
**Clay geosynthetic barriers —
Determination of permeability to gases**

Géosynthétiques bentonitiques — Détermination de la perméabilité aux gaz



Reference number
ISO 10773:2011(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

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ISO 10773 was prepared by Technical Committee ISO/TC 221, *Geosynthetics*.

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Clay geosynthetic barriers — Determination of permeability to gases

1 Scope

This International Standard specifies a method for measuring gas flow through a clay geosynthetic barrier.

As clay geosynthetic barriers are used to contain gases in long-term applications, this test especially focuses on the steady state of the phenomenon.

The test is conducted with nitrogen, e.g. N_2 ($\eta = 1,75 \times 10^{-5}$ Pa·s, $\rho = 1,15$ kg/m³ at 20 °C).

The test method and described apparatus allow the measurement of gas flows in the range 0,1 ml/min to 5 l/min on specimens with moisture contents in the range of 90 % to 130 %.

2 Normative references

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

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

3 Principle

Clay geosynthetic barrier specimens are hydrated in a controlled manner before testing. From the plot of gas flow to moisture content under a normal load of 20 kPa and a differential pressure equal to 15 kPa, a gas flow index, $GFI_{110/15}$, is determined, which is the gas flow at 110 % moisture content.

4 Apparatus

4.1 General

The apparatus includes:

- a device allowing to load the specimen at a constant normal stress of 20 kPa (see 4.2);
- a test cell (see 4.3);
- a device to apply inlet pressure in the upstream chamber (in contact with the upper face of the sample) (see 4.4);
- a device for measuring gas flow (see 4.5).

4.2 Loading device

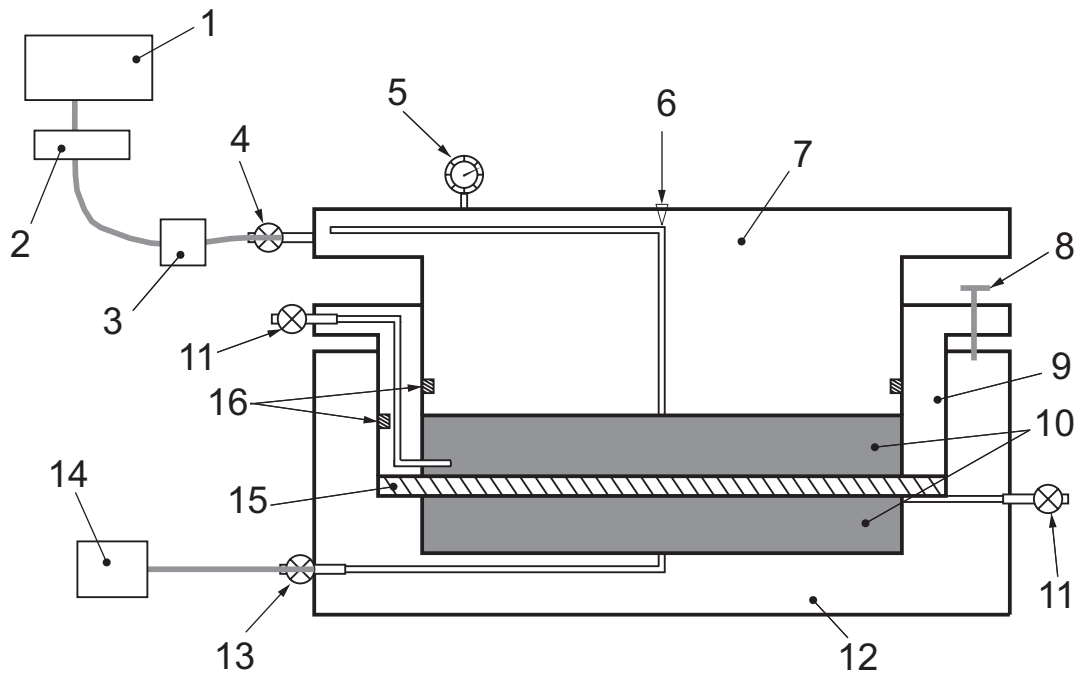
The loading device shall allow the application of the normal stress of 20 kPa with a tolerance of 5 % either by direct loading or with a controlled air supply.

4.3 Test cell

The test cell presented in Figure 1 shall allow:

- the testing of a specimen representative of the bulk clay geosynthetic barrier, where the diameter D_u of the flow cross-section is greater than or equal to 150 mm which makes it possible to study needle-punched and stitch geosynthetic clay barriers;
- the measurement of thickness reduction under a 20 kPa normal stress until stabilization;
- after stabilization of the thickness, the measurements of the evolution of the gas flow at the outlet with time.

The test cell shall have two chambers, one on each side of the specimen to accommodate the support material (lower chamber) and containment material (upper chamber). This material shall consist of glass beads, 1 mm to 2 mm diameter, likely to adapt to the variations of the specimen thickness. The edges of the clay geosynthetic barrier specimen shall be confined by a cylinder (part 9 in Figure 1), fixed to the base. The side sealing in the edge of the cell shall be achieved by adding a bentonite paste on top of the specimen. The absence of a leak can be checked by a soapy liquid on the circumference.



Key

- | | |
|----------------------------------|--|
| 1 gas tank | 9 cylinder for specimen edge containment |
| 2 inlet pressure regulator | 10 containment material |
| 3 inlet pressure gauge | 11 valve for purge |
| 4 valve for inlet gas | 12 base |
| 5 gas tank | 13 valve for outlet gas |
| 6 normal stress | 14 gas flow meter |
| 7 piston | 15 specimen |
| 8 screws to fix cylinder to base | 16 o-ring |

NOTE In cases where there is a high degree of certainty that no leaks will occur, the use of the cylinder can be avoided. In such circumstances a simpler test cell may be used. An example of such a cell is provided in Annex A.

Figure 1 — Scheme of gas flow apparatus

4.4 Device for applying inlet gas pressure

The application of a constant inlet gas pressure in the upstream chamber shall be ensured by a bottle of nitrogen equipped with a pressure reducer and a pressure meter connected to the piston. The inlet gas pressure shall be measured with a tolerance of 5 %.

4.5 Device for measuring gas flow

When a constant pressure difference ($\Delta p = 15$ kPa) is imposed between both sides of the specimen, a gas flow through the specimen is generated, which shall be measured by a gas flow meter connected to the base. It shall allow the measurement of a gas flow ranging between 0,1 ml/min and 5 l/min.

5 Samples

The samples shall be clean and free from any visible defects. Samples shall be conditioned according to ISO 554 for a minimum period of 24 hours unless it can be shown that omitting this step has no influence on the test result.

The test shall then be performed in the same conditions.

6 Testing procedure

6.1 Preparation and characterisation of samples

6.1.1 Cut three samples of geosynthetic clay barrier and bring them to three distinct values of water content close to 110 %, e.g. 100 %, 110 % and 120 %. Ensure that the values of bentonite water content are between 90 % and 130 % and are spaced at least 20 % between the lowest and the greatest value.

Complete the following steps:

- choose a representative section from the roll, undisturbed by transport, storage, and handling.
- cut a sample sufficient to accommodate $(D_r + 0,05)$ m, where D_r is the specimen diameter.
- determine the mass per unit area, its thickness under load of the sample and the water content of the bentonite.
- immerse the sample for a controlled duration in deionized water.

NOTE Absorption curves might be prepared to determine the immersion time necessary to reach the desired water content.

- remove the excess water on both faces using an absorbing paper when removing the clay geosynthetic barrier sample from the water, and then insert the sample in a plastic bag and seal it.
- load the sample under 20 kPa for one week.

6.1.2 Complete the following prior to the gas flow test:

- remove the sample from the plastic bag and cut out the specimen to the diameter D_r .
- determine the specimen weight.

Quickly perform the above operations in order to prevent free swell of the specimens.

6.2 Specimen set-up

6.2.1 Fill the lower chamber of the base with glass beads (1 mm to 2 mm diameter). Protect the hole for outlet gas flow with a geotextile if required. Adjust the quantity of beads so that they fill the cavity present under the specimen.

6.2.2 Put the specimen in the base.

NOTE If the test is conducted on a stitched clay geosynthetic barrier, make sure that a representative portion of clay geosynthetic barrier is selected for testing.

6.2.3 Add bentonite paste on the edges of the specimen.

6.2.4 Assemble the base with the cylinder, sealing the joint between the base and the cylinder with bentonite paste.

6.2.5 Fill the cylinder with glass beads (1 mm to 2 mm diameter) to a thickness greater than or equal to 10 mm. Smooth off the beads.

6.2.6 Install the piston and the displacement gauge to measure the vertical deformation of specimen and beads.

6.2.7 Apply a 20 kPa load.

6.3 Flow measurement

6.3.1 Measure the volumetric gas flow for a constant pressure difference across the specimen with the downstream pressure being atmospheric pressure, and pressure applied in the upstream chamber remaining constant during the test.

6.3.2 Set the difference between upstream and downstream pressures to 15 kPa.

6.3.3 Increase the normal stress by 15 kPa in order to avoid the piston rising when one applies a differential pressure (Δp) of 15 kPa.

6.3.4 Follow the outlet volumetric gas flow versus time until its stabilisation. The time to obtain steady flow is a function of the bentonite water content.

6.4 Analysis of the specimen

6.4.1 Immediately at the end of the test, disassemble the cell and retrieve the specimen. Clean off all beads.

6.4.2 Weigh the specimen.

6.4.3 Dry the specimen and measure its dry mass.

6.4.4 Calculate the final water content of the specimen.

7 Calculation of the index flow $GFI_{110/15}$

The steady-state gas flow is measured for the three specimens at three distinct final water contents close to 110 %, e.g. 100 %, 110 % and 120 %, and the gas flux, q_V , is calculated according to Equation (1):

$$q_V = \frac{Q}{A} \quad (1)$$

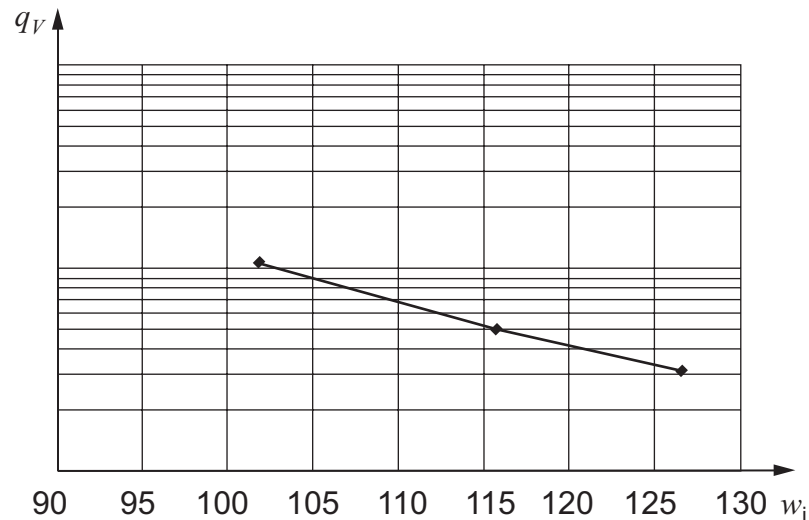
where

Q is the outlet volumetric gas flow at the atmospheric pressure;

A is the flow section of the specimen of diameter D_U .

Plot the log of the gas flux, q_V , against the water content of the bentonite, w_i , as shown in Figure 2, and select the best-fit curve.

NOTE The gas flux at 110 % final water content is the gas flow index $GFI_{110/15}$, where 110 % is the water content for the index flux and 15 kPa is the differential gas pressure.



Key

w_i water content of bentonite, percentage

q_V gas flux, metres per second

Figure 2 — Evolution of gas flow, q_V , versus bentonite water content, w_i

8 Test report

The test report shall include the following information:

- reference to this International Standard, e.g. ISO 10773:2011;
- identification of the clay geosynthetic barrier, including type;
- name of the product;
- references of the sample;

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- e) date of reception of the sample;
- f) total mass per unit area at reception, total mass per unit area of dry clay geosynthetic barriers and total mass per unit area of dry bentonite, m_a ;
- g) initial water content of bentonite;
- h) description of pre-hydration phase (any deviation from the pre-hydration phase shall be reported);
- i) quality of water, if other than deionized water;
- j) type of gas, if other than N_2 , and its dynamic viscosity;
- k) test operation and potential differences from this International Standard.

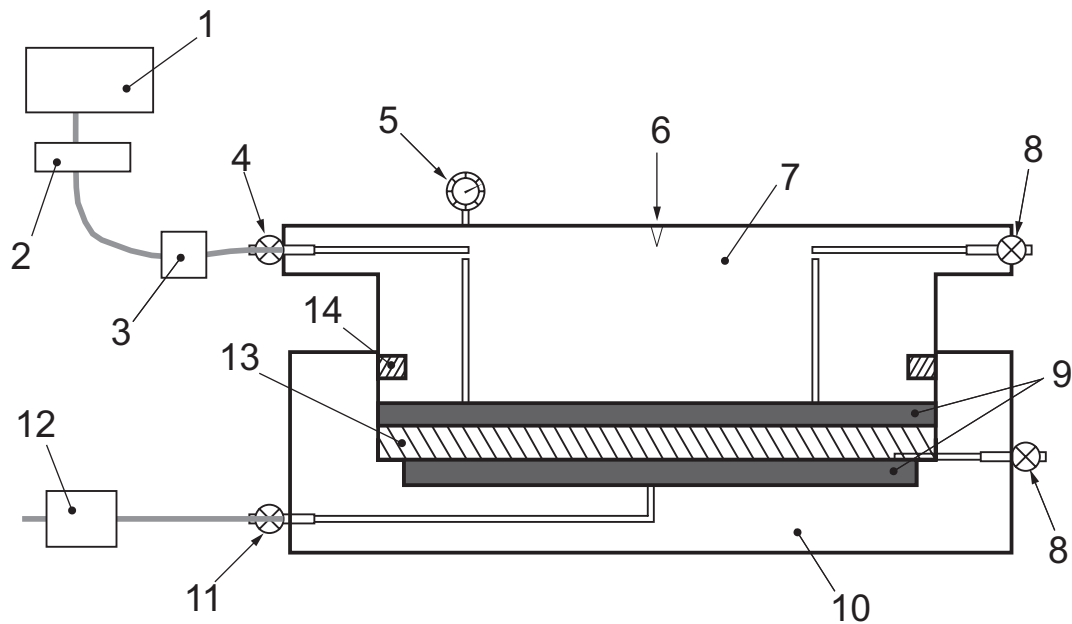
For each specimen tested:

- duration of sample immersion in water tank or indication of the volume of water added;
- final water content of bentonite at the end of pre-hydration phase;
- specimen weight before and after gas test;
- final water content of bentonite at the end of the test;
- summary of the test procedure.

Annex A (informative)

Test cell for clay geosynthetic barrier specimens with plane and parallel surfaces

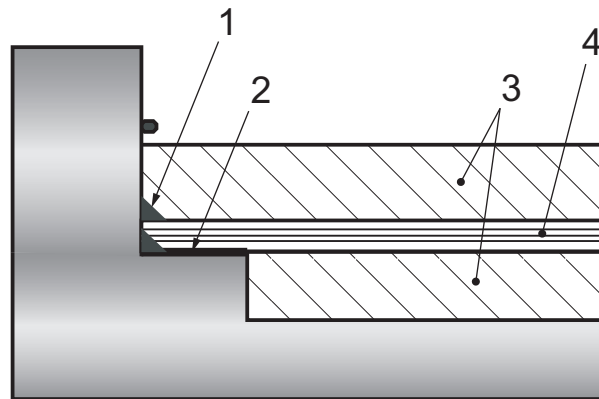
The test cell presented in Figure A.1 is adapted to perform tests on clay geosynthetic barrier specimens with plane and parallel surfaces. The cell comprises two main parts, the base and the piston, each one having an opening to be used for inlet and outlet gas via porous materials. The lateral sealing is carried out by the application of a light paste of bentonite on the circumference of the specimen (Figure A.2).



Key

- | | |
|----------------------------|-------------------------|
| 1 gas tank | 8 valve for purge |
| 2 inlet pressure regulator | 9 containment material |
| 3 inlet pressure gauge | 10 base |
| 4 valve for inlet gas | 11 valve for outlet gas |
| 5 displacement gauge | 12 gas flow meter |
| 6 normal stress | 13 specimen |
| 7 piston | 14 o-ring |

Figure A.1 — Scheme of gas flow apparatus



Key

- 1 bentonite fillet
- 2 bentonite paste
- 3 porous material
- 4 specimen

Figure A.2 — Lateral sealing

Bibliography

- [1] ISO 9863-1, *Geosynthetics — Determination of thickness at specified pressures — Part 1: Single layers*
- [2] ISO 9863-2, *Geotextiles and geotextile-related products — Determination of thickness at specified pressures — Part 2: Procedure for determination of thickness of single layers of multilayer products*
- [3] ISO 11465, *Soil quality — Determination of dry matter and water content on a mass basis — Gravimetric method*
- [4] EN 14196, *Geosynthetics — Test methods for measuring mass per unit area of clay geosynthetic barriers*

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