ISO 17455 – Determination of the Oxygen Permeability of the Barrier Pipe – Testing Equipment

Description

5 Apparatus

The test assembly shall include the following main elements: NOTE 1 The test temperature (40°C or 80°C) is specified in the relevant product- or system standard. NOTE 2 1 ppb = 1 g/m3.

5.1 Oven, capable of maintaining a constant temperature of (40 ± 0,5) °C and/or (80 ± 0,5) °C.

5.2 Test rig, a closed system consisting of stainless steel parts of pipes, couplings, valves (only for Method II) and taps, including the test piece.

5.3 Water circulation pump, capable of a variable delivery with a capacity range of from 0,15 dm3/min to 0,5 dm3/min.

5.4 Oxygen sensor, Capable of functioning at (40 ± 0,5) °C and/or (80 ± 0,5) °C, with a range of from 0,1 ppb to 20 ppm2).

5.5 Water pressure meter, with a range of (1 ± 0,1) to (4 ± 0,1) bar.

5.6 Atmospheric pressure meter, with a range of from (965 ± 1) mbar to (1035 ± 1) mbar.

5.7 Water flow meter, with a range of from (0,15 ± 0,05) dm3/min to (0,5 ± 0,05) dm3/min.

5.8 Water temperature meter, capable of functioning at (40 ± 0,05) °C and/or (80 ± 0,05) °C.

5.9 Air temperature meter, capable of functioning at (40 ± 0,05) °C and/or (80 ± 0,05) °C.

5.10 Airtight vessel, for preparation of water with an oxygen concentration of < 10 ppb (nominally oxygen-free) NOTE 3 Normally, sink plates or nitrogen are used to remove the oxygen from the water by purging.

5.11 Test medium, deionized water with PH 7 (demi/water). 5.12 Registration device, capable of registering (graphical writer or computer) oxygen concentration as a function of time.

6 Test piece
6.1 Number of test pieces
Unless otherwise specified, the number of pipe test pieces shall be one.
6.2 Preparation
The test piece shall have a free length of (20 ± 0,5) m.
Prepare the test piece in accordance with the manufacturer's instructions, taking into account the minimum free length.

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The free length between the couplings as well as the inside diameter of the test piece shall be measured and recorded.

9 Preparation for testing

9.1 Installation procedure

9.1.1 Connect the test piece in the closed system using the relevant stainless steel couplings.

9.1.2 Fill the closed system with water and remove all air (bubbles).

9.1.3 Establish the required pressure and temperature.

9.2 Removing the oxygen

9.2.1 Using the vessel, circulate the water through the closed system to produce water with an oxygen concentration of < 10 ppb.

9.2.2 Stop the production and circulation of this water after the oxygen sensor shows a level of u 220 ppb
(220 µg/l) for a test temperature of 40 °C, or 100 ppb (100 µg/l) for a test temperature of 80 °C.
NOTE As long as the final oxygen concentration is much smaller than the solubility values per Annex A, the driving force of the transfer of oxygen can be considered as being constant.

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10 Measuring procedure
10.1 General
For measuring the oxygen increase, two different methods are allowed: Method I and Method II.
NOTE With Method I the water is circulated; whereas, in Method II it is stagnant.

10.2 Dynamic test method (Method I) (see Figure 1)
10.2.1 Circulate the water continuously with a volume flow of maximum 0,5 dm3/min through the system
without refreshment. Maintain the temperature of the water as well of the surrounding air at the specified
values. Maintain the inside water at the specified pressure.
10.2.2 Using the oxygen sensor, continuously measure the total amount of the oxygen in the water.
10.2.3 After one hour, start the measurement of the oxygen concentration in the inside water.
NOTE During 5 h, the rate of change in oxygen concentration in the inside water is constant (Stage 2 in Figure 1).
10.2.4 Repeat the procedure according to 9.2 before each measurement.
10.2.5 Only when three measurements in succession have values within 5 % of each other during Stage 2,
calculate the value of oxygen concentration in the inside water, Fox.

10.3 Static test method (Method II) (see Figure 2)
10.3.1 After the step according to 9.2.2 (the water circulation has been stopped), close the valves on both

sides of the test piece to isolate (make airtight) the test piece from the closed system. To prevent a possible vacuum, first close the outlet valve and then the inlet valve.

10.3.2 Maintain the temperature of the water as well of the surrounding air at the specified values. Maintain the pressure of the inside water at the specified pressure.

NOTE The water is stagnant inside the test piece without refreshment.

10.3.3 Leave for a period of 6 h to let oxygen diffuse into the stagnant water.

10.3.4 After 6 h, open the valves on both sides of the test piece and force the oxygen-free water (coming
from the vessel) out the pipe.

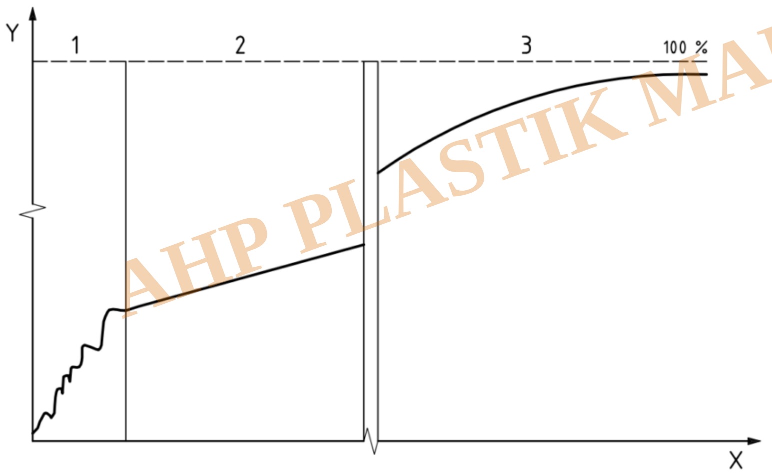
10.3.5 Using the oxygen sensor, measure the total amount of oxygen that issues.

NOTE 1 The water coming from the vessel forces out the stagnant water.

NOTE 2 When the observed concentration of oxygen is displayed as a function of time in Figure 2, the integration of the curve shows the total amount of oxygen flowing past the sensor.

10.3.6 Repeat the procedure according to 9.2 before each measurement.

10.3.7 Only when three measurements in succession have values within 5 % of each other, use the value of the total amount of oxygen in the inside volume of water for calculating Fox.



Key

X time *t*, h

Y oxygen concentration, g/m^3

1 stage 1

2 stage 2

3 stage 3

NOTE When the oxygen increase in time is graphically shown, as here, there are three different stages. In Stage 2, the rate of oxygen increase is constant. In Stage 3 the maximum solubility is reached.

Figure 1 — Oxygen increase in a closed system — Method I

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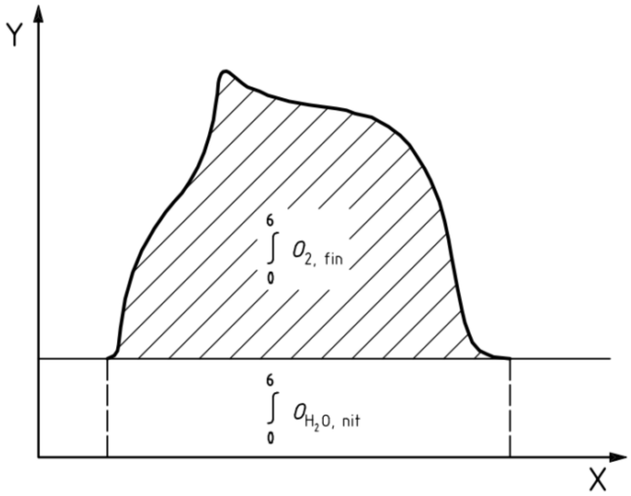

Key

X time t, h

Y oxygen concentration, g/m^3

Figure 2 — Oxygen concentration in a closed system — Method II

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11 Calculation of flux

11.1 Dynamic method (Method I)

Calculate the outside surface of the barrier layer using Equation (1):

$$A_{\text{barr}} = \frac{\pi \times l \times d_{\text{b}}}{1\,000} \tag{1}$$

Calculate the inside volume of the pipe using Equation (2):

$$V_{\text{pipe}} = \frac{\pi \times l \times d_{\text{i}}^2}{4 \times 10^6} \tag{2}$$

Calculate the total rate of transfer of oxygen through the pipe wall, expressed in grams per hour, using Equation (3):

$$C_{\text{ox},t} = \frac{(V_{\text{pipe}} + V_{\text{app}})}{t} \tag{3}$$

Calculate the influence of the atmospheric pressure using Equation (4):

$$\beta_{\text{pr}} = \frac{p_{\text{init}} + p_{\text{fin}}}{2p_{\text{a}}} \tag{4}$$

Calculate the flux, F_{ox}, expressed in grams per square metre per hour, using Equation (5):

$$F_{\text{ox}} = C_{\text{ox},t} \frac{(V_{\text{pipe}} + V_{\text{app}})}{A_{\text{barr}} t} \beta_{\text{pr}} \tag{5}$$

Calculate the flux per day, in milligrams per square metre, using Equation (6):

$$F_{\text{ox,day}} = 24\,000 \times F_{\text{ox}} \tag{6}$$

11.2 Static method (Method II)

NOTE Integration of the curve of Figure 2 yields the total amount of oxygen passing the sensor for the total inside volume of water in the pipe. Dividing this amount by the barrier surface area of the pipe and by the testing time and taking into account the variation of pressure yields the flux.

Calculate the total oxygen content of the pipe after six hours, expressed in grams, using Equation (7):

$$\int_0^6 O_{2,\text{abs}} = \int_0^6 O_{2,\text{fin}} - \int_0^{6=0} O_{\text{H}_2\text{O,init}} \tag{7}$$

Calculate the outside surface of the barrier layer, expressed in square metres, using Equation (8):

$$A_{\text{barr}} = \frac{\pi \times l \times d_{\text{b}}}{1\,000} \tag{8}$$

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Calculate the inside volume of the pipe using Equation (9):

$$V_{\text{pipe}} = \frac{\pi \times l \times d_{\text{i}}^2}{4 \times 10^6} \quad (9)$$

Calculate the influence of the atmospheric pressure using [Equation (5):]

$$\beta_{\text{pr}} = \frac{p_{\text{init}} + p_{\text{fin}}}{2p_{\text{a}}}$$

Calculate the flux, expressed in grams per square metre per hour, using Equation (10):

$$F_{\text{ox}} = \int_0^6 O_{2,\text{abs}} \frac{1}{A_{\text{barr}} t} \beta_{\text{pr}} \quad (10)$$

Calculate the flux per day, in milligrams per square metre, using Equation (11):

$$F_{\text{ox,day}} = 24\,000 \times F_{\text{ox}} \quad (11)$$

Then, determine the flux per day in relation to the water volume of the (tested) pipe, using Equation (12):

$$F_{\text{ox,vol}} = \frac{F_{\text{ox}} \times A_{\text{barr}}}{V_{\text{pipe}}} \times 24 \quad (12)$$

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Annex A
(informative)

Oxygen solubility as a function of temperature

The solubility of oxygen in water at a partial pressure of 0,18 bar and as a function of temperature is given in Table A.1.

Table A.1 — Oxygen solubility as a function of temperature, T

T °C)	Oxygen solubility g/m^3
20	8
30	6,5
40	5,5
50	5
60	4
70	3
80	2,5
When the relevant product or system standard gives no value for the application temperature, the following is recommended. For floor heating applications, 40 °C. For radiator systems, 80 °C.	

Oxygen Permeability Tester of the Barrier Pipe According to ISO 17455

The oxygen increase water inside test piece is measured during time. Increased amount of oxygen in the closed system of water is the result of the functioning of the oxygen barrier layer of the sample piece, because the only way of passing oxygen inside sample is through the wall of pipe piece. The test unit consists of a supply unit, oven and a drum to support the specimen of length 20 meter. System is fully controlled via PC.

- Including heating cabin 40-85C
- Circulation pump of capacity more than 30 l/min
- Includes temperature sensor both for water and cabin air
- Rotameter type flow meter up to 0.5 l/min
- Pressure gage 1000 mbar
- Oxygen analysis sensor installed
- Cooling water and drain connection G3/4
- Software is based on windows
- All parameters of testing controlled from computer
- Connection to PC is USB port
- Reporting in MS WORD
- Saving data as graph
- Structure powder coated
- Sample drum for pipe of 20 meter length

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Category

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