BRL-K17401 part A
16 April 2004

National Evaluation Guideline

for the Kiwa technical approval-with-product certificate for
District heating: flexible piping systems with plastic medium pipe for transport of warm drinking water

BRL-K17401 part A
16 April 2004

National Evaluation Guideline

for the Kiwa technical approval-with-product certificate for
District heating: flexible piping systems with plastic medium pipe for transport of warm drinking water

Validation
This Evaluation Guideline has been validated by the Director Certification and Inspection of Kiwa on 1 December 2003

Accreditation

Kiwa N.V
Certification and Inspection
Sir Winston Churchill-laan 273
P.O. Box 70
2280 AB Rijswijk
Telephone 070 – 41 444 00
Telefax 070 – 41 444 20
Internet www.kiwa.nl

Preface Kiwa

This National Evaluation Guideline has been prepared by the Kiwa Board of Experts "CKW" in which the parties interested in the area of district heating: flexible piping systems with plastic medium pipe for transport of warm drinking water, are represented.

Kiwa will use this Evaluation Guideline in conjunction with the Kiwa Regulations for Product Certification. These regulations detail the methods employed by Kiwa for conducting the necessary investigations prior to issuing the technical approval with product certificate and the method of external control. The inspection frequency is determined by the above mentioned Board of Experts.

1 Introduction

1.1 Subject

The requirements embodied in this Evaluation Guideline (BRL) shall be employed by certification institutes that are accredited by the Dutch Accreditation Council (RvA) when dealing with applications for the issue or maintenance of a technical approval-with-product certificate for district heating: flexible piping systems with plastic medium pipe for transport of warm drinking water.

Besides the requirements embodied in this Evaluation Guideline, certification institutes impose additional requirements in the sense of requirements with regard to general procedures for certification as laid down in the general certification regulations of the respective certification body.

1.2 Scope

The products are intended to be used in connections between the district heating distribution system and the separate house (blocks) for the supply of warm drinking water, at a design pressure (= maximum working pressure) of 1,1 MPa (11 bar absolute or 10 bar overpressure) or 0,9 MPa (9 bar absolute or 8 bar overpressure) under the conditions mentioned in table 1.

Remark:
Each pressure mentioned in this BRL is defined as overpressure.
(So, with "10 bar" a "10 bar overpressure" is meant).

Table 1 – Classification system

Class	Material medium-pipe: plastics	Temperature/time profile
2	X	49 years 70°C (T_D) + 1 year 80°C (T_{max}) + 100 h 95°C (T_{mal})
DH1*)	X	29 years 80°C (T_D) + 1 year 90°C (T_{max}) + 100 h 95°C (T_{mal})
Remark: Class 2 is according the temperature profile of ISO 10508 Class 2 Class DH1 is according the temperature profile of EN 253 (not according to a temperature profile of ISO 10508)		

*) DH = district heating

1.3 Application

Processing of an application for a Kiwa certificate will be done on the basis of the operative Kiwa evaluation guideline at the time of application.

In case reports from research institutes or test laboratories are presented which indicate that the products satisfy the requirements of this evaluation guideline, it must be demonstrated that these institutions fulfil one of the following accreditation standards:

- EN 45001 for laboratories
- EN 45004 for inspection institutes
- EN 45011 for certification institutes

The institute is supposed to fulfil these criteria in case an accreditation certificate issued by the Board of Accreditation (RvA) is available or the concerned institute signed a mutual agreement of acceptance with the RvA.

The scope of accreditation must cover the examinations as required by this evaluation guideline. In case no accreditation certificate is available, Kiwa by itself will investigate whether the accreditation standard has been met.

1.4 Definitions

1.4.1 Definitions: general

1.4.1.1 Heat distribution systems

Heat distribution is the collective use of heat, for the purpose of heating houses, businesses and other buildings and the possible delivery of warm tap water to those houses, businesses and buildings.

1.4.1.2 Flexible piping system

A piping system in which possible bends in the pipe can be made without any mechanical means and in which the pipe is not deformed and the flow capacity is not reduced due to the possible bends.

Remark: in case a minimum bending radius is required in the system, mechanical means according to the installation instructions of the supplier can be used.

1.4.1.3 Rigid piping system

A piping system in which possible bends in the pipe have to be made by mechanical means or by means of a fitting.

Remark: these systems do not apply within the scope of this BRL.

1.4.1.4 Lifetime

The time during which the piping system has to function with a certain operating temperature. See table 1.

1.4.1.5 Life expectancy

The time during which the piping system has to function for the intended application. In this BRL the life expectancy is put to at least 50 years or at least 30 years according table 1.

1.4.1.6 Operating temperature (T_D)

The temperature of the water in the piping system during operation, that occurs at least during a certain part of the lifetime of the piping system. See table 1.

1.4.1.7 Maximum temperature (T_{max})

The highest temperature of the water in the piping system during operation, that occurs during a certain part of the lifetime of the piping system (the highest occurring temperature during a short time). See table 1.

1.4.1.8 Peak temperature (T_{mal})

The highest temperature of the water in the piping system under abnormal circumstances, for example due to malfunctioning, during a short period (maximally 100 hours per 50 years). See table 1.

1.4.1.9 Temperature profile

On the basis of the employed design pressure in relation to the maximum and peak temperature, the temperature profile according table 1 may be used for a lifetime of 50 or 30 years.

1.4.1.10 *Reference lines*

A generic description of the minimum long-term hydrostatic pressure to be expected from a particular composite pipe construction type. The reference lines are parallel to the according ISO 9080 calculated regression lines and at least 97,5% of all individual experimental results shall lie on or above the reference lines. The procedure to find these lines is only valid for this Guideline.

1.4.1.11 *LPL (or P_C)*

Quantity with the dimension of pressure (for multilayer pipes), which represents the predicted mean pressure at a temperature T and a time t (97,5% value).

1.4.1.12 *LTHS*

Quantity with the dimension of pressure (for multilayer pipes), which represents the predicted mean pressure at a temperature T and a time t (50% value).

1.4.1.13 *Design pressure (P of P_D)*

The allowable pressure in the piping system that may occur for 50 years during continuous use. In this BRL 'design pressure' is defined as the prevailing overpressure (so, for example P=10 bar means a design pressure of 11 bar absolute).

1.4.1.14 *Predicted design pressure (P_{PD})*

The calculated pressure in the piping system after a lifetime of 50 years, using the 97,5% reference lines and according to the temperature profile of table 1 for a multilayer pipe construction (medium pipe).

- P_{PD2} for Class 2;
- P_{PD3} for Class DH1.

Remark: The value of p_{PD} is calculated using p_C see formula 2 of paragraph 7.3.1.

1.4.1.15 *Residual variance (s_R)*

The calculated value for the 97,5 % (one sided) lower confidence limit of the predicted hydrostatic strength for a complete set of rapture data, using the SEM analyses model of ISO 9080.

1.4.2 *Definitions: the construction*

1.4.2.1 *Piping system*

The total of pipes, (possible) outer casings, fittings (and joint assemblies), and insulation material, but excluding distributors.

1.4.2.2 *Medium-pipe*

The medium carrying pipe which is in contact with the warm water.

1.4.2.3 *Homogeneous medium-pipe*

Meant are the medium-pipes constructed of PE-X, PE-RT or PB and provided with an EVOH barrier layer. This barrier layer strongly prevents or reduces the diffusion of oxygen through the pipe wall. The barrier layer does <u>not</u> contribute to the mechanical strength of the pipe.

1.4.2.4 *Multilayer pipe*

A multilayer plastics medium-pipe provided with a thin metal (aluminium) barrier layer. This barrier layer strongly prevents or reduces the diffusion of oxygen through the pipe wall. The barrier layer can contribute to the mechanical strength of the pipe.

1.4.2.5 *Outer casing*

A separate applied outer layer of the piping package, protecting the construction during installation and protecting the construction against external influences (after installation).

1.4.2.6 *Insulation layer*

The thermal insulation layer is meant to provide for the desired insulating characteristics of the piping package.

1.4.2.7 *Piping package*

The complete pipe, existing of the medium-pipe, an insulation layer and (in general) an outer casing.

1.4.2.8 *Bonded piping package*

The different layers of the piping package are united in such a way that under influence of expansion forces no displacements at the interface of the mutual piping layers occur.

1.4.2.9 *Non-bonded piping package*

The different layers of the piping package can be mutually displaced under influence of expansion forces.

1.4.2.10 *Mechanical joints*

A connection between a pipe and a fitting, made by means of pressing a ring or case over the outside diameter of the pipe, with or without extra sealing elements and with possible use of a supporting ring in the pipe, according to NEN EN ISO 6708.

1.4.2.11 *Medium pipe: electro fusion joint*

A joint between a pipe and a fitting realised by melting together of the outer layer of the pipe and medium layer of the fitting. The melting of the material is realised by heat developed due to induction of an electrical resistance. The electrical resistance is composed of a metal thread that is embedded in the fitting.
Pipe and fitting are first pushed together till the required installation position, before the material is melted.

1.4.2.12 *Medium pipe: socket fusion joint*

A joint between a pipe and a fitting realised by melting together of the outer layer of the pipe and medium layer of the fitting. The melting of the material is realised by a solid body with the appropriate temperature that is in contact with the material concerned during a certain amount of time:
Socket shaped for the pipe and spigot shaped for the fitting. The material is first melted, after which the pipe and fitting are pushed together till the required installation position is obtained.

1.4.2.13 *Medium pipe: butt fusion joint*

A joint between two pipes, made by heating the planed ends of the pipes by holding them against a flat heating plate until the material reaches fusion temperature. After quickly removing the heating plate, the two softened ends are pushed against each other (according to a defined time/pressure diagram) forming a fusion rill and joining both pipes together.

1.4.2.14 *Mechanical outer casing joint*

The (watertight) joint between two outer casing parts by means of:
- a contraction socket;
- an electro fusion socket;
- two (metallic) half plates.

1.4.3 *Definitions and symbols: geometry*

1.4.3.1 D_n

Nominal outside diameter of the medium pipe.

1.4.3.2 $d_{n,m}$
Nominal outside diameter of the outer casing (=$d_{n,p}$).

1.4.3.3 $d_{n,p}$
Nominal outside diameter of the piping package.

1.4.3.4 d_{em}
Mean diameter of the medium-pipe.

1.4.3.5 $d_{em,m}$
Mean outside diameter of the outer casing.

1.4.3.6 $d_{em,p}$
Mean outside diameter of the piping package.

1.4.3.7 $d_{em,b}$
Mean outside diameter of the piping package.

1.4.3.8 $d_{i,gem}$
Mean internal diameter of the outer casing.

1.4.3.9 $d_{i,m}$
Internal diameter of the outer casing.

1.4.3.10 $e_{min,m}$
Minimum wall thickness of the outer casing.

1.4.3.11 $e_{max,m}$
Maximum wall thickness of the outer casing.

1.4.3.12 $e_{min,b}$
Minimum wall thickness of the medium pipe.

1.4.3.13 $e_{max,b}$
Maximum wall thickness of the medium pipe.

1.4.4 Definitions: material characteristics

1.4.4.1 S series
A number without dimension identifying the pipe according to ISO 4065, where the S series prescribes the pipe series for a certain design pressure according to the following formula:

$$S = \frac{d - e}{2e} = \frac{\sigma}{p}$$

1.4.4.2 SDR value

A number without dimension identifying the pipe according to ISO 4065, where the SDR value describes a relation between the pipe and his wall thickness for a certain design pressure according to the following formula:

$$SDR = \frac{d_n}{e} = \frac{(2\sigma + p)}{p} = \frac{2\sigma}{p} + 1 = 2.S + 1$$

1.4.4.3 Hydrostatic tension σ

Tension in the circumferential direction of the pipe wall caused by internal water pressure. This tension is derived from the internal pressure according the following formula:

$$\sigma = \frac{p \times (d_{em} - e_{min})}{20 \times e_{min}}$$

Where:

σ = the tension in the circumference direction of the pipe wall in MPa
p = the internal pressure in bar;
d_{em} = the mean outside diameter of the medium pipe in mm;
$e_{min,b}$ = the minimum wall thickness of the medium pipe in mm.

1.4.5 Definitions and symbols with regard to insulating characteristics

1.4.5.1 R_{eis} (m.K/W)

The heat loss per meter length of a piping package as allowed for a certain energy transport (requirement of the user) under local installation conditions.

1.4.5.2 R_l (m.K/W)

The heat loss per meter length of a piping package (including possible returning medium pipe) as it will occur under the specific local conditions at the end of the lifetime of the piping package (at local circumstances).

1.4.5.3 R_{instal} (m.K/W)

The heat loss per meter length of a piping package (including possible returning medium pipe) as it will occur under the specific local conditions at the end of the lifetime of the piping package (at local circumstances).

1.4.5.4 R_{decl} (m.K/W)

The normalised value of the heat loss per meter length of a piping package (with a single medium-pipe) as the manufacturer must demonstrate by means of measurements and calculations .

1.4.5.5 F_a

A factor without dimension that charges the influence of the ageing of the insulating layer in R_{instal} to the expected lifetime.

1.4.5.6 F_m

A factor without dimension that charges the influence of moisture in R_{instal} to the expected lifetime.

1.4.5.7 F_c
A factor without dimension that charges the influence of compression of the insulation layer in R_{instal} to the expected lifetime.

1.4.5.8 F_p
A factor without dimension that charges the influence of the radiation in R_{instal} to the expected lifetime.

1.4.5.9 F_T
A factor without dimension that charges the influence of the difference in temperature between the supplying medium-pipe and the outlet medium-pipe in R_{instal} to the expected lifetime.

1.4.5.10 F_{tot}
A factor without dimension that charges the total influence of the internal and external factors in R_{instal} to the expected lifetime.

Remark:
Values that are only used in an annex are defined in the concerning annex.

2 Requirements for the piping system

2.1 General

This chapter contains the requirements to be met by the flexible piping systems for heat distribution.

2.2 Toxicological requirements

Products and materials that (can) come into contact with drinking water may not emit substances to the drinking water in such amounts that it can be harmful for consumers. For guarantee the product must fulfil the criteria as laid down in the 'Guideline quality of materials and chemicals for drinking water supplies' (published in the ´Staatscourant´). As proof the application procedure Attest Toxicological Aspects (ATA) must be completed successfully.

2.3 Influence on drinking water: organoleptical requirements

All materials, which make contact to drinking water may not emit odour, flavour or colour in concentrations, which are disturbing for the consumer. This requirement is fulfilled if after conditioning of the test pieces according EN 1420-1 and after testing according to Kiwa publication PB 94-01, three or more members of the testing panel observe no difference in odour or flavour between the blank and test water. With regard to emitting colour the method according to EN 13052-1, with no higher intensity than 5 mg Pt/l after the third extraction, is applicable.

2.4 Lifetime of the system

The complete piping system must be designed for a lifetime expectancy according to paragraph 1.2.

Remark: with lifetime is meant the technical lifetime of the system during normal usage. The different lifetimes according to table 1 have to be added up in order to obtain the minimum lifetime of 50 years (class 2) or 30 years (class DH1).

2.5 Determination of R_{decl}

In order to be able to compare the different piping systems with regard to the energy transport capacity per meter length of the piping package, the following systematic is chosen:

The manufacturer must be able to submit calculations of an approved body (see paragraph 1.5) of R_{decl} (according annex 3) and/or measurements performed by an approved body (see paragraph 1.5) of R_{decl} (according annex 4) of different diameters of the piping package (=piping systems).

2.6 Maximum calculated heat emission R_{prak}

2.6.1 General

The supplier has to demonstrate that the piping system is still able to fulfil the minimum required heat emission requirements under local circumstances after 30 years (or 50 years).
The below mentioned procedure (paragraph 2.6.2 and 2.6.3) can be followed.

2.6.2 *Heat emission of the piping system R_I*

For a chosen piping system all parameters that influence the correct functioning of the piping system after installation have to be considered.

These are influences like ageing of the insulation (F_a), influence of moisture (F_m), compression of the piping package (F_c), influence of radiation losses (F_D) and influence of the temperature difference between the supplying medium-pipe and discharge medium-pipe (F_T).

The supplier of the piping system can demonstrate the value of the allowed heat emission per meter length (at the end of the lifetime of the piping system) according to annex 5:
R_I (in m.K/W).

2.6.3 *Heat emission of the piping system in the ground, R_{prak}*

For the determination of the total heat emission the procedure according to annex 6 can be followed.

Remark: also the calculated R_I has to be used in annex 6.

2.6.4 *Maximum allowed heat emission, R_{eis}*

The user of the piping system desires (also at the end of the lifetime) a certain minimum energy supply to the delivery point. Depending on the route to the delivery point, a maximum allowed heat emission per meter length is allowed:
R_{eis} (in m.K/W).

Now has to count:
$R_{prakt} \geq R_{eis}$

2.7 Requirements for the joints

2.7.1 *General*

The joints in the piping system have to be tested with regard to their proper functioning. In this chapter all joint tests required for the piping system are included.

The combination of a (possible) rubber seal, (possible) supporting ring and clamp construction in the fitting have to be tested with regard to the aspects mentioned in paragraph 2.7.3.

2.7.2 *Rubber*

Possible rubber seals have to be made from a synthetic rubber and has to fulfil the requirements of BRL 2013 (these requirements are parallel to NEN EN 681, table 3. Material types according table 4: type WD). The manufacturer has to declare to the approved body which type of rubber is applied, as well as the hardness and dimensions of the rubber seals.

2.7.3 *Tightness and strength of the joints of the medium pipe*

The fittings shall not deform during testing in accordance with table 2. After testing, the pipe ends shall show no severe damages. If not otherwise stated, the testing temperature is (23±2) °C.

Table23 - Tightness and strength of the joints of the medium-pipe

<table>
<tr><th>Aspect</th><th>Require-
ment</th><th colspan="3">Test parameters</th><th>Test
method</th></tr>
<tr><td>Cyclic
temperature
test</td><td>no
leakage</td><td colspan="3">n = 5000 cycli[3)4)]
T_{max} = (93±2) °C[1)]
T_{min} = (23±2) °C[2)]
t_{cyclus}= 30 min[3)].
$P_{design\ pressure}$ (bar)
One test piece</td><td>EN 12293</td></tr>
<tr><td>Resistance
to tensile force</td><td>no
leakage</td><td colspan="3">t = (60±1) min.
Three test pieces
$F = 1,5 \times \pi/4 \times d_{n,b} \times P_{wdesign\ pressure}$ (N)</td><td>EN 712</td></tr>
<tr><td>Resistance to
vacuum</td><td>≤ 0,05 bar</td><td colspan="3">t = (60±1) min.
Three test pieces
P= -0,8 bar</td><td>EN 12294</td></tr>
<tr><td>Resistance to
bending</td><td>no
leakage</td><td colspan="3">t = (60±1) min.
Three test pieces
P= depends on pipe material</td><td>EN 713</td></tr>
<tr><td rowspan="4">Resistance to
internal
hydrostatic
pressure, class 2</td><td rowspan="4">no
leakage</td><td colspan="3">t = 1000 h.
Three test pieces</td><td rowspan="4">ISO 1167</td></tr>
<tr><td rowspan="2">Medium-pipe
type</td><td colspan="2">Test pressure
P (bar)</td></tr>
<tr><td>8</td><td>10</td></tr>
<tr><td>PE-X
PB
PE-RT
PE-X/Al
PE-RT/Al
PE-X +Al</td><td>10,0
9,5
10,2
5)
5)
5)</td><td>12,5
11,9
12,8
5)
5)
5)</td></tr>
<tr><td rowspan="4">Resistance to
internal
hydrostatic
pressure, class DH1</td><td rowspan="4">no
leakage</td><td colspan="3">t = 1000 h.
Three test pieces</td><td rowspan="4">ISO 1167</td></tr>
<tr><td rowspan="2">Medium-pipe
type</td><td colspan="2">Test pressure
P (bar)</td></tr>
<tr><td>8</td><td>10</td></tr>
<tr><td>PE-X
PB
PE-RT
PE-X/Al
PE-RT/Al
PE-X +Al</td><td>11,0
11,6
13,7
5)
5)
5)</td><td>13,8
14,5
17,1
5)
5)
5)</td></tr>
<tr><td colspan="6">1) Maximum test temperature of the water
2) Minimum test temperature of the water
3) $t_{cyclus} = t_{max} + t_{min}$ (= 15 + 15 = 30 min total time = 2500 hours)
4) for diameters > 63 mm counts n = 100
5) on basis of the regression curve and at least equal to the value of the medium pipe material</td></tr>
</table>

2.7.4 *Damage to contact surfaces*

2.7.4.1 *Mutual corrosion of the metals*

No harmful electrolytic reactions may occur between the different materials. The following applies for multi-layer pipes:
In case the material of the fittings and joint assemblies do have a corroding effect on the intermediate metal layer of the pipe, then the electrical separation must be such that the electrical flow between the parts is smaller than 10×10^{6} Ampere. This requirement is tested according to the test method of paragraph 7.5.1.

2.7.4.2 *Corrosion due to water*

For piping systems with a multi-layer medium pipe applies that the construction must be such, that the aluminium in no case (after installation) comes into contact with the water.
After testing in accordance with paragraph 7.5.2, the aluminium layer shall show no damages.

2.8 Requirements for the piping package

2.8.1 *Long-term compression*

The long-term compression of the piping package has to fulfil the requirements according table 3.

Table 3 – Requirements with regard to the long-term compression of the piping package

Aspect	Requirement	Test parameters		test method
Ring stiffness	≥ 4 kN/m²	Temperature Compression Velocity of compression	(23 ±2)°C 3% (5±1) mm/min	NEN-EN-ISO 9969
Creep ratio	≤ 5	Temperature	(23±2) °C	NEN-EN-ISO 9967
Ring flexibility	No kink $d_{i,gem} \geq 80\%$ 1)	After 30 min conditioning Fc 2) stop at 30 % $d_{n,m}$		NEN-EN 1446

1) minimum inside radius of the bend
2) Fc = compression force = constant

2.8.2 *Dimensional stability*

After testing in accordance with annex 8, the decrease of the outside diameter of the piping package may not be higher than 10%.

2.8.3 *Sealing in longitudinal direction*

2.8.3.1 *Bonded systems*

When water leakage occurs from the outside into the piping system the maximum displacement speed in axial direction in the piping package shall not exceed 2 m per years from the start of leakage. Testing in accordance with 7.2.1 and 7.2.2.

Remark: with a test time of 1000 hours the axial displacement shall be less than1000 x 2000/24 x 365 mm.

The piping package shall be dry internally after testing in accordance with point 7.2.3.
All test specimens have been sampled from normal production.

2.8.3.2 Non bonded systems

The manufacturer of the system shall have a provision to stop leakage in axial direction. With the use of this provision the piping package shall be dry internally after testing in accordance with point 7.2.3.
All test specimens have been sampled from normal production and the joints have been installed according to the installation instruction of the manufacturer.

2.8.4 Sealing construction to main supply pipe and service pipe

After installation the joint construction between the main supply pipe as well as with the service pipe shall be such that:
The joint shall be leak tight at an internal pressure of 0,3 kPa, to be determined according paragraph 5.1.5 of NEN-EN 489, after a conditioning of the joint according paragraph 5.1.1 till paragraph 5.1.4 of NEN EN 489.
For the purpose of the test the manufacturer of the system shall supply a joint in accordance with their installation instructions.

2.9 Installation instructions

The supplier shall provide installation instructions in the Dutch language. A reference to these instructions shall be made at or near the packaging. The instructions must contain specific information with regard to storage, transport, processing temperature, construction of the joints and specific installation guidelines.

2.10 Marking

After conclusion of the certification agreement, the outer casing shall be provided, at intervals of not more than 2 m, with the following clearly legible and indelible markings:

- dependent on the type of medium pipe:
  - “PE/X “or "PE-X/Al" or “PE-X + Al”;
  - “PB”;
  - “PE-RT” or "PE-RT/Al".
- system name;
- classification (class DH1);
- design pressure: 8 or 10 bar;
- the number and the nominal outside diameter(s) plus wall thickness of the medium pipe(s) in mm;
- the nominal outside diameter of the outer casing in mm;
- the production code.

3 Requirements for the medium-pipe

3.1 General

In this chapter the requirements for the medium/pipe have been recorded.

3.2 Lifetime

The manufacturer shall submit pressure test data based on tests (in water or in air) in accordance with ISO 1167 for the raw material (PE-X, PE-RT or PB) to be used for the manufacturing of the pipes. The test specimens shall be extruded pipes manufactured from the raw material (PE-X, PE-RT or PB). The tests must have been performed for at least 10.000 hours and for the following temperatures: 60°C or 80°C, 95°C and 110°C. The data must be statistically processed and presented according ISO 9080:2002.
The elaborated LPL curves must be equal or better than the curves of the relevant material according to EN ISO 15875 (for PE-X) or EN ISO 15876 (for PB) or BRL-K536 part G (PE-RT).

3.3 PE-X pipes

The requirements in paragraph 3.2 and 3.3 are taken from EN ISO 15875.

3.3.1 Dimensions

The dimensions of the pipes are given in table 4. For the determination of the dimensions, the method according to ISO 3126 has to be followed.

Table 4 - Dimensions of PE-X pipes. Dimensions in mm.

d_n	(d_{em})		Out of roundness	Wall thickness			
				SDR 9		SDR 7,4	
	Min.	Max.		P = 8 bar S = 4		P = 10bar S = 3.2	
				$e_{min,b}$.	e_{max}	$e_{min,b}$.	e_{max}
18	18,0	18,3	0,5	2,0	2,4	2,4	2,8
20	20,0	20,3	0,5	2,3	2,7	2,8	3,2
22	22,0	22,3	0,5	2,5	3,0	2,9	3,3
25	25,0	25,3	0,6	2,8	3,2	3,5	4,0
28	28,0	28,3	0,6	3,2	3,7	3,9	4,4
32	32,0	32,3	0,8	3,6	4,1	4,4	5,0
40	40,0	40,4	1,0	4,5	5,1	5,5	6,2
50	50,0	50,5	1,2	5,6	6,3	6,9	7,7
63	63,0	63,6	1,4	7,1	8,0	8,6	9,5
75	75,0	75,7	1,4	8,4	9,4	10,3	11,5
90	90,0	90,9	1,4	10,1	11,3	12,3	13,7
110	110,1	111,0	1,6	12,3	13,7	15,1	16,8
125	125,0	126,2	1,6	14,0	15,4	17,1	18,9
140	140,0	141,3	1,6	15,7	17,4	19,2	21,3
160	160,0	161,5	1,8	17,9	19,8	21,9	24,2
180	180,0	181,5	1,8	20,0	22,1	24,6	27,2
200	200,0	201,5	2,0	22,4	24,8	27,4	30,3
225	225,0	226,5	2,0	25,0	27,6	30,8	33,9
250	250,0	251,5	2,0	27,9	30,9	34,2	37,6

3.3.2 PE-X pipes

Table 5 – Requirements for PE-X pipes

Aspect			Requirement	Test parameter		Test method
Dimensions			According table 5	Dimensions		EN 496
Appearance			Smooth without any flaws	Soundness		Visual inspection
Extent of cross linking[1)]	PE-Xa	Peroxide system	≥70 %	EN 579		EN 579
	PE-Xb	Silane system	≥65 %			EN 579
	PE-Xc	Radiation system	≥60 %			EN 579
	PE-Xd	AZO-system	≥60 %			EN 579
Resistance to internal pressure			≥ 1 h[4)]	20 °C	12 [2)]	ISO 1167
			≥ 1 h[4)]	95°C	4,8 [2)]	
			≥ 22 h[4)]	95°C	4,7 [2)]	
			≥ 165 h[4)]	95°C	4,6 [2)]	
			≥ 1000 h[4)]	95°C	4,4 [2)]	
Thermal stability			≥ 8760 h[4)]	110°C	2,52 [2)]	ISO 1167
Influence of heat			≤ 3 %[3)]	Change of length EN ISO 15875-2		NEN-EN 743 method B

1) The manufacturer must state the maximum allowed percentage of cross-linking of the system. The percentage measured during the determination according the above-mentioned method shall be in between both values.
2) σ (N/mm^2)
3) After the test, the test pieces may not show any cracks, blisters or cavities.
4) Minimum required test time

3.4 PB pipes

Remark: The relevant requirements are taken from EN ISO 15876.

3.4.1 Dimensions

The dimensions of the pipes are given in table 5. For the determination of the dimensions, the method according to ISO 3126 has to be followed.

Table 6 - dimensions of PB pipes. Dimensions in mm.

d_n	(d_{em})		Max. Out of round ness	Wall thickness			
				P = 8 bar S= 5		P = 10 bar S = 4	
	Min.	Max.		$e_{min,b}$	$e_{max,b}$	$e_{min,b}$	$e_{max,b}$
18	18,0	18,3	0,5	1,7	2,0	2,0	2,3
20	20,0	20,3	0,5	1,9	2,2	2,3	2,7
22	22,0	22,3	0,5	2,0	2,3	2,4	2,8
25	5,0	25,3	0,6	2,3	2,7	2,8	3,2
28	28,0	28,3	0,6	2,6	3,0	3,1	3,6
32	32,0	32,3	0,8	2,9	3,3	3,6	4,1
40	40,0	40,4	1,0	3,7	4,2	4,5	5,1
50	50,0	50,5	1,2	4,6	5,2	5,6	6,3
63	63,0	63,6	1,4	5,8	6,5	7,1	8,0
75	75,0	75,7	1,4	6,8	7,6	8,4	9,4
90	90,0	90,9	1,4	8,2	9,2	10,1	11,3
110	110,0	111,0	1,6	10,0	11,1	12,3	13,7
125	125,0	126,2	1,6	11,4	12,7	14,0	15,5
140	140,0	141,3	1,6	12,7	14,1	15,7	17,4
160	160,0	161,5	1,8	14,6	16,6	17,9	19,8
180	180,0	181,5	1,8	16,4	17,8	20,1	22,3
200	200,0	201,5	2,0	18,2	20,2	22,4	24,8
225	225,0	226,5	2,0	20,5	22,7	25,2	27,8
250	250,0	251,5	2,0	22,8	25,1	27,9	30,7

3.4.2 PB pipes

Table 7 – Requirements for PB pipes

Aspect	Requirement	Test parameter		Test methods
Dimensions	According table 8	Dimensions		EN 496
Appearance	Smooth without any flaws	Soundness		Visual inspection
Resistance to internal pressure	≥ 1 h	20 °C	15,5 2)	ISO 1167
	≥ 22 h	95°C	6,4 2)	
	≥ 165 h	95°C	6,2 2)	
	≥ 1000 h	95°C	6,0 2)	
Thermal stability	≥ 8760 h	110°C	2,4 2)	ISO 1167
MFR	Value may vary max. 30% of nominal value	T = 190°C t = 10 min. mass = 5 kg		ISO 1133
Influence of heat	≤ 2 % 1)	Change of length EN ISO 15876-2		NEN-EN 743 method B
1) After the test, the test pieces may not show any cracks, blisters or cavities. 2) σ (N/mm²).				

3.4.3 Welded joint of PB

The requirements for welded joints (socket fusion and electro fusion) in PB are according to EN ISO 15876-3.

3.5 PE-RT pipes

Remark: For the most part the relevant requirements are taken over from BRL5607.

3.5.1 Dimensions

The dimensions of the pipes are given in table 8. For the determination of the dimensions, the method according ISO 3126 has to be followed.

Table 8 – Dimensions of PE-RT pipes. Dimensions in mm.

d_n	(d_{em})		Max. Out of round ness	Wall thickness			
				SDR 6		SDR 5	
				P = 8 bar S= 2,5		P = 10 bar S= 2	
	Min.	Max.		$e_{min,b}$	$e_{max,b}$	$e_{min,b}$	$e_{max,b}$
18	18,0	18,3	0,5	3,0	3,4	3,6	4,1
20	20,0	20,3	0,5	3,4	3,9	4,1	4,7
22	22,0	22,3	0,5	3,7	4,2	4,4	5,0
25	25,0	25,3	0,6	4,2	4,8	5,1	5,8
28	28,0	28,3	0,6	4,7	5,3	5,6	6,3
32	32,0	32,3	0,8	5,4	6,1	6,5	7,3
40	40,0	40,4	1,0	6,7	7,5	8,1	9,1
50	50,0	50,5	1,2	8,4	9,4	10,1	11,3
63	63,0	63,6	1,4	10,5	11,7	12,7	14,1
75	75,0	75,7	1,4	12,5	13,9	15,1	16,8
90	90,0	90,9	1,4	15,0	16,6	18,1	20,1
110	110,0	111,0	1,6	18,3	20,3	22,1	24,5
125	125,0	126,2	1,6	20,8	23,0	25,1	27,8
140	140,0	141,3	1,6	23,3	25,8	28,1	31,1
160	160,0	161,5	1,8	26,6	29,4	32,1	35,5
180	180,0	181,5	1,8	29,9	33,0	36,1	39,9
200	200,0	201,5	2,0	33,2	36,7	40,1	44,3
225	225,0	226,5	2,0	37,4	41,3	45,1	49,8
250	250,0	251,5	2,0	41,5	45,8	50,1	55,3

3.5.2 Pipes of PE-RT

Tabel 9 – Requirements for PE-RT pipes

Aspect	Eis	Test parameter		Test methode
Dimensions	According to table 8	Dimensions		EN 496
Appearance	Smooth without any flaws	Soundness		Visual inspection
Resistance to internal pressure	≥ 1 h	20 °C	9,9 2)	ISO 1167
	≥ 22 hrs	95°C	3,8 2)	
	≥ 165 hrs	95°C	3,6 2)	
	≥ 1000 hrs	95°C	3,5 2)	
Thermal stability	≥ 8760 hrs	110°C	1,8 2)	ISO 1167
Influence of heat	≤ 3 % 1)	Change of length BRL5607		NEN-EN 743 method B
MFR	Value may vary max. 20% of nominal value	T = 190°C t = 10 min. mass = 2,16 kg		ISO 1133
1) After the test, the test pieces may not show any cracks, blisters or cavities 2) σ (N/mm2)				

3.6 Multi-layer pipes

3.6.1 Long-term characteristics

3.6.1.1 Inner layer

The following applies for the plastic inner-layer of the multi-layer pipe:
the medium-layer shall be made of PE-X, PE-RT or PB according to paragraph 3.1.

3.6.1.2 Multi-layer pipe

According to the test method of point 7.3.1 and table 10 the manufacturer shall prove that his multi-layer pipe construction will have a lifetime of at least 50 years for the relevant class according to table 1.

Table 10 - Requirement for P_{PD} .

Class	Requirement
2	$P_{PD1} \geq P_{D1}$
DH1	$P_{PD3} \geq P_{D3}$

One pipe diameter of the multi-layer construction type shall be tested according to point 7.3.1. All other diameters of the same construction type shall be tested according to ISO DIS 17456 point 6.5.
The regression lines (p_{LTHS}) shall have an angle equal to the lines obtained according to point 7.3.1.

3.6.2 Appearance

The internal and external surface of the pipes shall be homogeneous and free from imperfections, pits, blisters and discoloration. The ends of the pipes shall be smooth and square.

3.6.3 Dimensions

In principle diameter and wall thickness are not prescribed, as long as the preconditions as mentioned in paragraph 3.5.1.2 are met.

3.6.4 *Multi-layer pipe*

At present, only aluminium (Al) is used as strengthening layer. In case the manufacturer makes use of another metal, then the mechanical requirements for installation and lifetime have to be drafted in consultation with the certification body.

3.6.5 *Aluminium (Al) strengthening layer*

The following mechanical characteristics of the aluminium have to be stated by the manufacturers and shall be laid down and will form a part of the agreement:
- Tensile strength;
- 0,2% strain limit;
- Elongation at break.

The test method according to paragraph 7.4 has to be used for the determination of these characteristics.

3.6.6 *Resistance to internal water pressure*

After obtaining the p_{LTHS} line for each diameter, the S_R has to be used to calculate the test pressures for table 11 (see formula 2 of point 7.3.1).
The manufacturer shall use the calculated values for product verification testing.

Table 11– Resistance to internal pressure

Test temperature (°C)	P (N/mm²)	Test duration at least (h)
95 (in water or air)	P1	22
95 (in water or air)	P2	165
95 (in water or air)	P3	1000

3.7 Adhesive layer

Table 12 – Requirements for the adhesive layer

Aspect	Requirement	Test parameter	Test method
Material	Acc. IQC 3)	Acc. IQC3)	Acc. IQC3)
Dimensions2)	Acc. IQC3)	Acc. IQC3)	Acc. IQC3)
Melting temperature	≥ 120 °C	Test pieces: 1	ISO 3146, Method A
Good suture at aluminium layer	No delamination	Conditoneren1) Test pieces: 3	Paragraph 7.5.2
Good suture at aluminium layer	No delamination	Conditoneren1) Test pieces: 3	ISO/DIS 18124
Adherence force at plastics layer (homogeneous pipe)	Not to peel off or: no flow	Test pieces: 3	Paragraph 7.6.1

1) conditioning by testing of the assembled pipe, according table 3, aspect cyclic temperature test
2) as well as type as supplier of the adhesive layer
3) IQC: is laid down as part of the certification agreement, after approval of the testing body

3.8 Protection layer around the pipe

Multi-layer pipes may only be produced with a protection layer. For this applies that the composition must be laid down in the internal quality control scheme (IQC-scheme). The remaining requirements are mentioned in table 13.

Table 13 – Requirements for the protection layer of the medium-pipe

Aspect	Requirement	Test parameter	Test method
Dimensions	Acc. IQC[1)]	Test pieces: 1	ISO 3126
Appearance	Smooth without impurities	Test pieces: 1	Visual inspection
Oxidative induction time	≥ 20 min	Test pieces:1 Temperature: 200 °C	EN 728
Thermal stability[2)1)]	≥ 50 years at 80°C	See annex 7	Annex 7
1) IQC: is laid down as part of the certification agreement, after approval of the testing body 2) Counts for material other than PE-X, PB or PE-RT			

3.9 Marking of the medium-pipe

After conclusion of the certification agreement, the medium-pipes shall be provided, at intervals of not more than 2 m, with the following clearly legible and indelible markings:

- Word mark 'Kiwa';
- for medium pipes made of homogeneous material, depending on the type of used plastic: PB, PE-X or PE-RT;
- for multilayer pipes, dependent on the material used for the medium pipe: PE-X/Al, or PE-X+Al or PE-RT/Al;
- design pressure: 8 or 10 bar;
- the nominal outside diameter and the nominal wall thickness in mm;
- the production code.

4 Requirements for the fitting

4.1 Requirements for the plastics fittings

4.1.1 Loaded parts

Remark: with "loaded parts" is meant: by internal hydraulic pressure loaded parts

Table 14 – Requirements for metal fittings

Aspect	Requirement	Test parameter	Test method
Dimensions	Specification manufacturer	Dimensions	
Appearance	Smooth without any flaws	Soundness	Visual inspection EN 496
Material	According IQC[1)]	According IQC[1)]	According IQC[1)]
Long term strength fitting body	According table 1	Resistance to internal hydraulic pressure at 60 °C or 80 °C and at 95 °C	ISO DIS 9080[2)]
Behaviour at heating	No damage deeper than 30% of the wall thickness	Temperature and test duration in consultation with manufacturer	EN 734
Thermal stability	≥ 8760 h No cracks	110 °C 8760 h	ISO 1167

1) IQC: is laid down as part of the certification agreement, after approval of the testing body
2) Tested with cylindrical injection moulded test specimens

4.1.2 Unloaded parts

The requirements applying for plastics (other than according 4.1.1), that are used for the not by internal hydraulic pressure loaded parts of the fittings, are determined separately. Hereby, the manufacturer has to submit the required information to the certification body.

4.2 Metal fittings

Table 15 – Requirements for metal fittings

Aspect	Requirement	Test parameter	Test method
Material composition	NEN-EN 1254-3	-	Information manufacturer
Dimensions	NEN-EN 1254-3	Minimum thickness	ISO 3126
Construction	NEN-EN 1254-3	Construction drawings	ISO 3126
Strength fitting body:	Resistance to internal hydraulic pressure	NEN-EN 1254-3 paragraph 5.1	ISO 1167
Resistance to stress corrosion	No cracks	9,5 >pH > 10	EN-ISO 6957

Remark: for metal fittings not manufactured from copper diverge parameters apply which are determined with approval and in consultation with the certification body.

4.3 Marking

The method of marking of mechanical fittings is given below.
After conclusion of the certification agreement, the fittings shall be provided with the following clearly legible and indelible markings:

- Word mark ‘Kiwa’;
- supplier’s name or registered trademark or logo;
- the outside diameter in mm of the accompanying pipe;
- for plastics fittings: the material indication of the material from the fitting body according ISO 1043-1.

5 Requirements for the insulation material

5.1 Functional requirements

The materials shall meet the requirements of table 16.

When the functional requirements are fulfilled according to another material, then at least the following requirements apply:

- Sufficient dimensional stability and uniform dimensions of the cell structure;
- Recorded closed cell percentage;
- For polyolefines: OIT, see table 16;
- For polyolefines: a provable lifetime according to 3.1;
- Thermal dimension stability in accordance with Table 16.

The requirements to be applied are, in this case, determined and evaluated in consultation with the certification body.

Table 16 – Mechanical requirements for the insulation material.

Aspect	Requirement		Test parameter		Test method
Material composition	According IQC 1)		According IQC 1)		According IQC 1)
Water absorption	PUR: ≤10%	PE, PE-X ≤1%	Test pieces 3	T = 80 °C or T = 100 °C	NEN-EN 253 paragraph 5.3.5
OIT	>15 min at 200°C		1 test piece	L = 300mm	NEN-EN 728
Cell structure distribution	Uniform dimensions		Test pieces	1	NEN-EN 253 paragraph 5.3.2.1
Cell dimension	According IQC 1)		Test pieces	3	NEN-EN 253 paragraph 5.3.2.1
Closed cell %	According IQC 1)		Test pieces	3	NEN-EN 253 paragraph 5.3.2.2
Thermal characteristics	According IQC 1)		Test pieces	10	EN-ISO 8497
Dimensional stability	Compression ≤10%		Annex 8		Annex 8
1) IQC: is laid down as part of the certification agreement, after approval of the testing body					

6 Requirements for the outer casing

6.1 Functional requirements

This chapter concerns flexible, corrugated and non-corrugated outer casings of polyolefines (PE, PP), where the functional requirements for the outer casing are translated to specific material requirements for the outer casing.

In case the functional requirements are fulfilled according to another construction, then in any case the following requirements apply:
- Sufficient dimensional stability and smoothness;
- Resistance to impact, see table 18;
- Resistance to traffic load, see table 4;

The requirements to be applied are, in this case, determined and evaluated in consultation with the certification body.

6.2 Material

Not more than 15 % of mass recycled material of the same pipe production may be added.

Table 17– PE and PP material requirements for the granulated material

Aspect	Requirement		Test parameter			Test method
Material composition	According IQC1)		According IQC1)			According IQC1)
Nominal density	PE	930 ± 20 kg/m^3	Test temperature Test pieces		23 °C 3	Method D ISO 1183
	PP	900 ± 20 kg/m^3				
Carbon black content	PE	2 – 2,5% mass	According ISO 6964: 1986			ISO 6964
Oxidative induction time3) (OIT)	20 minutes		Test temperature Test pieces		200 °C 3	EN 728
Melt flow index (MFI)	PE	± 20%2)	Weight Test temperature Test pieces	PE	5 kg 190°C 3	ISO 1133 Method T
	PP	± 30%2)	Weight Test temperature Test pieces	PP	2,16 kg 230°C 3	ISO 1133 Method 12

1) IQC: is laid down as part of the certification agreement and after approval of the certification body
2) % of the value stated by the supplier of the raw material
3) is applicable in case the outer casing can be welded

6.3 Mechanical requirements of the PE or PP outer casing

Unless otherwise stated, a test temperature of (20±5) °C applies.

Table 18 – mechanical requirements for the PE or PP outer casing

Aspect	Requirement	Test parameter		Test method	
Appearance	Sound, no holes or blisters	According IQC [1]		Visual inspection	
Dimensions	According IQC [1]	According IQC [1]		ISO 3126	
Mass per length	According IQC [1]	Weight/m ± 1,0g		Weighing	
Longitudinal expansion	≤ 3%	wall thickness ≤ 8 mm wall thickness ≥ 8mm	30 min 60 min	PE Method B EN743 110 °C	PP Method B EN743 110 °C
Oven test	No cracks bumps or delamination	wall thickness ≤ 8 mm wall thickness ≥ 8mm	30 min 60 min	ISO 12091 110 °C	
UV-resistance [3]	< 30% relative deformation [4]	Light energy Type test piece Tensile velocity	≥3,5 GJ/m^2 Type 2 100 mm/min	EN 1056 ISO 6259-1 EN ISO 6259-3	
Creep ratio [2]	≤5	Test pieces	3	NEN-EN-ISO 9967	
Ring stiffness [2]	≥4 KN/m^2	Compression velocity Test pieces	(2±0,4) mm/min 3	EN-ISO 9969	
Ring flexibility [2]	≥80% relative reduction di,m	Conditioning Test pieces	EN-ISO 9969 3	EN1446	
Resistance to impact [5]	H50 ≥ 1000mm No cracks below H = 500 mm	Test temperature Falling weight Falling weight d ≤ 110 mm 110 <d <125 mm 125 < d < 160 mm	0 °C d 90 4,0 kg 5,0 kg 6,25 kg	EN 1411	

1) IQC: is laid down as part of the certification agreement, after approval of the testing body
2) Only applicable in case the insulation material does not contribute to the stiffness of the piping package
3) Only applicable in case the carbon black content ≤ 2% mass weight and/or for pipes different from black coloured
4) Comparison of the elongation at break before and after UV exposition
5) Only applicable for outer casings provided with an after extrusion applied profile

7 Test methods

7.1 Multi layer pipe: Determination of dimensions

The thickness of the outer-layer, the thickness of the aluminium sheet and of seams as well as the geometry of the barrier layer (distance of diffusion) are determined from a pipe ring, including the coating, of approximately 0,30 m that is cut or sawed longitudinally. The dimensions are determined according ISO 3126.

7.2 Sealing in longitudinal direction

7.2.1 General

The following aspects are mandated for the testing according to 7.2.2 and 7.2.3:

- Testing in accordance with ISO 1176
- Number of test pieces: 3
- Minimum diameter of piping package: 110 mm
- Length of specimens between the clamps construction: 3 x d_n
- Outside water temperature: 20°C
- Mark fluid in the water: a mark fluid is added to the water to locate the penetration of water in longitudinal direction.
- Water above the test piece: 0,5 m

Remark 1: for test fluids the penetration is visual detectable. Mostly an additive like (fluorescence natrium in ethanol) is used or ethylene bleu) is added as tracer to the fluid.

Remark 2: The test piece including the test fluid can be separated from the water in a normal water bath by using a not penetrable plastic bag

7.2.2 Determination of the axial transport time of the leakage water

Testing shall be executed as follows:

- The test piece shall be immersed in the water without stresses;
- Testing time: 1000 hours.
- After the testing period the test piece shall drain for 24 hours at (23 ± 2) °C;
- The test piece is cut open in axial direction;
- By visual inspection the penetration of the signal fluid between the outer casing and the insulation shall be measured.

7.2.3 Determination of water leakage through the casing joints

Testing shall be executed as follows:

- On one side a straight coupling shall be mounted to the piping package. On the other side a T-piece shall be mounted. This shall be done according the installation instructions of the manufacturer;
- The test piece shall be immersed in the water without stresses;
- Testing time: 1000 hours.
- After the testing period the test piece shall drain for 24 hours at (23 ± 2) °C;
- If possible the joints shall be removed on both sides;
- The test piece is cut open in axial direction;
- By visual inspection the penetration of the signal fluid shall be measured.

7.3 Test methods for the multilayer pipe

7.3.1 Determination of long-term strength

Per construction type of the pipe p_{PD} shall be determined as follows:

- Use test temperatures of 60 °C and 95 °C according to the test method of ISO DIS 17456 point 6.1, 6.2 and 6.3;
- By using the SEM software of ISO 9080 (4-parameter model) the values (C_1, C_2, C_3 and C_4) shall be calculated for a LPL of 97,5%
- Use the calculated lines to determine the 97,5% reference lines;
- The reference values of A,B,C and D can now be used to calculate p_{PD} as follows:
  - Use the relevant design coefficient according to table 19;
  - Use Miners Rule (ISO 13760) in formula (1) to calculate p_{PD} for Class 2 or Class DH1 (see table 1):

$$\log(t) = A + \frac{B}{T} + C \times \log(p \times C_x) + D \times \frac{\log(p \times C_x)}{T} \quad (1)$$

where:

- p = P_{PD} : the predicted design pressure (bar)
- t = time (hour)
- T = temperature(Kelvin)
- A, B, C and D = parameters for the 4-parameter model for the reference lines
- C_x = a design coefficient according to table 19.

Tabel 19 – design coefficient per temperature class

Design coefficient	PE-X	PB	PE-RT
T_D	1,5	1,5	1,5
T_{max}	1,3	1,3	1,3
T_{mat}	1,0	1,0	1,0

7.3.2 Determination pressure test control values

Use ISO DIS 17456 to determine the LPL lines for all diameters. By using formula (2) the 95°C, 97,5% lines for all diameters can be calculated.

$$P_{PD} = P_C \left(1 - \frac{1{,}96\sqrt{S_R}}{P_C} \right) \quad (2)$$

where

P_{PD} = predicted design pressure

P_C = calculated pressure (from the LPL line for 22 h, 165 h or 1000 h)

S_R = residual variance

The values of P1, P2 en P3 can now be determined per diameter**.**

7.4 Determination of material strength of the aluminium

Determination of the in 3.5.5 mentioned aspects takes place in accordance with NEN EN 10002, Part 1, annex A, type 1. Hereby applies: L_0 = the original length of the test piece in mm; the tensile speed is 10 mm/min till the 0,2% strain limit and maximum 20 mm/min above that.

7.5 Influence of corrosion, test method

Test of the electrical transitional resistance.

7.5.1 Test pieces

The test is carried out with a test piece according to figure 1. Installation of the test piece must take place in accordance with the installation instructions of the manufacturer. Length of the pipe from the fitting: 100 mm.

7.5.2 Test arrangement

The test arrangement consists of a sodium-chloride solution with a concentration of 0,1 mol/l. A metal (anti)electrode (copper for example) is connected to the aluminium layer and the fitting is connected to the negative pole. Further, use must be made of an adjustable direct current source till 50 V, an ampere meter with a sensitivity of at least 10 nA (10 x 108 ampere) and a voltage meter. See figure 2.

Now the dielectric current can be measured.

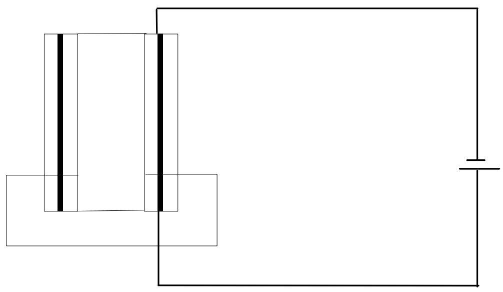


Figure 2. Test set-up: measurement of electrical transitional resistance

7.5.3 Influence of water, test method

Samples, filled with water with a pH > 10 (for example 50 gram NaOH per litre water), are during 1000h and with a pressure of 10 bar, placed in a water bath with a temperature of 95ºC.

7.6 Determination of the characteristics of the adhesive layer

7.6.1 Determination of good suture of the pipes

Cut, with the help of a razor blade or another sharp object, the protection layer and pull off the outer-layer with a tensile speed of 10 mm/min. The vector of the tensile force to be applied goes through the hart of the test piece (pipe), square to the axial axis of the pipe.

7.6.2 Determination of good suture of the multi-layer pipes

After testing according table 3, cyclic temperature test, the pipe must be cut open with the help of a razor blade or knife, in such a way that a spiral is obtained. Then the piece of pipe is pulled open with manual power, in such a way that visual inspection of the different layers is possible.

8 Requirements to be met by the quality system

8.1 General

This chapter contains the requirements that have to be met by the suppliers quality system and the methods used by Kiwa to evaluate this quality system.

8.2 Internal quality control

As part of the quality system the manufacturer must have an internal quality control schedule (IQC schedule) at his disposal.

This IQC schedule shall contain:

- the inspected aspects
- the used inspection methods
- the inspection frequency
- the way in which the inspection results are recorded and stored

This IQC schedule shall be in the format as shown in the appendix.

8.3 Procedures and working instructions

The manufacturer should also be able to present:
- a procedure for:
    a. the handling of products or semi-finished products rejected or to be repaired
    b. the handling of complaints regarding the products and/or services supplied
- the handled work instructions and inspection sheets

8.4 External inspection

The manufacturers quality system shall be assessed by Kiwa with regard to at least the aspects mentioned in the Kiwa-Regulations for Product Certification.
The Board of Experts will determine the inspection frequency. At the time of validation of this evaluation guideline this frequency has been fixed at 4 inspection visits per year.

9 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 with regard to toxicological requirements and product requirements;
- Inspection of the quality system.

The frequency with which the certification body (CB) will carry out inspection tests is also stated in the summary. See table 20.

9.1 Test matrix

Table 20

Description of requirement	**Article BRL**	**Tests within the scope of**		
		Pre-certification tests	**Supervision by CB after granting of the certificate[1)]**	
			Inspection visit[2)]	**Frequency (per year)**
Performance requirements				
Toxicological aspects	2.2	X	X	1 x year
Organoleptic aspects	2.3	X	X	1 x year
Standardised heat emission	2.6	X	X	1 x year
Strength of the joints	2.7.3	X	X[3)]	1 x 2 year
Leak tightness of the joints	2.7.3	X	X	1 x 2 year
Long-term compression	2.8.1	X	X	1 x 2 year
Flexibility	2.8.1	X	X	1 x 2 year
Dimensional stability	2.8.2	X	X	1 x 2 year
Sealing in longitudinal direction	2.8.3	X	X[3)]	1 x year
Sealing construction to mains supply and service pipe	2.8.4	X	X[3)]	1 x year
Product requirements				
Lifetime of medium-pipe material	3.2	X	X[3)]	1 x year
Mechanical aspects of medium-pipe	3.3, 3.4, 3.5, 3.6	X	X	1 x year
Lifetime of plastics fitting material	4.1.1	X	X[3)]	1 x year
Mechanical aspects of plastics fitting	4.1.1	X	X	1 x year
Metal fitting	4.2	X	X[3)]	1 x year
Mechanical aspects of insulation material	5.1	X	X	1 x 2 year
Material of outer casing	6.1, 6.2	X	X	1 x year
Mechanical aspects of outer casing	6.3	X	X	1 x year

1) When significant changes of the product or production process occur the performance requirements have to be determined once again.

2) All product properties which can be determined within the inspection time (maximum 1 day) are determined by the inspector or by the certificate holder in presence of an inspector. When this is not possible arrangements, how inspection will take place, will be made for this aspect between the CB and the certificate holder.

3) This aspect is compared on the basis of IKB inspection (indirectly by means of direct related parameters) with the aspect found for approval.

10 Requirements to be met by certification bodies

10.1 General

The certification body has to fulfil the requirements of EN 45011.
Furthermore, the certification body has to be accredited for the subject of this BRL by the Dutch Accreditation Council (RvA) or by an equivalent accreditation body (an accreditation body with whom RvA has concluded an agreement of mutual recognition).

The certification body must have the disposal of a regulation, or an equivalent document, in which the general rules for certification are laid down. In particular these are:

- The general rules for carrying out the pre-certification, to be distinguished in:
  - The way suppliers are informed about the handling of the application;
  - Execution of the pre-certification;
  - The decision with regard to the pre-certification executed.
- The general rules with regard to the execution of inspections and the inspection aspects to be employed:
  - The measures to be taken by the certification body in the event of non-conformities;
  - The rules for termination of the certificate;
  - The possibility of lodging appeal against decisions or measures made by the certification body.

10.2 Certification staff

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

- certification experts: they are in charge of carrying out the pre-certification tests and assessing the inspectors reports;
- inspectors: they are in charge of carrying out external inspections at the supplier's works;
- decision makers: they are in charge of taking decisions in connection with the pre-certification tests performed, continuing the certification in connection with the inspections performed and taking decisions on the need of corrective actions.

10.2.1 Qualification requirements

The Board of Experts has set the following qualification requirements for the subject matter of this Evaluation Guideline.

Certification staff	**Education**	**Experience**
Certification expert	Level of higher professional education *(HBO)* in one of the following disciplines: • Technology	2 years
Inspector	Level of intermediate professional education *(MBO)* in one of the following disciplines: • Technology	1 year
Decision-maker	Level of higher professional education *HBO)* in one of the following disciplines: • Technology	1 year management experience

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

10.2.2 *Qualification*

Certification staff must be demonstrably qualified by evaluation of education and experience of the above mentioned requirements. In case qualification takes place on the basis of other criteria, then this has to be recorded in writing.
- Decision-makers: qualification of the certification and inspectors;
- Management of the certification body: qualification of the decision-makers.

10.3 Report pre-certification tests

The certification body records the results of the pre-certification tests in a report. The report must fulfil the following requirements:
- Completeness: the report judges about all requirements of the Evaluation Guideline;
- Traceability: the findings whereupon the judgements are based must be recorded in a traceable way;
- Basis for decision: the decision-maker with regard to granting of the certificate, must be able to base his decision upon the findings recorded in the report.

10.4 Decision with regard to granting of the certificate

The decision with regard to granting of the certificate must be made by a qualified decision-maker, which was not involved at the pre-certification tests. The decision must be traceable recorded.

10.5 Quality declaration

The technical approval-with-product certificate has to be in accordance with the model included in the annex.

10.6 Nature and frequency of external inspections

The certification body must enforce inspections at the supplier to investigate whether the obligations are met. The Board of Experts advises about the number of inspection visits. At the time of validation of this Evaluation Guideline this frequency has been fixed at four inspection visits per year.

Inspections shall invariably include:
- The product specifications laid down in the quality declaration;
- The production process of the supplier;
- The IQC-schedule of the supplier and the results of tests recorded by the supplier;
- The correct marking of the certified products;
- The compliance with the required procedures.

The findings of the performed inspection visits shall be traceably recorded by the certification body in a report.

10.7 Report to Board of Experts

The certification body reports at least once a year about the certification activities performed. In this reporting, the following subjects must be addressed:

- Mutations in number of certificates (new/cancelled);
- Number of inspections performed in relation to the fixed frequency;
- Results of the inspections;
- Measures imposed at non-conformities;
- Complaints received from third parties concerning certified products.

10.8 Interpretation of requirements

The Board of Experts may lay down the interpretation of this Evaluation Guideline in a separate interpretation document. The certification body is obliged to inform whether an interpretation document is available. If this is the case, then the interpretations as laid down in the interpretation document must be employed.

11 List of stated documents

11.1 Standards / normative documents

Number	Title
BRL K536/03 part G	Plastic piping systems PE/Al for the transport of cold and hot drinking water
BRL 2013: 1999	Rubber rings foor joints in drinking water and sewage systems.
NEN-EN 253: 1995	Specification for pre-insulated bonded pipe systems for underground hot water networks. Pipe assembly of steel service pipes, polyurethane thermal insulation and outer casing of high density polyethylene
NEN-EN 489: 1995	Pre-insulated bonded pipe systems for underground hot water networks. Joint assembly for steel service pipes, polyurethane thermal insulation and outer casing of polyethylene
NEN-EN 579:1994	Plastics piping systems. Cross-linked polyethylene (PE-X) pipes. Determination of degree of cross-linking by solvent extraction
NEN-EN 638: 1995	Plastics piping and ducting systems. Thermoplastics pipes. Determination of tensile properties
NEN-EN 681:1996	Elastomeric seals - Materials requirements for pipe joint seals used in water and drainage applications - Part 1:Vulcanized rubber
NEN-EN 712: 1995	Thermoplastics piping systems. End-load bearing mechanical joints between pressure pipes and fittings. Test method for resistance to pull-out under constant longitudinal force
NEN-EN 713: 1995	Plastics piping systems. Mechanical joints between fittings and Polyolefin pressure pipes. Test method for leaktightness under internal pressure of assemblies subjected to bending
NEN-EN 728: 1997	Plastics piping and ducting systems – Polyolefin pipes and fittings – Determination of oxidation induction time.
NEN-EN 743: 1995	Plastics piping and ducting systems. Thermoplastics pipes. Determination of the longitudinal reversion
NEN-EN 1056: 1996	Plastics piping and ducting systems. Plastics pipes and fittings. Method for exposure to direct (natural) weathering
NEN-EN 1254-3: 1998	Copper and copper alloys. Plumbing fittings. Fittings with compression ends for use with plastics pipes
NEN-EN 12293: 2000	Plastics piping systems. Thermoplastics pipes and fittings for hot and cold water. Test method for the resistance of mounted assemblies to temperature cycling
NEN-EN 12294: 2000	Plastic piping systems. Systems for hot and cold water. Test method for leaktightness under vacuum
NEN-EN 1411: 1996	Kunststofleiding- en mantelbuissystemen; Buizen van thermoplasten; Bepaling van de weerstand tegen uitwendige slagbelasting met de trapjesmethode
NEN-EN 1420-1: 1999	Invloed van organische materialen op water bestemd voor menselijke consumptie; Bepaling van de reuk en smaak van water in leidingsystemen; Deel 1: Beproevingsmethode
NEN-EN 1446: 1996	Plastics piping and ducting systems. Thermoplastics pipes. Determination of ring flexibility
NEN-EN 10002: 2001	Tensile testing of metallic materials. Method of test at ambient temperature

NEN-EN 13052-1: 2001	Invloed van materialen op water bestemd voor menselijke consumptie;Organische materialen;Bepaling van de kleur en troebelheid van water in pijpleidingsystemen;Deel 1: Beproevingsmethode
NEN-EN 45004: 1995	General criteria for the operation of various types of bodies performing inspection
NEN-EN 45012: 1998	General requirements for bodies operating assessment and certification/registration of quality systems
NEN-EN 45013: 1989	General criteria for certification bodies operating certification of personnel
NEN-EN 10002: 1991	Metallic materials – Tensile testing – Method of testing at ambient temperature
NEN-EN ISO 6509: 1995	Corrosion of metals and alloys. Determination of dezincification resistance of brass
NEN-EN-ISO 6708: 1995	Pipework components – Definition and selection of DN (normal size)
NEN-EN ISO 8497: 1997	Thermal insulation. Determination of steady-state thermal transmission properties of thermal insulation for circular pipes
NEN-EN ISO 9967: 1995	Thermoplastics pipes. Determination of creep ratio
NEN-EN-ISO 9969: 1995	Thermoplastics pipes. Determination of ring stiffness
NEN-EN-ISO/IEC 17025; 2000	General requirements for the competence of testing and calibration laboratories
EN ISO 15875	Plastics piping systems for hot and cold water installations — Crosslinked polyethylene (PE-X)
EN ISO 15876	Plastics piping systems for hot and cold water installations — Polybutylene (PB)
ISO 1043: 2002	Plastics. Symbols and abbreviated terms. Basic polymers and their special characteristics
ISO 1183: 1999	Plastics. Methods for determining the density of non-cellular plastics. Gas pykometer method
ISO 1133: 1997	Determination of the melt mass flow rate (MFR) and the melt volume (MVR) of thermoplastics
ISO 1167: 1996	Methods of testing plastics. Thermoplastic pipes, fittings and valves. Thermoplastics pipes, for the conveyance of fluids. Resistance to internal pressure. Test method
ISO 3126	EN ISO 3126. Plastics piping systems. Plastics piping components. Measurement and determination of dimensions
ISO 3146: 2000	Plastics. Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarising-microscope methods
ISO 4065: 1996	Thermoplastic pipes - Universal wall thickness table.
ISO 6957: 1988	Cupper alloys – ammonia test for stress corrosion resistance
ISO 6259-1: 2001od.	Thermoplastics pipes. Determination of tensile properties. General test met
ISO 6259-3: 1997	Thermoplastics pipes -- Determination of tensile properties -- Part 3: Polyolefin pipes
ISO 6957: 1988	Copper alloys -- Ammonia test for stress corrosion resistance
ISO 6964: 1986	Polyolefin pipes and fittings -- Determination of carbon black content by calcination and pyrolysis -- Test method and basic specification
ISO 10508	Thermoplastics pipes and fittings for hot and cold water systems
ISO 12091	Structured-wall thermoplastics pipes -- Oven test
ISO 13760: 2000	Plastics pipes for the conveyance of fluids under pressure. Miner's rule. Calculation method for cumulative damage
ISO 62591:1997	Thermoplastics pipes - Determination of tensile properties - Part 1: General test method

ISO 62593:1997	Thermoplastics pipes - Determination of tensile properties - Part 3: Polyolefin pipes
ISO 9080: 2002	Plastics piping and ducting systems - Determination of long term hydrostatic strength of thermoplastics materials in pipe form by standard Extrapolation method.
ISO DIS 17455: 2003	Plastics piping systems — Multilayer pipes — Determination of the oxygen permeability of the barrier pipe.
ISO DIS 17456: 2003	Plastics piping systems — Multilayer pipes — Determination of the long term hydrostatic strength.
ISO DIS 18124: 2003	Plastics piping systems — Multilayer M pipes — Test method for the adhesion of the different layers by the use of a cone
DIN 4726: 2000	Rohrleitungen für WarmwasserFussbodenheizungen; Algemeine Anforderungen.

12 Annex 1: Technical approval with product certificate

Certificate

kiwa
Partner for progress

Number	12345	Replaces	Appendix 1
Issued		Dated	

Technical approval-with-product certificate

System name

Based on pre-certification tests as well as periodic inspections by Kiwa, the products referred to in this technical approval-with-product certificate and marked with the Kiwa-mark as indicated under "Marking", manufactured by

Company

may, on delivery, be relied upon to comply with the Kiwa evaluation guideline BRL-K17401 part A "District heating: Flexible piping systems with plastics medium pipe for transport of warm drinking water".

Kiwa N.V.

ing. B. Meekma
Director
Certification and Inspection

This certificate is issued in accordance with the Kiwa-regulations for Product Certification and consists of X pages.
Publication of this certificate is permitted.

Company

Kiwa N.V.
Certification and Inspection
Sir W. Churchill-laan 273
Postbus 70
2280 AB Rijswijk
Telephone +31 (0)70 41 44 400
Telefax +31 (0)70 41 44 420
Internet www.kiwa.nl

PRODUCT SPECIFICATION

General

Flexible piping systems with plastics medium pipe for transport of warm drinking water according to BRL-K17401 part A.
The piping system consists of the following parts:

- a piping package existing of:
  - XX medium pipes;
  - XX insulation layer around the medium pipe;
  - XX outer casing around the insulation layer.
- plastic and mechanical fittings;
- products to connect the piping package to the supply pipe.

Specification

The diameters and thicknesses given in the table below are part of this technical approval with product certificate.

Nominal outside diameter x wall thicknes in mm of medium pipe		**Nominal outside diameter of outer casing in mm**
16 x 2,2	50 x 4,6	90 125

The piping package can be equipped with one (single-pipe) or with two (twin-pipe) medium pipes. The joints for the medium pipes (electro fusion, socket welding, clamp fitting) are made with special tools.

The producer declaresthe heat loss per meter, calculated according to annex 6 of BRL5609 part A, for every system configuration (combination medium pipe/casing).

Toxicological aspects

The pipes and fittings used in this system are approved on the basis of the requirements set in the "Regeling materialen en chemicaliën leidingwatervoorziening" (“Regulation Materials and Chemicals for Drinking Water Supplies”; published in the Staatscourant). The ATA-criteria are recorded in the respective product certificates.

Logistics

Production and assembling of the system is recorded in the appendix(es) with the certification agreement.

APPLICATION AND USE

The products are destined for transport of warm drinking water. All joints must be leak tight and possess sufficient clamp force to resist external influence. For all parts of the system applies that they are designed for a lifetime of 30 years at a working pressure of 8 or10 bar absolute and a temperature profile class DH1 according to BRL-K17401 part A.

MARKING

The products are marked with the Kiwa mark.

The medium pipes are provided with the following marks:
- word mark Kiwa or logo;
- manufacturer´s name, trade name or logo;
- material: PB, PE-X, PE/Al;
- nominal outside diameter and nominal wall thickness in mm;
- production code;
- System name or logo.

The realization of the marks is as follows: clear and indelible, at intervals of not more than 2 m.

The fittings are provided with the following marks:
- word mark Kiwa or logo;
- manufacturer's name, trade name or logo;
- nominal outside diameter in mm of the accompanying pipe;
- production code;
- system name*.

The realization of the marks is as follows: clear and indelible on each fitting*.

* If desired the system name may be printed on the packaging. In case the system name has been fully printed on the fittings the trade name may be printed in code or logo.

The outer casing is provided with the following marks:
- word mark Kiwa or logo;
- manufacturer's name, trade name or system name.
- material indication medium pipe: PB, PE-X;
- class DH1;
- design pressure: 8 or 10 bar;
- number of medium pipes with nominal outside diameter and wall thickness in mm;
- production code.

The realization of the marks is as follows: clear and durable, at intervals of not more than 2 m.

Method of marking: indelible imprint.

RECOMMENDATIONS FOR CUSTOMERS:

1. Check at the time of delivery whether:
   - 1.1 the producer has delivery in accordance with the agreement;
   - 1.2 the mark and the marking method are correct;
   - 1.3 the products show no visible defects as a result of transport etc.

2. If you should reject a product on the basis of the above, please contact:
   - 2.1 **<Company name>** and, if necessary,
   - 2.2 Kiwa N.V.

3. Consult the producer's processing guidelines for the proper storage and transport methods.

4. Check whether this certificate is still valid by consulting "gecertificeerde bedrijven" on www.kiwa.nl.

13 Annex 2: Model IQC scheme

Inspection subjects	Inspection aspects	Inspection method	Inspection frequency	Inspection registration
Raw materials or materials supplied: -recipe sheets -incoming goods inspection raw materials	 - Recipe according annex product agreement - meltflow-index - moisture content thermal stability (PE)	 Comparison supplied certificate with agreement - ISO 1133 - ISO 760 - ISO TR 10837	 Each delivery Each delivery	 Entry control document
Production process, production equipment, plant: - procedures - working instructions - equipment - release of product	 - tuning parameters - maintenance aspects - dimensions - soundness	 - adjustments machine -maintenance scheme - measuring - visual evaluation	 - continuously - continuously - start up new product	 - "digital" - work sheet - inspection document
Finished-products	- soundness - dimensions - resistance internal pressure	- visually - measuring - ISO 1167	- continuously - each 3 hours - per day per product per machine	End control documents
Measuring and testing equipment - measuring equipment - calibration	 - proper functioning - accuracy within the range of measurement	 - during usage - records of non-conformities	 - continuously - 1 x year	 - end control document - calibration document
Logistics - internal transport - storage - Preservation - packaging - identification	 - circumstances in practise - comparison with order	 -comparison with procedure -visual inspection	 - continuously	 - keep logistical procedures up to date

14 Annex 3: Calculation of R_{decl}

14.1 General

The manufacturer is responsible for the determination of the declared value of the heat loss per meter R_{decl}. His products shall comply to R_{decl}.

The R_{decl} are the expected values of this heat technical property during a defined service lifetime and have been determined on the basis of measured values under reference conditions.

For flexible piping systems with concentric installed thermal insulation material or with a known form factor the declared values of the heat delivery per meter can be determined by calculation with the declared values of the heat conductivity coefficient of the construction part. This calculation is according to EN ISO 12241 and supplemental documents, which are currently in preparation in CEN/TC89/WG3.

14.2 Initial testing

The producer shall submit testing results of the determination of the heat delivery per meter for at least the biggest and the smallest diameter of his system. He also must have the value λ_l coming from the thermal insulation material sampled from the same production.

The declared values of the heat delivery per meter shall be determined according to 13.3.1 and 13.3.2.

14.3 Declared values

14.3.1 Declared values based on measured values according EN ISO 8497

The value λ_l, from the same production as the measured pipg system can be used to calculate λ_{refM} (14.1):

$$\lambda_{refM} = \lambda_1 \cdot F_{\Delta\vartheta} \cdot F_m \cdot F_c \cdot F_d \cdot F_a \text{ in W/(m.K)} \qquad \text{(F14.1)}$$

If no value of λ_l available the start data set of $\overline{\lambda}$ of the thermal insulation material λ_D can be used (14.2):

$$\overline{\lambda} = \lambda_D - k \cdot s \text{ in W/(m.K)} \qquad \text{(F14.2)}$$

Now λ_{refM} can be calculated (14.3):

$$\lambda_{refM} = \overline{\lambda} \cdot \frac{F_{\Delta\vartheta} \cdot F_m \cdot F_c}{F_a \cdot F_d} \qquad \text{(F14.3)}$$

met

λ1	thermal conductivity of the thermal insulation material from the piping system of from the same production in W/(m.K)
$\overline{\lambda}$	mean value of the data set in W/(m.K)

λ_D declared value of the thermal conductivity coefficient in W/(m.K)
k k-value for a one sided 90% tolerance and 90% reliability.
S standard deviation
λ_{refM} thermal conductivity of the thermal insulation material

Coefficients in preparation by CEN TC 89 WG3:
$F_{\Delta\varphi}$ influence of the temperature difference
$F_{\Delta\varphi}$ is approximately 1,0 - 1,5
F_m for the influence of vapour

Remark: when the measured value (Rdecl) is equal to the real circumstances the values of Fm and Fa are 1,0.

F_c for the influence of the compression of the material
F_c is approximately 0,95 to 1,05
F_d for the heat radiation effect (F14.4)
F_c is approximately 1,0 to 1,1
F_a for the influence of ageing

With R_i the total influence of all coefficients can be calculated during the measurement of λ_{refM} by using a correction factor $f_{c,i}$:

$$f_{c,i} = \lambda_{refM} \frac{R_i - \frac{1}{20\,\lambda_p} In \frac{d_2}{d_1} - \frac{1}{2\pi\lambda n} In \frac{d_{4,i}}{d_{3,i}}}{\frac{1}{2_\pi} In \frac{d_{3,i}}{d_{2,i}}} \quad \text{(F14.5)}$$

where:
R_i the measured value of the heat loss per meter for a specific diameter in (m.K/W)
$\lambda_{refM,i}$ thermal conductivity of the thermal insulation material
λ_p thermal conductivity of the medium pipe
λ_M thermal conductivity of the protection pipe
D diameter of a particular part of the piping package

By calculating the mean value:

$$f_c = \frac{1}{n}\sum_{j=1}^{n} f_{c,i} \quad \text{(F14.6)}$$

where:
n number of measured piping packages with different diameters or by a significant influence of the diameter per diameter:

$$F_c = f_c \quad \text{(F14.7)}$$

the specific design factors are defined of the piping package for the influence of:
- heat cracks (fundaments)
- open tile joints etc
- installation aspects.

R_{decl} follows from:

$$R_{decl} = \frac{1}{\dfrac{2\pi}{\dfrac{1}{\lambda_p} In \dfrac{d_2}{d_1} + \dfrac{f_c}{\lambda_{refD}} In \dfrac{d_3}{d_2} + \dfrac{1}{\lambda_M} In \dfrac{d_4}{d_3}}}$$ in m.K/W (F14.8)

where:

λ_{refd} thermal conductivity of the thermal insulation material during the measurement:

$$\lambda_{refd} = \lambda_d \frac{F_{\Delta\vartheta} F_m F_c}{F_a F_d}$$ in W/(m.K) (F14.9)

With the formulas F14.8 and F14.9 R_{decl} can be calculated for all diameters.

14.3.2 Declared values based on measurements according to EN ISO 12241

With the same aspects as under 14.3.1 formula F14.8 and F14.9 can be used Also f_c shall be calculated according to F14.

$$f_c = \frac{1}{F_{couv} F_j + \dfrac{\Delta\lambda}{\lambda_{refM}}}$$ (F14.10)

where:

$\Delta\lambda$ - heat cracks (fundaments) in W/(m.K)

F_j- open tile joints, etc

F_{couv} convection

15 Annex 4: : Measuring of R_{decl}

15.1 General

This annex describes the procedure for measuring R_{decl} according to EN ISO 8497. Measuring is in accordance with EN 1946-15.

15.2 Test pieces

Perpendicular cut pipe packages have to be used. Test pieces without cell gas have to be conditioned 1 week. Test pieces with cell gas have to be conditioned 6 weeks. Only straight cut test pieces shall be used.

15.3 Test equipment

Allowed are apparatuses with protected heating or with calibrated or calculated pipe parts. The diameters of the pipe must fit in the medium pipe. With possible sand filling in the air crack convection must be prevented during the measurement.

15.4 Calculating the measuring parameters

The measuring parameters will be designated as function of the average temperature.

15.5 R of the pipe package

The heat loss per meter shall be calculated as follows:

$$R = \frac{\upsilon_a - \upsilon_i}{\theta \frac{1}{L}}$$ in m.K/W (F15.1)

For piping packages with a plastics medium pipe the value of υ is the mean inside medium pipe temperature.
For piping packages with a metal medium pipe the value of υ is the mean inside temperature in the medium pipe according to formula F15.2:

$$\upsilon_i = \frac{\theta}{L} \frac{1}{2\pi\lambda_R} In \frac{d_2}{d_1} + \upsilon_1$$ in °C (15.2

The mean temperature of the pipe package is:

$$\upsilon_{'m} = \frac{\upsilon_i + \upsilon_a}{2}$$ in °C (F15.3)

15.6 Thermal conductivity of the thermal insulation material

De thermal conductivity of the thermal insulation material λ_{refM} is according to formula F15.4:

$$\lambda_{refM} = \frac{\frac{f_c In \frac{d_2}{d_3}}{2\pi}}{\frac{\theta / L}{\upsilon_3 - \upsilon_2} - \frac{1}{\lambda_m} In \frac{d_4}{d_3} - \frac{1}{\lambda_R} In \frac{d_1}{d_2}}$$ in W/mK (F15.4)

where:

$$\upsilon_3 = \upsilon_4 + \frac{\theta / L}{2\pi\lambda_M} In \frac{d_4}{d_3}$$ in °C (F15.5)

$$\upsilon_2 = \upsilon_1 + \frac{\theta / L}{2\pi\lambda_R} In \frac{d_2}{d_1}$$ in °C (F15.6)

$$\upsilon_m = \frac{\upsilon_3 + \upsilon_2}{2}$$ in °C (F15.7)

To determine f_c formula F14.10 shall be used.

15.7 Determination of λ_{WD}

To determine λ_{WD} formula F15.10 shall be used.

$$\lambda_{WD} = \frac{\theta / L}{(\upsilon_a - \upsilon_i)} \frac{In \frac{d_a}{d_i}}{2\pi}$$ in W/mK (F15.8

$$\upsilon_m = \frac{\upsilon_3 + \upsilon_2}{2}$$ in °C (F15.7)

16 Annex 5: Measuring R_I

$$R_I = \frac{\frac{1}{2\pi}}{\frac{1}{\lambda_p} In \frac{d_2}{d_1} + \frac{f_c}{\lambda_{design,d}} In \frac{d_3}{d_2} + \frac{1}{\lambda_M} In \frac{d_4}{d_3}}$$ in Mk/W (F16.1)

with:

$$\lambda_{design,d} = \lambda_d \frac{\lambda_{\Delta\upsilon} F_m F_c}{F_a F_d}$$ in W/mK (F16.2)

where:

$\lambda_{design,d}$	value of the thermal conductivity of the thermal insulation material
f_c	correction factor for the air holes , heat cracks and changes because of deformation of the piping package during installation
$F_{\Delta\delta}$	for the influence of the differences in temperature
$F_{\Delta\delta}$	is approximately 1,0 to 1,05
F_m	for the influence of vapour
F_c	for the influence of the compression of the thermal insulation material
F_d	for the radiation influence
F_d	is approximately 1,0 to 1,05
F_a	for the influence of ageing

17 Annex 6: Calculation of R_{eis}

17.1 General

With this annex the value of R_{eis} can be calculated.

17.2 Heat transport of a piping package with return pipes

See formula (17.1):

$$\left(q_F + q_r\right)L = 2\left(U_1 - U_2\right)\left(\frac{\upsilon_f + \upsilon_r}{2} - \upsilon_a\right)W \qquad \text{(F17.1)}$$

where:

q_f the heat loss per meter of the supply pipe
q_r the heat loss per meter of the return pipe
L the length of the pipe package
ν_f de heat loss per meter of the supply pipe
ν_r de heat loss per meter of the return pipe
ν_a de temperature of the environment (air) in °C

The heat loss per meter per medium pipe:

$$q_f = U_1\left(\upsilon_f - \upsilon_a\right) - U_2\left(\upsilon_r - \upsilon_a\right) \quad \text{in W/M} \qquad \text{(F17.2)}$$

$$q_r = U_1\left(\upsilon_r - \upsilon_a\right) - U_2\left(\upsilon_f - \upsilon_a\right) \quad \text{in W/M} \qquad \text{(F17.3)}$$

The heat loss per meter:

$$U_1 = \frac{R_s + R_I}{\left(R_s + R_I\right)^2 - R_u^2} \quad \text{in W/m.K} \qquad \text{(F17.4)}$$

$$U_2 = \frac{R_u}{\left(R_s + R_I\right)^2 - R_u^2} \quad \text{in W/m.K} \qquad \text{(F17.5)}$$

where:

R_s Heat loss per meter in the ground see F17.7
R_I measured value of the heat loss per meter.
R_u Heat loss per meter between the supply and return medium pipe, see F17.8

Per medium pipe:

$$U = U_1 = U_2 = \frac{1}{R_s + R_I + R_u}$$ in W/m.K (F17.6)

$$R_s = \frac{1}{2\pi\lambda_s} In \frac{4 Z_c}{d_a}$$ in m.K/W (F17.7)

where:

Z_c correction factor for the heat resistance from ground surface to the installation depth of the package

$$Z_c = Z + R_0 \lambda_s$$ in m

Z distance of the ground surface to the middle of the piping package

$$Z = \frac{d_a}{2} + H$$ in m

λ_s thermal conductivity of the soil = 1,5 W/m.K

R_0 thermal conductivity from the ground surface to the environment = 0,0685 m K/W

H Installation depth of the piping package = 0,6 m

R_U The value of R between supply and return pipe.

$$R_u = \frac{1}{2\pi\lambda_s} In \left(1 + \left(\frac{2 Z_c}{c}\right)^2\right)$$ in m.K/W (F17.8)

where

c = the distance of the centrelined medium pipes (supply and return pipe).

18 Annex 7: Thermal stability

18.1 Principle

Tensile test bars made of the material that has to be examined are exposed to different temperatures. After certain exposure times at the specified temperatures, the elongation at break is determined. This elongation at break as a percentage of the elongation at break of the non-exposed tensile bars is plotted versus the logarithmic exposure time for the different temperatures.
In a thermal endurance graph (Arrhenius graph) the logarithm of the time to reach the specified elongation at break percentage is plotted versus the reciprocal thermodynamic (absolute) test temperature.
From this graph an extrapolation is carried out to determine the temperature at an exposure time of 50 years.

Remark: This way to determine the thermal stability at 50 years is derived from EN-ISO 2578.

18.2 Apparatus

The oven shall be in accordance with EN-ISO 2578 clause 9, with temperature tolerances of ± 2°C.
The tensile test machine shall be in accordance with EN-ISO 527-1 clause 5.
The test speed shall be declared by the manufacturer and taken from the recommend test speed as described clause 5.1.2 of EN-ISO 527-1.

18.3 Sample Preparation

The manufacturer shall declare the production method of the test pieces (e.g. injection moulded or pressed).
The type of test pieces shall be in accordance with EN-ISO 527-2 clause 6 and shall be declared by the manufacturer.
The number of test pieces shall be 5 at least for each temperature to determine the elongation at break.
The number of exposure temperatures shall be at least 3.

18.4 Procedure

Manufacturing of the test pieces shall be in accordance with clause 3 of this annex.
For the determination of the elongation at break of the non-exposed test pieces, five test pieces shall be tensile tested on a tensile test machine in accordance with clause 2.2 of this annex. The test temperature shall be (23±2)°C. The mean elongation at break of the non-exposed test pieces is set to be 100%.
For the determination of the elongation at break of the exposed test pieces, tensile testing shall be in accordance with EN-ISO 6259-1. The proposed exposure temperatures are 150- 140- 130°C.
The minimum of 5 test pieces for each temperature are exposed for a certain exposure time, after this period the test pieces shall be removed from the oven and conditioned.
The elongation at break of the exposed test pieces is declared as a percentage of the elongation at break of the non-exposed test pieces. The covering results of the fractional elongation at break values shall be as follows:

- at least one value of the fractional elongation at break shall be between 50 and 75%;
- at least two values of the fractional elongation at break shall be between 25 and 50%;
- at least one value of the fractional elongation at break shall be lower than 25%.

The fractional elongation at break values shall be plotted versus the logarithm of their exposure times (see figure B1). A curve shall be constructed for each temperature. The point at which these curves intersect the horizontal line representing the specified percentage of the elongation at break is taken as the time to failure. This specified percentage shall be 25%.
The calculation of the thermal endurance curve (Arrhenius plot) is based on the failure times to reach the specified elongation at break percentage (see paragraph 5.4 of this annex) and the respective thermodynamic (absolute) exposure temperatures in Kelvin (see paragraph 5.3 of this annex). If mean values are used, the logarithmic mean represents the time to failure.
The logarithm of the calculated elongation at break is plotted versus the reciprocal absolute temperature (see figure B2). From this graph a first-order regression line can be calculated in accordance with Annex A of EN-ISO 2578.
By using the first-order regression line of the thermal endurance curve, the temperature of the 25%-elongation-at-break-value can be determined for an extrapolated exposure time of 50 years (T50y).

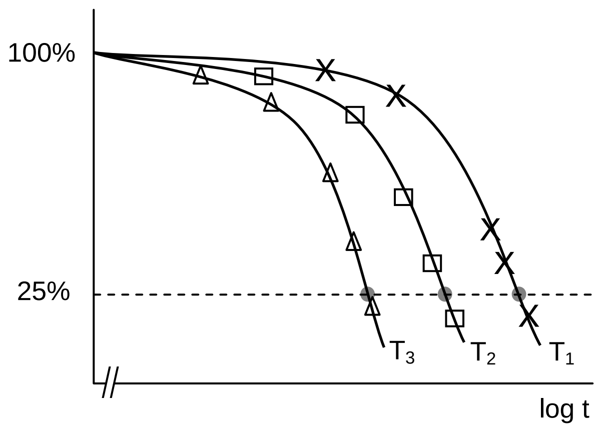


Figure 18.1, fractional elongation at break vs. time

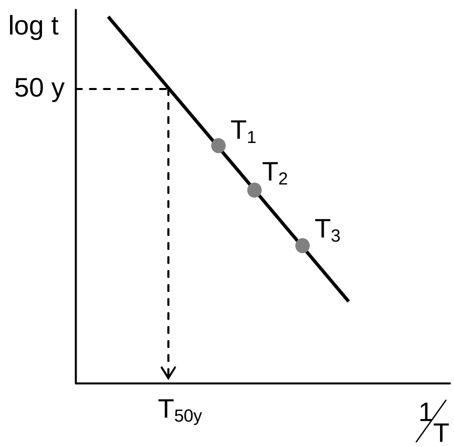
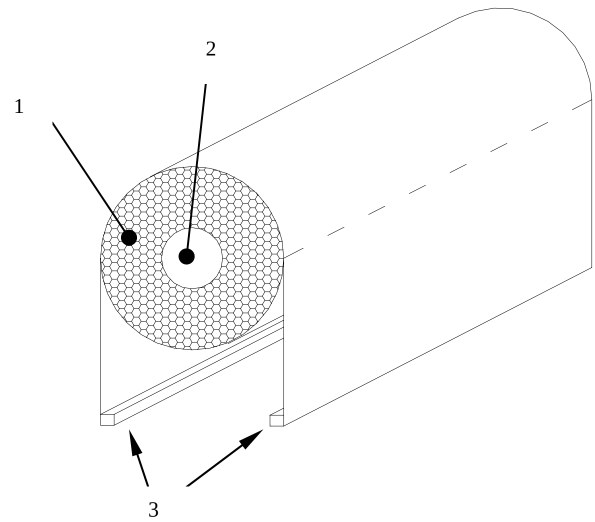


Figure 18.2, time vs. temperature

19 Annex 8: Dimension stability of the piping package

19.1 General

The measurement of the dimension stability is performed with the same method used for measuring the maximum service temperature for preformed pipe insulation according to NEN EN 14707. The test is is in accordance with NEN EN 14707 annex B, with the below mentioned adaptations.



1. insulation material
2. heated medium pipe
3. weights for loading

Figure 19.1 – test set up for determination of the thermal stability of the piping package

19.2 Procedure

- Determine the length l_0, inner diameter D_i and the thickness d_0 of the test specimen according to NEN-EN 13467.
- Place the insulation material over the inner pipe.
- Calculation of the static load (P_w) is carried out as follows:

$$P_w = \frac{(F_b + F_w)}{d_e} \text{ (N/m}^2\text{)}$$

in which:

P_w = static load;
F_b = mass per length of the plastic pipe (N/m)
F_{bw} = mass per length of the water in the pipe (N/m)
d_e = outside diameter of the plastic pipe (m).

- The test piece will be conditioned during 24 hours with a pre-load of 10% of the total static load at room temperature (23 ± 2°C). The height d_s of the test piece after conditioning will be the initial value of the determination.

- Next the test is executed according to table 25

Table 25 – Resistance of the insulation to static compression

Load (N/m)	Test temperature T (°C)	Testing time (h)
P_w	90	300
P_w	70	1000
Remark: materials with diffusion closed cells will be tested using a flushing gas (e.g. CO_2) with (5 ± 3) mbar effective pressure.		

- The dimensional stability is calculated as follows:

$$\varepsilon = \frac{d_{bel} - d_s}{d_s} \times 100 \text{ (\%)}$$

in which:

d_s = the height of the test piece after conditioning
d_{bel} = the height of the test piece after testing according to table 13.
ε = proportional decrease of the height of the test piece

- For all determinations (2x 3 test pieces = 6): $\varepsilon \leq 10$ %.