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Testing of PEX-pipe with protection pipe from LK-PEX

The revision concerns correcting the unit for the TOC-value in the hygienic tests.

Object

Pipe made from cross-linked polyethylene, PEX, with a protective pipe.

Date of delivery


2017-12-08

Supplier

Ahlsell Sverige AB, Article number/RSK: 1870788

Dimension and marking

The following pipes were bought by RISE from the open market and were delivered to RISE Pipe Centre in Gothenburg.

Dimension	Marking
Ø 16x2.2 mm	LK LK PEX Universal Pipe x16 (16x2,2) PE-Xa for heating and potable water 10 bar 95°C Oxygen barrier acc. To DIN 4726  1913 NPS-0675 17.11.19 08:39 L6 0887 m Made in Sweden
Grey protection pipe	LK LK Systems 456 m 17-11-29

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TEST PROCEDURES

The following mechanical and hygienic testing has been performed.

Mechanical testing

All of the mechanical tests except the exchangeability has been performed by RISE Pipe Centre in Gothenburg. The exchangeability test has been performed by RISE in Borås.

Characteristics	Method standard	Accreditation EN ISO 17025
Geometrical characteristics and ovality	EN ISO 3126	Yes
Hydrostatic pressure test	ISO 1167	Yes
Elongation at break	ISO 6259-1, ISO 6259-3	Yes
Longitudinal reversion	EN ISO 2505	Yes
Cross-linking level	EN 579	Yes
Flexibility*	Measuring of force required to bend the pipe	No
Necking at tensile*	Measuring of necking force CSTB 3597, version 2007	No
Burst testing*	ASTM D1599	No
Exchangeability	Nordtest NT VVS 129 (6.4.13 and 6.4.14)	Yes

* Detailed test description below.

Hygienic testing

RISE has anonymized the pipes and sent samples to *Hygiene-Institut des Ruhrgebiets* in Germany for accredited Hygien tests according to the table below and the KTW Guideline, issue date 2016-03-07.

Evaluated property	Standards and guidelines	Comment
Colour	SOP 14.5, 2008-11	Tests were performed at both 23 and 60 °C for 31 days.
Turbidity	SOP 14.5, 2008-11	
Tendency to foam formation	SOP 14.5, 2008-11	
Threshold odour number (TON)	DIN EN 1622, 2006-10	
Threshold flavour number (TFC)	DIN EN 1622, 2006-10	
Total organic carbon (TOC)	DIN EN 1484, 1997-08	
2,5-Dimethyl-3-hexyne-2,5-diol CAS 142-30-3	Hygien institute In-house method (GC-MS)*	

*These results are not accredited.

Flexibility

The main steps in the procedure were as following and the purpose was to evaluate the force needed to bend the pipe during pipe installation:

1. Cutting out a sample of pipe having a length of 1570 ± 3 mm.
2. Condition at ambient temperature 23 ± 2 °C.
3. Bending the pipe into a ring along the pre-curvedness.
4. Insertion of the pipe ring into a tensile tester.
5. Pre-testing, compress the pipe ring to force 5 N at speed 50 mm/minute.
6. Reset load and position measurement.
7. Testing, compress the pipe 100 mm at 200 mm/minute and record the final force.



Figure 1 Generic picture of flexibility testing.

Necking at tensile

The test pieces for this tests are whole pipes approximately 10-12 cm long.

The testing speed is chosen according to test procedure according to CSTB 3597 Version 2007 clause 8. The main steps in the test procedure are as following:

1. Mount one test piece in a tensile testing machine.
2. Measure the force while the pipe is elongated, 100 mm/min.
3. Record the force at necking of the pipe, i.e the yield point of the material.

Burst testing

The burst testing are performed at 81 ± 1 °C in a water bath. The pressure was ramped during 60 seconds according to the table below. The aim was to find in which test case the pipe failed and record the pressure at failure. What constitutes a failure are described in ASTM D1599-99 clause 5. Five samples were used for each test case.

Test case	Nominal outside diameter mm	Nominal minimum wall thickness mm	Hoop stress at 60 seconds	Pressure at 60 seconds	Rate of loading
			MPa	bar	bar/s
1	16	2.2	5.25	16.74	0.28
2	16	2.2	7.88	25.11	0.42
3	16	2.2	10.5	33.48	0.56

TEST RESULTS

Measurement uncertainty

Reported uncertainty corresponds to an approximate 95 % confidence interval around the measured value. The interval has been calculated in accordance with EA-4/16 (EA guidelines on the expression of uncertainty in quantitative testing), which is normally accomplished by quadratic addition of the actual standard uncertainties and multiplication of the resulting combined standard uncertainty by the coverage factor $k=2$. The results apply only to the tested objects.

Geometrical characteristics

The oxygen diffusion barrier thickness was measured by microscope to 0.09 mm and the values in the table below includes the barrier.

Test no	Mean outside diameter mm	Out of roundness mm	Wall thickness	
			min. mm	max. mm
Ø 16x2.2 mm				
1	16.1	0.7	2.10	2.25
2	16.1	0.7	2.10	2.25
3	16.1	0.7	2.10	2.25

Test method:

EN ISO 3126:2005

The measurements were performed at 23 ± 2 °C with equipment with the following accuracy

Wall thickness:

0.01 mm

Diameter:

0.1 mm

Length:

0.1 mm

Date of test:

2018-02-01

Resistance to internal pressure

The results from hydrostatic pressure testing are associated with a big uncertainty of the method. The actual temperature, pressure and wall thickness have a very significant effect on the rupture time. The uncertainty originating from the geometrical measurement is especially big for pipes with a small wall thickness. To decrease the statistical uncertainty of the time to rupture at the specified hoop stress, a wider testing with several more samples needs to be performed.

Test no	Hoop stress MPa	Test temp. °C	Test pressure MPa	Time to rupture h	Requirement h
Ø 16x2.2 mm					
1	4.7	95	1.360	337	>22
2	4.7	95	1.360	204	>22
3	4.7	95	1.360	168	>22

The ruptures were ductile. The tested pipes have fulfilled the requirement regarding time to rupture in EN ISO 15875-2:2003.

Pressure test method: EN ISO 1167-1:2006, End caps of type A

Dimension measurement method: EN ISO 3126:2005

The test conditions parameters were:

Free length between the end caps: 400 mm

Conditioning time: 1 h

Internal/External medium: Water/water

Time to achieve the pressure: <5 minutes

Test temperature: ± 0.3 °C

Test pressure: ± 0.7 %

Date of test: 2018-02-02 –02-17

Elongation at break

Test no	Test piece	Testing speed mm/minute	Stress at yield MPa	Results %
Ø 16x2.2 mm				
1	Cutted Type 2	100	19.9	414
2		100	19.5	421
3		100	19.7	412
4		100	20.0	406
Average			<u>19.8</u>	<u>413</u>

Test method: ISO 6259-1:2015
 Test piece chosen according to: ISO 6259-3:1997 and ISO 6259-3:2015
 Test temperature: 23 ± 2 °C
 The calculated uncertainty at determination of elongation at break is <10 %-units
 Date of test 2018-01-25

Longitudinal reversion

The tests were performed in air and in two points, due to the curvature of the pipe.

Test no	Testing time minutes	Length variation			Longitudinal reversion %
		before mm	after mm	difference mm	
Ø 16x2.2 mm					
1	60	99.6	97.7	-1.9	1.9
2	60	99.1	97.4	-1.7	1.7
3	60	98.9	97.3	-1.6	1.6
Average					<u>1.7</u>

No bubbles or cracks were observed after the test.

Test method: EN ISO 2505:2005
 Test temperature: 120 ± 1 °C
 The calculated uncertainty for longitudinal reversion is <0.2 %-units.
 Date of test: 2018-02-02

Degree of crosslinking

Dimension	Sample no	Measured crosslinking %
Ø 16x2.2 mm	1	79
	2	80
	Average	<u>79</u>

Test method: EN 579:1993
 Weighting uncertainty: 0.1 mg
 Date of test: 2018-01-25

Flexibility

Test no	Test piece	Testing speed mm/minute	Force at end of test N
Ø 16x2.2 mm			
1	See figure 1	200	25.7
2		200	26.1
3		200	26.9
Average			<u>26.2</u>

Test method: See test procedures, page 3
 Test temperature: 23 ± 2 °C
 The calculated uncertainty for the force measurement is <1%
 Date of test 2018-03-07

Necking at tensile,

The stress at necking are calculated from nominal pipe dimensions.

Test no	Test piece	Testing speed mm/minute	Necking force N	Stress at necking MPa
Ø 16x2.2 mm				
1	10-12 cm pipe	100	1760	18.5
2		100	1730	18.1
3		100	1706	17.9
Average			<u>1732</u>	<u>18.2</u>

Test method: See test procedures, page 3
 Test temperature: 23 ± 2 °C
 The calculated uncertainty for the force measurement is <1%
 Date of test 2018-01-25

Burst testing

The hoop stress is calculated from nominal pipe dimensions.

Test no	Critical test case	Rate of loading bar/s	Max pressure before burst bar	Max hoop stress before burst MPa
Ø 16x2.2 mm				
1	Case 2	0.42	22.5	7.06
2		0.42	22.5	7.06
3		0.42	24.2	7.59
4		0.42	22.2	6.96
5		0.42	23.5	7.37
Average			<u>23.0</u>	<u>7.21</u>
6	Case 3	0.56	21.6	6.77
7		0.56	22.5	7.06
8		0.56	22.9	7.18
9		0.56	22.3	6.99
10		0.56	22.3	6.99
Average			<u>22.3</u>	<u>7.00</u>

Test method: ASTM D1599-99, see test procedures, page 4
Test temperature: 81 ± 1 °C
Conditioning time: 1 h
Internal/External medium: Water/water
The calculated uncertainty for the burst pressure measurement is <5%
Date of test March 2018

Exchangeability

The following additional products were used in addition to the PEX-pipe and protection pipe:

Product	Reference number
LK Wall bending fixture	RSK 187 79 99
LK Exchange nipple	RSK 187 37 91

Despite several attempts, it was not possible to fix the Exchange nipple to the PEX-pipe. The installation manual states that the used nipple was intended for the Ø 16x2.2 mm-dimension. The installation was instead performed according to “Lommehåndboken”.

Installation method: Byggforsk Vannskadkontoret Rör-i-rör-systemer Lommehåndbok, utgåva 2, daterad 2006
Lubrication: Mineral oil (10W-40)
Result: Leakage in the bend in the wall bending fixture.

Test method: Nordtest NT VVS 129 clause 6.4.13 and 6.4.14
Test set up: Figure 6 in NT VVS 129
Test temperature: 23 ± 2 °C
Date of test January 2018

Hygienic testing

The following results were reported to RISE by *Hygiene-Institut des Ruhrgebiets* 2018-03-29.

The reference number for the report was *K-296510-18-Ä-Ko*, and report date: 2018-03-28.

Parameter	Method	Cold water test (23 °C)		Warm water test (60 °C)	
		10 days	31 days	10 days	31 days
Colour	SOP 14.5, 2008-11	Colourless	Colourless	Colourless	Colourless
Turbidity	SOP 14.5, 2008-11	Clear	Clear	Clear	Clear
Tendency to foam formation	SOP 14.5, 2008-11	Slightly	Slightly	Significant	Slightly
Threshold odour number (23°C)	DIN EN 1622, 2006-10	32	20	64	13
Threshold flavour number (23°C)	DIN EN 1622, 2006-10	-	-	-	-
Total organic carbon (TOC) [Ctap mg/l]	DIN EN 1484, 1997-08	2.0	1.3	17	6.0
2,5-Dimethyl-3-hexyne-2,5-diol CAS 142-30-3 [Ctap µg/l]	Hygien institute In-house method (GC-MS)	140	79	7000	1630

Date of test

2018-01-16 – 2018-02-21

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