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Geotextiles and geotextile-related products — Determination of water permeability characteristics normal to the plane, without load

Géotextiles et produits apparentés — Détermination des caractéristiques de perméabilité à l'eau normalement au plan, sans contrainte mécanique

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Contents

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso .org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 11058:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

— editorial modifications;

— formula corrections.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Geotextiles and geotextile-related products — Determination of water permeability characteristics normal to the plane, without load

1 Scope

This document specifies two test methods for determining the water permeability characteristics of a single layer of geotextile or geotextile-related product normal to the plane:

a)   the constant head method; and

b)   the falling head method.

2 Normative references

The following referenced documents are referred to in such a way that some or all of their content constitutes requirements 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 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

ISO 5813, *Water quality — Determination of dissolved oxygen — Iodometric method*

ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*

ISO 10320, *Geosynthetics — Identification on site*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

—   ISO Online browsing platform: available at https://www.iso.org/obp

—   IEC Electropedia: available at http://www.electropedia.org/

3.1
velocity index
v-index
velocity corresponding to a head loss of 50 mm across a specimen, expressed to the nearest ±1 mm/s

4 Test specimens

4.1 Handling

The sample shall not be folded and shall be handled as infrequently as possible to avoid disturbance to its structure. The sample shall be kept in a flat position without any load.

4.2 Selection

Test specimens shall be taken from the sample in accordance with ISO 9862.

4.3   Number and dimensions

Five test specimens shall be cut from the sample, each of suitable dimensions for the water permeability apparatus to be used.

If it is necessary to determine the results to within a given confidence interval of the mean, the number of test specimens shall be determined in accordance with ISO 2854.

4.4   Specimen conditions

The specimens shall be clean, free from surface deposits and without visible damage or folding marks.

5   Constant head method

5.1   Principle

A single, unloaded layer of geotextile or geotextile-related product is subjected to a unidirectional flow of water normal to the plane under a range of constant heads.

5.2   Apparatus

5.2.1   Apparatus in which it is possible to observe the presence of air bubbles on the surface of the specimen, with an internal diameter of minimum 50 mm, conforming to the following requirements.

a)   The apparatus shall be capable of applying a maximum head loss of at least 70 mm and maintaining a constant head for the duration of each test with water on both sides of the specimen.

   NOTE   Some examples of apparatus are shown in Figure 1.

b)   The mean internal diameter of the apparatus shall be known to an accuracy of at least 0,1 mm. The exposed diameter of the specimen shall be the same as the internal diameter of the apparatus. The diameter of the apparatus shall remain identical on both sides of the specimen over a length of at least twice its internal diameter [see Figures 1 a) and 1 b)]. Abrupt changes in diameter shall be avoided.

   Alternatively [see Figure 1 c)], the outflow may discharge into a reservoir with a diameter of at least four times the exposed diameter of the specimen. In this case, the distance from the geotextile to the base of the reservoir shall be at least 1,5 times the exposed diameter of the specimen.

   If the product shows an obvious pattern, this pattern shall be included at least three times along any diameter of the specimen.

c)   Where necessary, to avoid any visible deformation, a grid of 1 mm diameter wire and a mesh size of (10 ± 1) mm shall be placed downstream of the specimen to support it during the test.

d)   The head loss measured at any velocity when a test is performed without the test specimen, but including any specimen-supporting grid, shall be less than 1 mm.

5.2.2   Water supply, of the following quality and condition.

a)   The water shall be at a temperature of between 18 °C and 22 °C.

   As the temperature correction (see Annex A) relates only to laminar flow, it is advisable to work at temperatures as close as possible to 20 °C to minimize inaccuracies associated with inappropriate correction factors, should the flow be non-laminar.

b)   Water shall not be fed into the apparatus directly from a main supply due to problems caused by the release of air bubbles, which can be entrapped in the structure of the specimen. The water

should preferably be de-aired or fed from a stilling tank. The water should not be continuously recycled.

c) The oxygen content shall not exceed 10 mg/kg. The oxygen content shall be measured at the point at which the water enters the apparatus.

d) The water shall be filtered if suspended solids are visible to the naked eye or if solids accumulate on or in the specimen, thus reducing the flow with time.

5.2.3   Dissolved-oxygen meter, or apparatus in accordance with ISO 5813.

5.2.4   Stopwatch, with an accuracy of 0,2 s.

5.2.5   Thermometer, with an accuracy of 0,5 °C.

5.2.6   Measuring vessel, of appropriate size for determining the volume of water to an accuracy of 1 % of the capacity of the vessel.

When the water flow is determined by volume, use a measuring vessel for determining volume to an accuracy of 1 %. When direct measurement of water flow velocity is made by gauge, the flow velocity shall be measured to an accuracy of 5 %. When determining the water volume by mass, it shall be determined to an accuracy of 1 %.

5.2.7   Measurement device for determining the applied head, to an accuracy of 3 %.

5.3   Procedure

5.3.1   Place the specimens under water containing 0,1 % volume (1 ml/l) non-ionic surfactant at laboratory temperature, gently stir to remove air bubbles and leave to saturate for at least 12 h.

5.3.2   Place a specimen in the apparatus and ensure that all joints are watertight.

5.3.3   Fill the apparatus with water until there is a 50 mm water head difference across the specimen. Shut off the water supply and, if the water heads do not equalize on each side of the specimen within 5 min, investigate the likelihood of any trapped air within the apparatus and repeat the procedure. If the water heads cannot be equalized within 5 min, this shall be noted in the test report.

NOTE   If the full permeability characteristics of the geotextile or geotextile-related product have previously been established, then for control purposes it can be sufficient to determine the velocity index at a head loss of 50 mm only.

5.3.4   Adjust the flow to attain a head loss of (70 ± 5) mm and record this value to the nearest 1 mm. When the head has been steady for a minimum of 30 s, collect the water passing through the system in the measuring vessel over a fixed period of time and record the volume of water collected to the nearest 10 cm³ and the time to the nearest 1 s. The volume of water collected should be a minimum of 1 000 cm³ and the collection time should be a minimum of 30 s.

5.3.5   When the water flow is determined by volume, the volume of the measuring vessel shall not exceed twice the volume of the collected water.

5.3.6   If a flow velocity gauge is used, then a maximum velocity giving a head loss of about 70 mm should be set. The real velocity shall be taken as the average of three consecutive readings with a minimum time interval between readings of 15 s.

3

5.3.7 Repeat 5.3.4 for four lower head losses of approximately 0,8; 0,6; 0,4 and 0,2 times the maximum head loss, starting with the highest velocity and ending with the lowest.

5.3.8 The same principle applies to the velocity when using a flow velocity gauge.

5.3.9 Record the water temperature to the nearest 0,5 °C.

5.3.10 Repeat 5.3.2 to 5.3.9 with each of the remaining specimens.

5.4 Calculation and expression of results

5.4.1 Calculate the flow velocity at 20 °C, v_{20}, in metres per second, using Formula (1):

$$v_{20} = \frac{V R_T}{At} \tag{1}$$

where

V is the water volume measured, in cubic metres (m^3);

R_T is the correction factor for water temperature T, in degrees Celsius, to a water temperature of 20 °C (see Annex A);

A is the exposed specimen area, in square metres (m^2);

t is the time measured to achieve the volume (V), in seconds (s).

Where the flow velocity, v_T, has been measured directly, a temperature correction is necessary according to Formula (2):

$$v_{20} = v_T R_T \tag{2}$$

NOTE   The flow velocity, v_{20}, expressed in millimetres per second, equals the discharge, q, expressed in litres per square metre second.

5.4.2 For each of the five specimens, calculate the flow velocity, v_{20}, for each head loss, H.

5.4.3 Plot the head loss, H, against velocity, v_{20}, and select the best-fit curve through the origin for each specimen (see Figure B.1) in accordance with Annex B, either by mathematical or graphical means. Present the five specimen curves on one graph.

NOTE   If the full permeability characteristics of the geotextile or geotextile-related product have previously been established, then for control purposes it can be sufficient to determine the velocity index at a head loss of 50 mm only.

5.4.4 Produce a flow velocity value at the head loss of 50 mm, either by calculation or by graphical interpretation.

6 Falling head method

6.1 Principle

A single unloaded layer of geotextile or geotextile-related product is subjected to a unidirectional flow of water normal to the plane under a falling head.

6.2 Apparatus

6.2.1 **Water-permeability apparatus**, with the possibility of seeing the specimen from beneath, via a transparent tube or window, consisting of two interconnected cylinders of the same diameter of minimum 50 mm, complying with the following requirements.

a) The apparatus shall be capable of achieving water heads of at least 250 mm for appropriate calculations.

   To achieve a water head of at least 250 mm, it should start with a higher water level because the water head values recorded during the opening time of the valve cannot be used for calculation.

b) The mean internal diameter of the cylinder of apparatus shall be known to an accuracy of at least 0,1 mm. The exposed diameter of the specimen shall be the same as the internal diameter of the apparatus. The diameter of the apparatus on both sides of the specimen shall remain identical over a length of at least twice its internal diameter. Within the range of changing water levels, the diameter shall be constant. Abrupt changes in diameter should be avoided.

   If the product shows an obvious pattern, this pattern shall be included at least three times, along any diameter of the specimen.

c) Where necessary, to avoid any visible deformation, a grid of 1 mm diameter wire and a mesh size of (10 ± 1) mm shall be placed downstream of the specimen to support it during the test.

d) The head loss measured at any velocity when a test is performed without the test specimen, but including any specimen-supporting grid, shall be less than 1 mm.

   NOTE   Some examples of apparatus are shown in Figure 2.

e) The connecting tube between the two cylinders shall have a minimum diameter of 40 % of the diameter of the cylinders. It shall be flexible if the weighing cell method is used.

6.2.2 **Water supply**, of the following quality and condition.

a) The water shall be at a temperature between 18 °C and 22 °C.

   As the temperature correction (see Annex A) relates only to laminar flow, it is advisable to work at temperatures as close as possible to 20 °C to minimize inaccuracies associated with inappropriate correction factors, should the flow be non-laminar.

b) Water shall not be fed into the apparatus directly from a main supply due to problems caused by the release of air bubbles which can lodge in the test specimen. The water should preferably be de-aired or fed from a stilling tank. The water in the apparatus should be replaced daily.

c) The oxygen content shall not exceed 10 mg/kg. The oxygen content shall be measured at the point at which the water enters the apparatus.

d) The water shall be filtered if suspended solids are visible to the naked eye or if solids accumulate on or in the specimen thus reducing the flow with time.

6.2.3 **Dissolved-oxygen meter**, or apparatus in accordance with ISO 5813.

6.2.4 **Measuring device for determining the changing water head**, with an accuracy of 3 %.

NOTE   Possible means are:

a) measuring the change in column mass (to ±1 g);

b) measuring the change in water pressure (to ±1 Pa); and

c) measuring the change in water level by an optical method (reading of water level using digitalized video equipment) or by an ultrasonic method.

Continuous recording of the data by an analogue writer or computer, from the beginning to the end of the test, is recommended (see Figure 3).

6.2.5 **Thermometer**, with an accuracy of 0,5 °C.

6.3 Procedure

6.3.1 Place the specimens under water containing 0,1% volume non-ionic surfactant at laboratory temperature, gently stir to remove air bubbles and leave to saturate for at least 12 h.

6.3.2 Place a specimen in the apparatus and ensure that all joints are watertight.

6.3.3 Fill the apparatus with water until there is a 50 mm water head difference across the specimen. Shut off the water supply and, if the water heads do not equalize on each side of the specimen within 5 min, investigate the likelihood of any trapped air within the apparatus and repeat the procedure. If the water heads cannot be equalized within 5 min, this shall be noted in the test report.

6.3.4 Close the valve. Fill the specimen cylinder of the apparatus to a height such that a useful head difference of at least 250 mm after complete opening of the valve is achieved [see the second paragraph of 6.2.1 a)].

6.3.5 Record the water temperature to the nearest 0,5 °C.

6.3.6 Switch on all instruments required for the method used (see 6.2.4) and open the valve.

6.3.7 The test ends when head loss and flow velocity reach zero.

NOTE   For highly permeable specimens, it is possible for the water levels at v = 0 m/s to not equalize due to inertia effects (see Figure 3). In these cases, the water level corresponding to v = 0 m/s for the first time is taken as the reference level for calculating head losses.

6.3.8 Repeat 6.3.2 to 6.3.7 with each of the remaining specimens.

6.4 Calculation and expression of results

6.4.1 From a chosen water-level interval on the graph of the analogue writer (see Figure 3) or the computerized data, calculate the flow velocity, v_{20} at 20 °C, in metres per second, using Formula (3):

$$v_{20} = \frac{\Delta h}{t} R_T \tag{3}$$

where

Δh is the difference between the upper water level, h_u, and the lower water level, h_l, in meters, at time interval t;

t is the time interval between h_u and h_l, in seconds;

R_T is the correction factor to a water temperature of 20 °C (see Annex A);

and the head loss, H, in metres, which is given by Formula (4):

$$H = h_u + h_l - 2h_0 \tag{4}$$

where

h_0 is the height of the water level at $v = 0$ m/s (see NOTE in 6.3.7);

h_u and h_l are the upper and lower levels of the head range on which the calculation is based.

NOTE   The flow velocity, v, expressed in millimetres per second, equals the discharge, q, expressed in litres per square metre second.

6.4.2   For each of the five specimens, calculate the flow velocity, v, for each water head loss, H, at a minimum of five points along each curve.

6.4.3   In calculating the falling head curve, it is recommended that time intervals be 1/5 to 1/10 of the total time to carry out the experiment.

6.4.4   Plot the head loss, H, against velocity, v, and select the best-fit curve through the origin for each specimen, in accordance with Annex B, by either mathematical or graphical means. Present the five specimen curves on one graph (see Figure B.1).

6.4.5   The test shall be used to produce a flow velocity value at the head loss of 50 mm either by calculation or by graphical interpretation.

7   Test report

The test report shall include the following information:

a)   the number and year of publication of this document, i.e. ISO 11058:2019;

b)   the test laboratory and, if required, the test operator;

c)   a description of the product tested in accordance with ISO 10320;

d)   the exposed specimen area;

e)   only where the full permeability characteristics are being measured, a collective plot of the velocity, v, and head loss, H, for each specimen;

f)   the velocity index for a head loss of 50 mm (v-index) and, if required, specimen values, sample mean, specimen maximum and minimum (see Annex C);

g)   the water temperature range;

h)   the water type (stilled, de-aerated, de-ionized, filtered) and dissolved oxygen values;

i)   the type of flow gauge, if used;

j)   any deviation from this document;

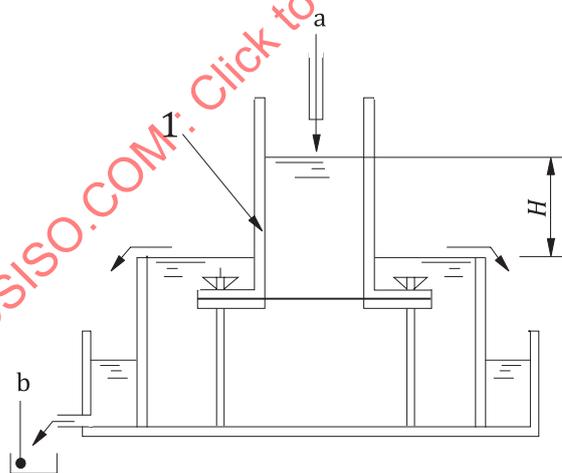k)   any anomaly in the hydraulic behaviour of the product;

and, if required:

l)   details of apparatus used, including a diagram;

m)   the experimental data and calculations for each specimen can be tabulated. Examples are given in Annex D.
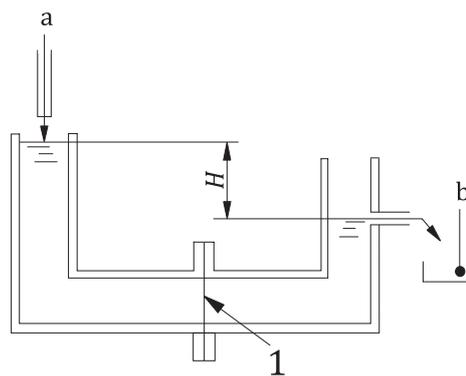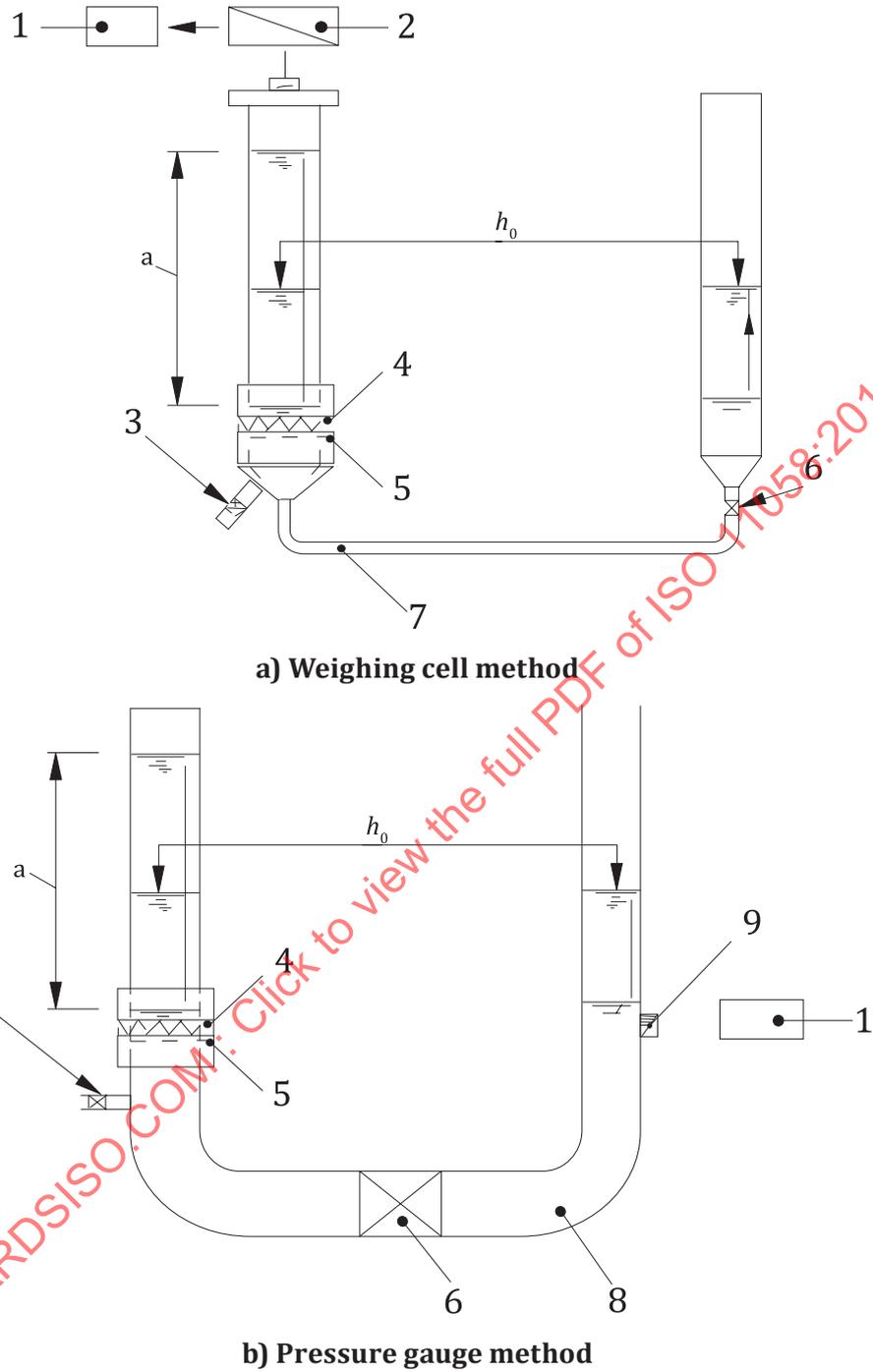
a) Horizontal
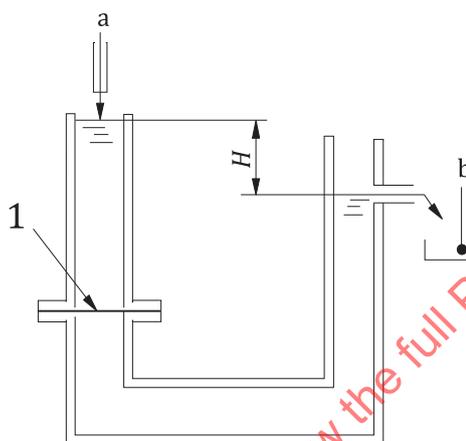
b) Vertical

c) Open

Key

1   specimen
a   Inflow.
b   Collected outflow.
H   head loss

Figure 1 — Examples of apparatus for the constant head method

a) Weighing cell method

b) Pressure gauge method

Key

1	analogue recorder or computer	6	main valve
2	weighing cell	7	flexible connecting tube
3	release valve	8	fixed connecting tube
4	specimen	9	pressure gauge
5	support grid	a	Water level difference at test start.

Figure 2 — Examples of apparatus for the falling head method

Key

a   Time to completely open the valve.

b   Water level height, in metres.

c   Time, t, in seconds.

	Explanations	Remarks
(1)	Water level at test start	(1) – (2) range inappropriate for calculation
(2)	Water level after complete opening of the valve	(2) – (8) range appropriate for calculation
(8)	Lowest water level (reference level for calculation)	
(4)	Course of water level alteration (low permeable geotextile)	See Note in 6.3.7.
(5)	Course of water level alteration (high permeable geotextile)	
(6)	Example for calculation	See Table D.2.

Figure 3 — Example of a falling water level as recorded by an analogue writer

Annex A
(informative)

Determination of the correction factor, R_T, to a water temperature of 20 °C

$$R_T = \frac{\eta_T}{\eta_{20}} = \frac{1{,}762}{1 + 0{,}0337\,T + 0{,}000\,22\,T^2} \qquad \text{(dimensionless)}$$

with

$$\eta_T = \frac{1{,}78}{1 + 0{,}0337\,T + 0{,}000\,22\,T^2} \qquad \text{(mPa·s)}$$
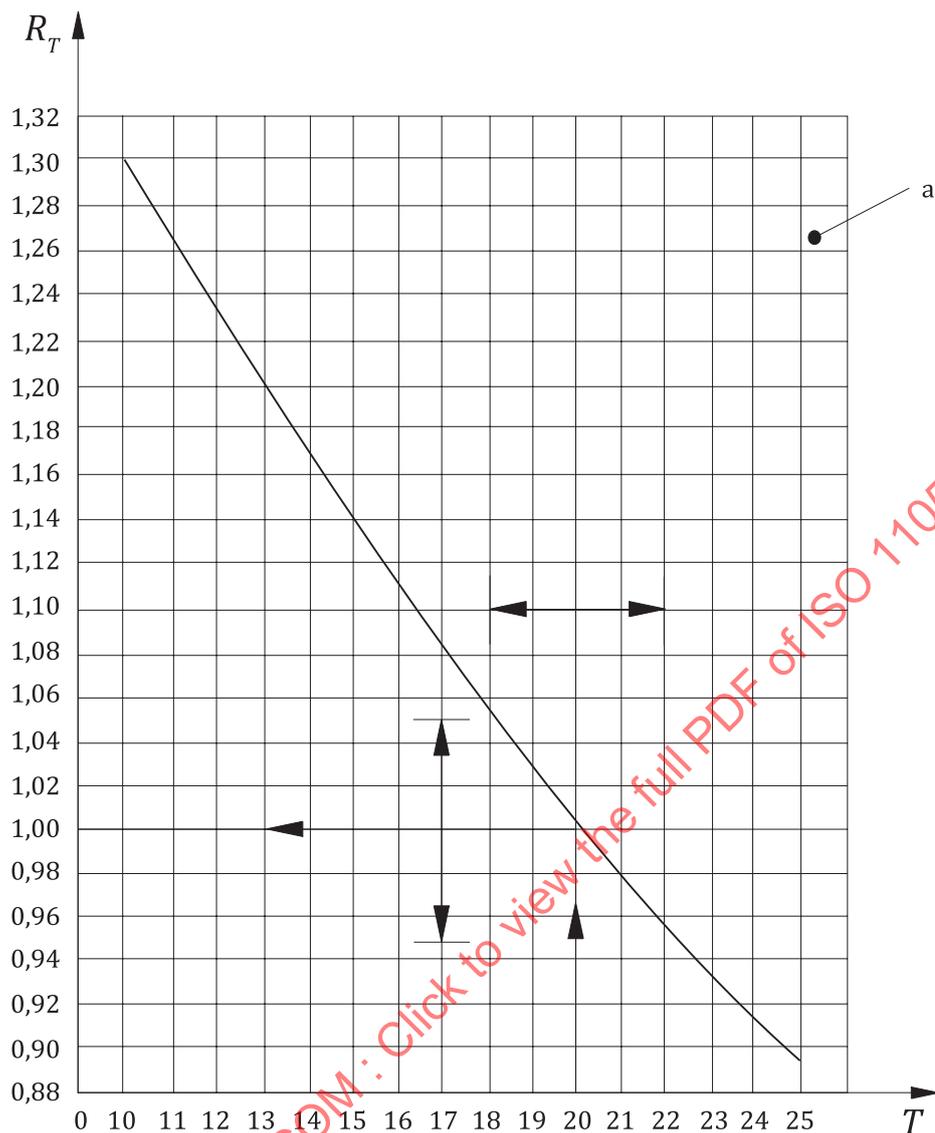
where

η_T is the dynamic viscosity at T °C, in millipascal seconds;

T is the water temperature, in degrees Celsius;

η_{20} is the dynamic viscosity at 20 °C, in millipascal seconds;

R_T is the correction factor to a water temperature of 20 °C.

Key

T test temperature, in degrees Celsius

R_T correction factor

a   Temperature range from 18 °C to 22 °C [see 5.2.2 a)].

Figure A.1 — Graphical presentation of the correction factor, R_T

Annex B
(normative)

Relationship between head loss and flow velocity

The general relationship between head loss, H, and flow velocity, v, can be expressed by the quadratic function:

$$H = av + bv^2$$

Using the experimental data v_{20} and H in Table B.1, the best-fit quadratic curve passing through the origin can be determined through the paired terms v and H, as illustrated in Figure B.1.

This graph allows the determination of the velocity at a head loss of 50 mm.

Table B.1 — Experimental data of velocity, v, and head loss, H, after temperature correction

v_{20} mm/s	H mm
19,7	20,0
28,3	30,1
35,3	40,0
41,9	50,0
46,8	60,0