documented in:</td></tr>
<tr><td><u>Inspection and test records</u>
All records shall be maintained for a minimum of years.</td></tr>
<tr><td><u>Specific agreements/comments/explanations</u></td><td colspan="3">Signature of the manufacturer/supplier:

Date :</td></tr>
</table>

[1)] In case the QMS is ISO 9001 certified and covers the scope of the product certificate(s), reference to the applicable procedure(s) on the next pages is sufficient and the tables A till F do in principle not have to be further filled-out except for the frequency of tests/inspections (to be approved by Kiwa) in tables B, C and D.

A. Calibration of measuring and test equipment Applicable procedure(s) nr(s):				
Equipment to be calibrated	Calibration aspect	Calibration method	Calibration frequency	Calibration file (name and location)

B. Raw material and additives
Applicable procedure(s) nr(s):

B.1 Receipt
For each delivery of raw material or additives data with respect to dates, producers, types and quantities are recorded as follows:

B.2 Entry control

Type of raw material	Inspection aspect	Inspection method	Inspection frequency	Registration file (name and location)

C. Batch release tests per machine (including in-process and finished product testing)
Applicable procedure(s) nr(s):
Production process(es):

Type of product	Type of test	Test method	Test frequency	Registration file (name and location)

Specific agreements/comments/explanations:

D.	**Process verification tests** Applicable procedure(s) nr(s):			
Type of product	Type of test	Test method	Test frequency	Registration file (name and location)

E.	**Control of nonconforming and/or rejected products** Applicable procedure(s) nr(s):
E.1	**Method of registration**
E.2	**Method of identification**
E.3	**Method of nonconformity review and disposition**

F.	**Inspection with regard to packaging, storage and transportation of the finished product** Applicable procedure(s) nr(s):			
Inspection aspects		Inspection method	Inspection frequency	Registration file (name and location)
F.1	**Packaging/storage/ transportation etc**			

Specific agreements/comments/explanations:

Raw materials list **(not required to fill-out this appendix in case reference can be made to the Kiwa ATA part of the certification agreement)**	**Appendix I** Date: ………
I.1 **The product is built-up of the following raw materials:** **a) In case of products made from ready-made raw materials: listing of name and/or unique code of the raw material(s);** **b) In case of products made from own compounded raw materials: reference to raw material/compound sheets which are (only) available at the production location and which have to be authenticated by Kiwa (e.g. by the Kiwa inspector);** **c) In case of composed products (e.g. plastics fitting body, with separate nut, clamp ring and rubber sealing ring): of each part a specification according to a) or b) (whatever applicable).** - - - - -	

List of technical drawings			**Appendix II** Date:……..
Drawing title and number	Drawing date	Drawing title and number	Drawing date

III Background information development of this evaluation guideline (informative)

III.1 History

In the seventies it turned out that methyl bromide (applied as a soil disinfectant in horticulture) had polluted the drinking water in a part of The Netherlands (Westland). The cause was to be found in the permeation behaviour of the used polyethylene piping systems. There were also complaints concerning the odour and flavour of drinking water from pipes near petrol stations.
As a result Kiwa carried out a large-scale investigation [1]. Hereby it was concluded that the phenomenon 'permeation' (and as a result the pollution of drinking water) depends e.g. on:
- the type of plastics;
- the kind of pollution;
- the concentration of pollution in the soil;
- the time drinking water is stationary in the piping system.

The investigation also resulted in the development of this BRL.

III.2 Permeation

The permeation process in piping materials in polluted soil takes place in three phases, namely:

- Substance transfer at the interface of the exterior of the pipe wall and the surrounding soil material. Here the substance will enter the plastics material.
- Mass transport of the substance in the pipe wall as a result of the concentration gradient in the pipe wall (= diffusion).
- Substance transfer at the interface of the interior of the pipe wall and the drinking water. Here the substance leaves the plastics material.

III.3 Types of pollution

Inorganic pollution like heavy metals, salts and bases cannot permeate through plastics like PE, PVC and epoxy. Only organic pollution, like monocyclic hydrocarbons (for example benzene), chlorinated hydrocarbons (like chloroform) and phenol can permeate through plastics. Therefore only the permeation behaviour of organic pollution shall be determined within the framework of this BRL.

[1] Mededeling nr. 85 "Permeatie en drinkwaterleidingen" KIWA N.V. dr M.W. Vonk Vakgroep Analytische Chemie Nieuwegein, mei 1985.

III.4 Model liquid

It is impossible to take all possible organic pollution into account within the framework of an evaluation of the permeation behaviour of plastics piping systems. Therefore a limited number of substances is included in such a test. The following substances were chosen for the model liquid based on the following criteria, see table III.1.

Table III.1 – Substances of the model liquid for this BRL

Substance	**Toluene**	**Tri-chloro-ethylene**	**p-di-chloro-benzene**
Frequently found as ground polluting substance	Yes	Yes	Yes
Group (polarity)	Aromatic	Chlorinated aliphatic	Chlorinated aromatic
Size	Small	Small	Small
HS trap GC/MS detectable	Yes	Yes	Yes
required accuracy (mg/l)	5×10^{-5}	5×10^{-5}	5×10^{-5}
Solubility in water (mg/l) at 20 °C	515	1100	49

III.5 Test methods

In theory, there are a number of test methods available to determine the permeation behaviour of a plastic piping system. An inventory of possible test methods is given below and a description of these tests can be found in reference [1].

Immersion test, can be applied on a specific component of the piping system e.g. the adhesive which is used to connect the barrier layer (aluminium tape) to the other layers e.g. inner pipe material, protection layer.
The test piece is usually a sheet made of the adhesive material. The test piece is completely immersed in a certain concentration of a substance in water or to the pure substance itself. Test can be carried out at a temperature of 20 °C or at higher temperatures up to and including 60 °C depending on the softening point of the material tested. In this immersion test the diffusion coefficient and solubility will be determined and the permeability coefficient will be calculated for the substance used in the test. Finally, these material characteristics can be used to predict the permeability of the substances of the model liquid through the piping system.

Bottle method, can be applied to a pipe or joint. The required test time can become very long if break through time is waited for (see definition time-lag). An Option to decrease the duration of the test is increasing the test temperature. A time gain of a factor 7 can be reached by increasing the test temperature from 20 °C to 60 °C. Reducing the tortuous path in the barrier layer (labyrinth path) by reducing the overlap distance between subsequent windings (OL) of the barrier tape gives a time gain of factor 100 by decreasing the tortuous path by a factor 10). Other factors which could be used: smaller wall thickness of inner pipe and test performing without protection layer.

III.6 Piping systems

Each piping system consists of a combination of pipes, fittings and joints. If it is unavoidable that joints are located in polluted soil as well, the barrier function of the joints must fulfil the requirements also.

[1] Mededeling nr. 85 "Permeatie en drinkwaterleidingen" KIWA N.V. dr M.W. Vonk Vakgroep Analytische Chemie Nieuwegein, mei 1985.

III.7 Elastomeric seals

Rubber seals are used in the majority of piping systems. In general rubbers have a low resistance to diffusion of pollution. The high flexibility of the molecule chains and the big molecular gaps cause a very short time-lag. Therefore rubber seals may not be used in CLASS II piping systems.

III.8 The maximum allowable concentration in drinking water

Many of the substances applied in materials and chemicals can be absorbed by the consumer through food additives or by migration from food packaging material. For this reason the CGCMD employs the following criterion: the contribution of drinking water to the consumption of a substance may not be more than 10 % of maximum allowed daily amount for this substance. The concentration levels in the 'Waterworks Decree' are based upon this criterion and the contribution in drinking water may be fully confiscated by permeation.
Permeation occurs through all parts of the distribution system for drinking water: pipes, joints and fittings. Kiwa shall take this into account during the evaluation of the piping system.

IV Guidance for prevention of contamination during transport and storage of new products (informative)

Importance of a hygienic operation
Hygiene and hygienic work is since decades an important issue with respect to the transport and distribution of drinking water in the Netherlands.
The impact of pollution can have big consequences for the water distribution[1)] and need substantial efforts to clean the system, especially because in the Netherlands chlorine is not used. Already in the 1983 published “guideline for installation of PVC-U piping systems, paragraph 4.2 "Storage", mentions this topic as follows: *For the prevention and risk of difficulties disinfecting of the pipe line afterwards, it is recommended to use plugs in pipe ends for storage of the pipes.*
The importance of hygiene also reflected in recent documents e.g. Dutch Hygiene code: "Hygiënecode Drinkwater; Opslag, transport en distributie’ with the accompanying work instructions ("werkboekje") for mechanics. As result of the Hygiene code a wide range of courses for parties involved (installers, personnel of water companies, etc.) can be followed. Last but not least the Hygiene code is also mentioned in the drinking water law of July 1, 2011 and is therefore part of the Dutch law.

Protection of the products during storage and transport
In the "Hygiënecode Drinkwater: Opslag, transport en distributie” with the accompanying work instructions for mechanics the aspect how to work hygienically is extensively described. It involves dealing with parts for piping systems (pipes, fittings, values and hydrants) starting with the arrival of the parts at the construction site to the realization and commissioning of the pipeline. The primary approach to hygienic work is "prevention". Secondly, there are measures described in order to make pipelines suitable for the delivery of clear drinking water. The hygiene aspects in the process from the manufacture of the product in the factory, assembly hall or other production location are briefly described in the "Hygiënecode Drinkwater". Also in this process is the primary approach prevention: For each product applies the sooner the product is protected against contamination [2)], the better the hygiene of the product can be guaranteed. To close the hygiene chain completely and to be eligible for certification, producers of part for piping systems for drinking water shall have a procedure in which measures are described for storage and the route to the water companies (delivery address), as will be defined in general terms or laid down in relevant Kiwa evaluation guidelines. The producer shall have a procedure for the protection of the products during transport and storages, to be able to guarantee that hygiene requirements are meet.

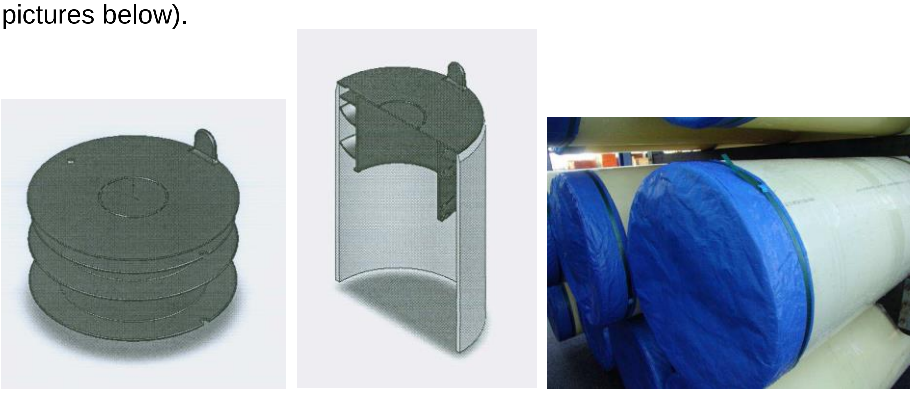
Remark:
1) Mostly this is a microbiological contamination coming from the surrounding area on macro- and micro scale like dust, but also faeces and dead beasts.
2) In this context he word "protection" is used as a combination of packing (e.g. providing the product with a casing) and, when applicable, providing end caps (e.g. for pipes and fittings).

Requirements for the protection
For all preventive (protective) actions taken to protect the products against pollution, it is important that the protection is sufficient during the complete process starting after production of the product (followed by e.g. storage, transport and again storage) and ending with the installation of the products.

Capabilities to protect the product:
The used packaging depends on the product itself (shape, dimensions, etc.)
Some packaging solutions (not binding and not exhaustive) are mentioned below:

- For small fittings (couplings, rings, rubber seals) a plastic bag eventually in a box;
- "Bubble wrap" foil in combination with adhesive tape for all openings for large(r) fittings;
- The combination of bags made of fibre reinforced material or heat shrink foil and the use of a box for smaller part;
- End-caps / plugs or stern plastics bags for the pipe ends (where the complete pipe package is wrapped in foil).

In 2007 representatives of the manufacturers and the water companies organized in the commission ‘OnderhandelingsCommissie Kunststoffen’ (OCK) started a project to improve the quality of packaging.
The project resulted in the following construction of end-capes for pipes.
The end cap is unmovable fixed in the pipe by using flaps in a labyrinth structure to let in air but prevent pollution.
The end cap is developed for a 110 mm PVC pipe but can also be developed for other diameters (50, 63, 75 , 90, 160, 200 and 250 mm), and for all used pipe materials.
For closing pipe ends with a diameter of 315, 400, 500 and 630 mm a fiber reinforced cover in combination with adhesive tape or lashing straps can be used (see the pictures below).



Left: end cap with flaps. Right: fibre reinforced cover in combination with adhesive tape.

Mess bags cannot be sealed against dust and dirt, and for this reason are not recommended as the only packaging for small parts.

V C_{24h} by an example calculation (normative)

The final flux, (J_∞) of a chemical through a barrier layer with thickness (e_b), diffusion coefficient (D_b) and the concentration difference (Δc_b) is given by:

$$J_\infty = D_b \times \frac{\Delta c_b}{e_b} = \frac{D_b \times a \times C_{p,a}}{e_b} \qquad \text{V-1}$$

Directly after exposure of the pipe wall to the chemical none of the chemical will have penetrated yet through the pipe. It will take time before a noticeable flow of chemical can be detected at the inside of the pipe. This time is associated with the time-lag (t_L) and is calculated as follows:

$$t_L = \frac{{e_b}^2}{6 \times D_b} \qquad \text{V-2}$$

Starting from time zero the flux of chemicals that enter the drinking water inside the pipe as function of time J(t) is given by the equation:

$$J(t) = J_\infty \times \left[1 + 2 \times \sum_{n=1}^{\infty} (-1)^n \times \exp\left(-\frac{\pi^2 \times n^2}{6} \times \frac{t}{t_L}\right)\right] \qquad \text{V-3}$$

Equation V-3 can be written as the product of the final flux (J_∞) and a time dependent part (f(t)) as follows:

$$J(t) = J_\infty \times f(t) \qquad \text{V-4}$$

where

$$f(t) = 1 + 2 \times \sum_{n=1}^{\infty} (-1)^n \times \exp\left(-\frac{\pi^2 \times n^2}{6} \times \frac{t}{t_L}\right) \qquad \text{V-5}$$

The shape of the function f(t) versus the relative time t/t_L is shown below:

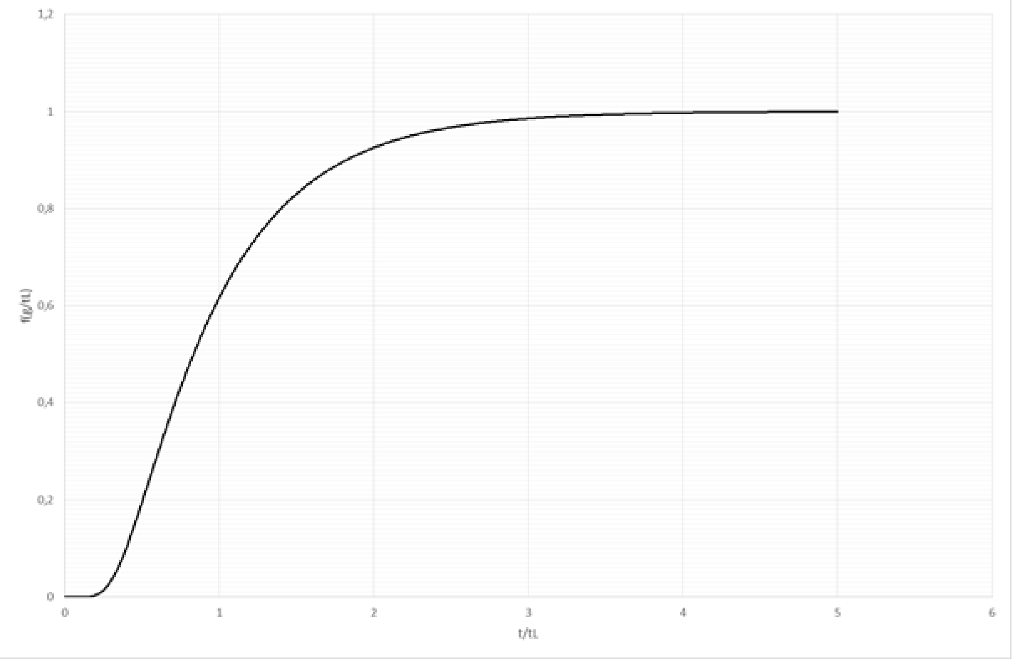


Figure V-1 – shape of the function f(t) as a function of t/t_L.

Table V-1 – Calculated values of f(t) for various values of relative time (t/t_L)

Relative time t/t_L	f(t)
0	0
0.05	1.16×10^{-12}
0.07	5.16×10^{-9}
0.10	2.67×10^{-6}
0.12	2.97×10^{-5}
0.14	1.64×10^{-4}
0.20	3.42×10^{-3}
0.30	3.40×10^{-2}
0.40	0.102
0.60	0.293
0.80	0.474
1.00	0.617
1.50	0.830
2.00	0.925
3.00	0.986

At a time equal to the time-lag (t_L) the flux of chemicals is about 62 % of the final flux (J_∞). The final flux is reached in a time which is approximately equal to 3 times the time-lag.

Example
Outside diameter of the inner pipe: d_{ei} = 50.0 mm and wall thickness: e = 3.0 mm.
Thickness of the barrier layer: e_b=1.0 mm.
Outside diameter of the barrier layer; d_{eb} = 52.0 mm.
Wall thickness of the protective layer is 1.0 mm
Assuming equation 8.7 is valid ; i.e. the D_b is << $D_{other\ layers}$
Diffusion coefficient of barrier layer (D_b) is 1.38×10^{-12} m^2/day

Assuming that the concentration chemical substance (model substance) in the material at the outside the barrier layer is 138 kg/m^3. Concentration chemical substance (model substance) at the inside of the barrier layer approximates 0 kg/m^3, thus Δc_b = 138 kg/m^3.

Calculation of the final flux, J_∞, after steady state conditions are reached:

$$J_\infty = D_b \times \frac{\Delta c_b}{e_b} = 1.38 \times 10^{-12} \times \frac{138}{1\times10^{-3}} = 1{,}91 \times 10^{-7} \left(\frac{kg}{m^2\times day}\right)$$

Calculation of flux after 100 years, $J_{100\ years}$:

$$J_{100\ years} = J_\infty \times f(t)$$

Where f(t) depends on $t_{100\ years}/t_L$ (see table V-1)

$$t_L = \frac{{e_b}^2}{6\times D_b} = \frac{(1\times10^{-3})^2}{6\times1.38\times10^{-12}} = 1.21 \times 10^5\ days;\ \ 330\ years$$

$$\frac{t(100\ years)}{t_L} = \frac{100}{330} = 0.30;\quad f(t) = 3{,}40 \times 10^{-2}$$

$$J_{100\ years} = J_\infty \times f(0.30) = 1{,}91 \times 10^{-7} \times 3.40 \times 10^{-2} = 6{,}49 \times 10^{-9}$$

$$C_{24h,100years,} = J_{100\ years} \times \frac{A_o}{V_i} = J_{100\ years} \times \frac{\pi \times d_o}{\frac{\pi}{4} \times {d_i}^2}$$

$$C_{24h,100years} = 6{,}49 \times 10^{-9} \times \frac{0{,}052}{\frac{1}{4} \times 0{,}044^2} =$$

6.97×10^{-7} kg/m^3
which is;
$C_{24h,100years}$ = 0,697 µg/l

VI Target values and intervention values (informative)

Table VI-1 - Target values groundwater and intervention values soil and groundwater. Levels are given for standard soil with 10% organic compounds and 25% clay soil (lutum).

Organic compound	Groundwater Target values µg/l	Groundwater Intervention values µg/l	Soil Intervention Values mg/kg d.s.
Monocyclic aromatic hydrocarbons			
Benzene	0.2	30	1.1
Ethylbenzene	4	150	110
Toluene	7	1000	32
Xylenen	0.2	70	17
Styrene	6	300	86
Phenol	0.2	2000	14
Cresolen	0.2	200	13
Polycyclic aromatic hydrocarbons (PAK's)			
Naphtalene	0.01	70	
Fenantrene	0.003	5	
Anthracene	0.0007	5	
Fluoranthene	0.003	1	
Chrysene	0.003	0.2	
Benzo(k)fluoranthene	0.0001	0.5	
Benzo(a)pyrene	0.0005	0.05	
Benzo(k)fluoranthene	0.0004	0.05	
Indeno(1,2,3cd)pyrene	0.0004	0.05	
Benzo(gh)perylene	0.0003	0.05	
PAK's (total) sum of 10		-	40
Chlorinated Hydrocarbons			
a. Volatile Hydrocarbons			
Monochloroethene (Vinylchlorid)	0.01	5	0.1
Dichloromethane	0.01	1.000	3.9
1,1- dichloroethane	7	900	15
1,2- dichloroethane	7	400	6.4
1,1- dichloroethene	0.01	10	0.3
1,2- dichloroethene	0.01	20	1
Dichloropropanen (sum)	0.8	80	2
Trichloromethane (chloroform)	6	400	5.6
1,1,1- trichloroethane	0.01	300	15
1,1,2- trichloroethane	0.01	130	10
Trichloroethene (Tri)	24	500	2.5
Tetrachloromethane (Tetra)	0.01	10	0.7
Tetrachloroethene (Per)	0.01	40	8.8
b. Chlorobenzenen			
Monochlorobenzene	7	180	15
Dichlorobenzene	3	50	19
Trichlorobenzene	0.01	10	11
Tetrachlorobenzene	0.01	2.5	2.2
Pentachlorobenzene	0.003	1	6.7

Hexachlorobenzene	0.00009	0.5	2.0
c. Chlorophenoles	0.3	100	5.4
Monochlorophenoles (sum)	0.2	30	22
Dichlorophenoles (sum)	0.03	10	22
Trichlorophenoles (sum)	0.01	10	21
Tetrachlorophenoles (sum)	0.04	3	12
Pentachlorophenoles (sum)			
d. Polychlorobiphenyles (PCB's)	0.01	0.01	1
PCB's (sum of 7 PCB's)			
	-	30	50
e. Rest chlorinated	-	n.a.	0.00018
hydrocarbons	-	6	23
Monochloroanilines			
Dioxine (sum I-TEQ)			
Chloronaphtalene (sum)			
Insecticides			
a. Organochloropesticides			
Chloordane	0.02 ng/l	0.2	4
DDT (sum)	-	-	1.7
DDE (sum)	-	-	2.3
DDD (sum)	-	-	34
DDT/DDE/DDD (sum)	0.004 ng/l	0.01	-
Aldrin	0.009 ng/l	-	0.32
Dieldrin	0.1 ng/l	-	-
Endrin	0.04 ng/l	-	-
Drins (sum)	-	0.1	4
α - endosulfan	0.2 ng/l	5	4
α - HCH	33 ng/l	-	17
β - HCH	8 ng/l	-	1.6
γ – HCH (Lindane)	9 ng/l	-	1.2
HCH compounds (sum)	0.05	1	-
Heptachlor	0.005 ng/l	0.3	4
Heptachlorepoxide (sum)	0.005 ng/l	0.3	4
b. Organo phosphorus pesticides	0.05	0.7	2.5
c. Organo tin compounds (sum)			
d. Chlorophenoxy acetic acid herbicides	0.02	50	4
MCPA	29 ng/l	150	0.71
e. Rest pesticides	2 ng/l	50	0.45
Atrazine	9 ng/l	100	0.017
Carbaryl			
Carbofuran			
Rest compounds			
Asbestos	-	-	100
Cyclohexanone	0.5	15000	150
Dimethylphtalate	-	-	82
Diethylphtalate	-	-	53
Di-isobutylphtalate	-	-	17
Dibutylphtalate	-	-	36

Butyl benzylphtalate	-	-	48
Dihexylphtalate	-	-	220
Di(2-thylhexyl)phtalate	-	-	60
Phtalates (sum)	0.5	5	-
Mineral oil	50	600	5000
Pyridine	0.5	30	11
Tetrahydrofuran	0.5	300	7
Tetrahydrothiphene	0.5	5000	8.8
Tribromoethane (bromoform)	-	630	75

Reference: Intervention values soil remediation volume 2013 No 16675 published on June 27, 2013.

Permeation tests shall be performed with the concentrations listed in table VI-2.

Table VI-2 - Model liquid for the benefit of class II and class III piping systems

Substance / CAS nr	Concentration level (µg/l) Class II	Solubility in groundwater (µg/l) Class III
Toluene / 108-88-3	309000	515000
Trichloroethylene / 79-01-6	660000	1100000
P-dichlorobenzene / 106-46-7	29400	49000