BS EN 14701-2:2013

BSI Standards Publication

Characterisation of sludges — Filtration properties

Part 2: Determination of the specific resistance to filtration

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 14701-2:2013. It supersedes BS EN 14701-2:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/5, Sludge characterization.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 78076 9

ICS 13.030.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 14701-2

April 2013

ICS 13.030.20

Supersedes EN 14701-2:2006

English Version

Characterisation of sludges - Filtration properties - Part 2: Determination of the specific resistance to filtration

Caractérisation des boues - Propriétés de filtration - Partie 2: Détermination de la résistance spécifique à la filtration

Charakterisierung von Schlämmen - Filtrationseigenschaften - Teil 2: Bestimmung des spezifischen Filtrationswiderstands

This European Standard was approved by CEN on 1 March 2013.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 14701-2:2013: E

Contents

Page

Foreword

This document (EN 14701-2:2013) has been prepared by Technical Committee CEN/TC 308 "Characterization of sludges", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2013, and conflicting national standards shall be withdrawn at the latest by October 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14701-2:2006.

Other parts of EN 14701 are:

— *Part 1: Capillary suction time (CST)*;
— *Part 3: Determination of the compressibility*;
— *Part 4: Determination of the drainability of flocculated sludges*.

Most significant changes made since the latest edition:

— "Part 4 …" added to Foreword;
— Introduction modified;
— CEN/TR 14742 added to Normative References;
— Clause "Principle" modified and better specified;
— List Entry 5.1.3 modified and better specified;
— List Entry 5.8 added;
— Clause 6 better specified;
— In Formula (1), "m" instead of "C_o";
— Table 1 simplified;
— text added in Clause 7;
— List Entry c) added in Clause 9;
— former Annex A deleted;
— bibliographical references added.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The specific resistance to filtration is a parameter which indicates the suitability of sludge to be filtered. The value of the specific resistance to filtration has great importance in filtration processes as it can be useful for estimating the performance of full-scale filtering devices, mainly pressure filters, and comparing filterability characteristics of sludges produced in different plants. Specific resistance measurements can also give indications on both the optimal type and dosage of conditioner to be used (CEN/TR 14742).

This revised version only includes editorial changes that do not influence the original, validated method.

1 Scope

This European Standard specifies a method for determining the specific resistance to filtration of conditioned and non-conditioned sludges, provided that no sedimentation occurs during filtration (i.e. single phase suspension with particles in suspension).

This European Standard is applicable to sludges and sludge suspensions from:

— storm water handling;

— urban wastewater collecting systems;

— urban wastewater treatment plants;

— industrial wastewater that has been treated similarly to urban wastewater (as defined in Directive 91/271/EEC);

— water supply treatment plants.

This method is also applicable to sludge and sludge suspensions of other origins.

2 Normative references

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

EN 12832:1999, *Characterization of sludges — Utilization and disposal of sludges — Vocabulary*

EN 12880, *Characterization of sludges — Determination of dry residue and water content*

CEN/TR 14742, *Characterization of sludges — Laboratory chemical conditioning procedure*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12832:1999 and the following apply.

3.1
specific resistance to filtration
property representing the resistance to filtration of a layer of particles having a unit mass of dry solids deposited on a unit filtering area

4 Principle

This method is based on the flow of a liquid through a porous medium in accordance with Darcy's law (see Annex A). The specific resistance to filtration is determined by pouring a suitable volume of sludge into a filtering device, allowing the liquid to be filtered under constant vacuum or pressure, whilst recording the amount of filtrate over time.

Considering that for sludges this parameter is affected by pressure value, this standard has been validated for the determination of specific resistance to filtration at pressure values (50 ± 5) kPa, (150 ± 10) kPa and (300 ± 15) kPa, as specifically indicated in Clause 6.

If necessary, as in the case of tests intended to size or optimise industrial filters, tests may be carried out at different pressures, provided results have been validated in advance.

5 Apparatus

5.1 Filtration apparatus with a capacity of 250 ml, and filter diameters between 60 mm and 90 mm (see Annex B).

5.1.1 Apparatus for filtration under reduced pressure (see Figure B.1).

5.1.2 Apparatus for filtration under pressure up to 1 MPa (see Figure B.2 a)).

5.1.3 Apparatus for filtration under pressure up to 1 MPa with a piston (see Figure B.2 b)) equipped with a pressure sensor under the piston to measure the actual applied pressure.

If this set-up is not given, piston friction is not taken into account in the pressure measurement and air filtration is preferred.

5.2 Graduated cylinders with a capacity of 100 ml and 250 ml.

5.3 Vacuum pump, or air pressure system, or hydraulic system for pressure application, including pressure adjustment system (regulator or reducer) and pressure gauge.

5.4 Chronometer, e.g. stopwatch, computer.

5.5 Beaker with a capacity of 500 ml.

5.6 Pipettes.

5.7 Filtering medium, filter paper (extra fast, ash-free), with a particle retention between 20 µm and 25 µm and a filtration flow rate of about 100 ml/min and a thickness of 0,22 mm (e.g. Whatman 41®[1])).

Synthetic, or stainless metallic cloth may also be used if they can be shown to lead to the same results.

5.8 Filtering medium support.

5.9 Apparatus for determining sludge dry residue and water content (see EN 12880).

5.10 Thermostatic cell, for determinations at non-ambient temperatures.

6 Procedure

6.1 General

Measure the dry residue of the sludge, C_o, in accordance with EN 12880 and assume that the dry residue measured in g/kg is equivalent to the concentration measured in g/l. Prior to measuring, ensure the sludge is at room or test temperature.

If sludge has to be conditioned, this operation shall be carried out according to CEN/TR 14742.

6.2 Reduced pressure (Figure B.1)

6.2.1 Keep the valve between filter (5.1) and vacuum/pressure system (5.3) closed during the procedure, maintaining the system at an absolute pressure of (50 ± 5) kPa.

1) This information is given for the convenience of users of this document and does not constitute an endorsement by CEN of the product named. Equivalent products may be used if they can be shown to lead to the same results.

6.2.2 Put the filtering medium (5.7) in the funnel, moisten it with water and avoid any air entrance into the filter.

6.2.3 Measure the temperature, put (100 ± 1) ml of non-conditioned sludge or (200 ± 2) ml of conditioned, or of easily filterable sludge into the funnel after gentle homogenisation by pouring the sludge 3 times to 4 times from one beaker to another (only in case of non-conditioned sludge), open the valve and start filtration.

6.2.4 Record filtrate volumes, V, and corresponding times, t, only after collecting at least 10 % of the initial filtrate volume. Recording depends on flow rate and could range from every 5 s at the beginning until every 60 s or more (for sludge of low filterability) at the end. Stop the filtration when one of the following conditions occurs:

— pressure drops down (breaking of cake);

— filtrate flow rate instantaneously drops down;

— plot t/V vs. V deviates from linearity;

— filtration time exceeds 60 min.

6.2.5 Measure the dry mass of the cake after filtration in accordance with EN 12880, and measure the dynamic viscosity of the filtrate at test temperature.

6.3 Under pressure (Figure B.2 a))

6.3.1 While keeping the valve between the filter (5.1) and the air pressure system (5.3) closed, adjust the system to (50 ± 5) kPa, or (150 ± 10) kPa, or (300 ± 15) kPa above atmospheric pressure. The pressure shall be constantly maintained during the whole procedure.

6.3.2 Put the filtering medium (5.7) into the filtration cell, moisten it with water and avoid any air entrance into the filter.

6.3.3 Measure the temperature and put 100 ml of non-conditioned sludge or 200 ml of conditioned, or of easily filterable sludge into the apparatus after gentle homogenisation by pouring the sludge 3 times to 4 times from one beaker to another (only in case of non-conditioned sludge).

6.3.4 Close the sludge inlet, open the valve of the air pressure system and start the filtration process.

6.3.5 Record filtrate volumes, V, and corresponding times, t, only after collecting at least 10 % of the initial filtrate volume. Recording depends on flow rate and could range from every 5 s at the beginning until every 60 s or more (for sludge of low filterability) at the end. Stop the filtration when one of the following conditions occurs:

— pressure drops down (breaking of cake);

— instantaneous filtrate flow rate drops down;

— plot t/V vs. V deviates from linearity;

— filtration time exceeds 60 min.

6.3.6 Measure the dry mass of the cake after filtration in accordance with EN 12880 and measure the dynamic viscosity of the filtrate at test temperature.

6.4 Under pressure with a piston (Figure B.2 b))

6.4.1 Follow the procedure as described in 6.3.1 to 6.3.3.

6.4.2 Close the sludge inlet.

6.4.3 Insert the piston into the filtration cell. Make sure that the piston is in close contact with the sludge surface by purging the air through the air outlet.

6.4.4 Close the air outlet and close the filtration system.

6.4.5 Open the pressure system valve and start filtration.

6.4.6 Record filtrate volumes, V, and corresponding times, t, only after collecting at least 10 % of the initial filtrate volume. Recording depends on flow rate and could range from every 5 s at the beginning until every 60 s or more (for sludge of low filterability) at the end. Stop the filtration when one of the following conditions occurs:

— pressure measured by the sensor drops down (beginning of the compression phase);

— plot t/V vs. V deviates from linearity;

— filtration time exceeds 60 min.

6.4.7 Measure the dry mass of the cake after filtration in accordance with EN 12880 and dynamic viscosity of filtrate at test temperature.

NOTE In 6.2 to 6.4, it is assumed that the volume of the cake can be neglected.

In 6.2 to 6.4, results of tests carried out at different pressures have to be validated in advance.

7 Expression of results

For the calculation of the specific resistance to filtration, r, Formula (1) is used:

$$r = \frac{2 \cdot \Delta p \cdot A^2 \cdot b}{\mu \cdot m} \qquad (1)$$

where

Δp is the pressure drop across the filter;

A is the filtration area;

b is the slope of the linear part of the curve obtained by plotting t/V vs. V;

μ is the viscosity of filtrate at the temperature of the sludge (if not known, use water viscosities as a function of temperature as reported in Table C.1 by assuming that filtrate viscosity is equal to water viscosity);

m is the mass of solids deposited on the filtering medium per unit volume of filtrate.

NOTE It is assumed that filtrate viscosity is equal to water viscosity.

The following measurement units apply:

Table 1 — Measurement units

r	m/kg
A	m^2
μ	Pa · s
m	kg/m^3
C_o	kg/m^3
b	s/m^6
Δp	Pa
t	s
V	m^3

The slope of the linear part of the curve obtained by plotting t/V vs. V is to be determined between the point where linearity begins (i.e. when the regression coefficient of $t/V = f(V)$ becomes constant) and the point where filtration ends (see 6.2.4 or 6.3.5 or 6.4.6).

The procedure described is limited for extremely compressible materials such as biological sewage sludge. Specific resistance can be defined only when Formula (1) is valid, i.e. when the curve $t/V = f(V)$ is a straight line without slope variation or presents a linear part during the removal of the most important part of filtered volume, i.e.:

- the pressure drop remains constant during filtration (Δp constant);
- no sedimentation (sedimentation velocity at least < 1 mm/s) occurs (m constant);
- the initial clogging of the filtering medium does not increase during filtration (R_m constant);
- no migration of fines, deformation of particles or cracking of cake occurs during filtration (r constant).

In case of fast tests, it is possible to replace m by C_o, the initial dry residue of the sludge, provided that the sludge concentration is low (dry solids mass < 1 % of sludge mass) and mass of water in the cake inferior to mass of solids so that the mass of the cake is very low compared to the mass of the sludge. Correlation between m and C_o is given by Formula (2):

$$m = \frac{\frac{\rho_l}{\rho_{susp}} \cdot C_o}{1 - \left(1 + \frac{\rho_l}{\rho_s} \cdot \frac{\varepsilon}{1-\varepsilon}\right) \cdot \frac{C_o}{\rho_{susp}}} \quad (2)$$

where

ρ_{susp}, ρ_s, ρ_l are the respective volumetric masses of each respective suspension (solids and liquids);

ε is the cake porosity.

A sludge can be considered as filterable on industrial scale when its specific resistance to filtration is lower than 5×10^{12} m/kg at 50 kPa.

8 Precision

Results of validation trials are summarised in Annex D.

9 Test report

The test report shall include at least the following information:

a) reference to this document (EN 14701-2);

b) all information necessary for the complete identification of the sample;

c) operating conditions (pressure, temperature, filtering medium);

d) method used with a reference to this document (6.2, 6.3 or 6.4);

e) test results obtained with the respective method used;

f) any details which are optional and any details or other factors not specified in this document which may have affected the results.

Annex A
(informative)

Supplementary information to Darcy's law

Darcy's law is represented by a relationship that originates from a force-momentum balance on the fluid flowing through a filter cake or porous medium. It states that (for laminar flow) the volumetric flux of fluid, i.e. instantaneous flow rate (dV/dt) per unit area, is directly proportional to the pressure difference over the bed and inversely proportional to the bed thickness and fluid viscosity.

$$\frac{dV}{dt} = \frac{A \cdot k \cdot \Delta p}{\mu \cdot L} = \frac{A \cdot \Delta p}{\mu \cdot R} \tag{A.1}$$

$$R = R_\mathrm{m} + R_\mathrm{c} \tag{A.2}$$

$$R_\mathrm{c} = r \cdot \frac{m \cdot V}{A} \tag{A.3}$$

where

Δp is the pressure difference over the bed, in Pascal (Pa);

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

k is the cake permeability, in square metres (m^2);

L is the cake thickness, in metres (m);

μ is the viscosity of filtrate at the temperature of the sludge, in Pa · s;

R is the filtration resistance, in m^{-1};

R_c is the cake resistance, in m^{-1};

R_m is the filtering medium resistance, in m^{-1};

m is the mass of solids deposited by unit volume of filtrate, in kilograms per cubic metre (kg/m^3);

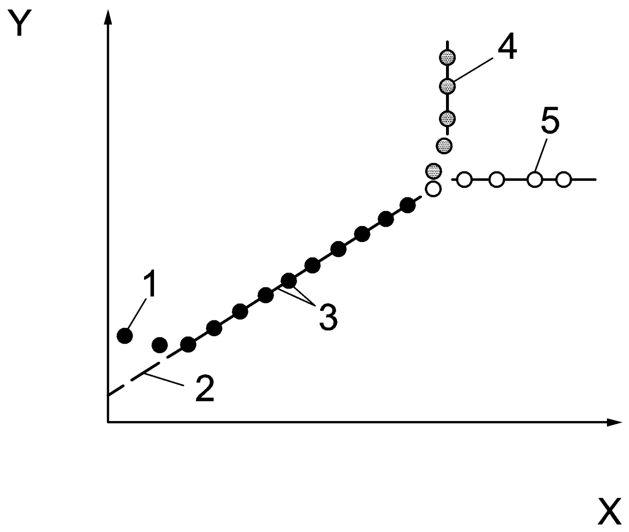
V is the volume of the filtrate, in cubic metres (m^3);

r is the specific resistance to filtration, in meters per kilogram (m/kg).

Integration of the formula above, with the assumption of constancy of r, m, R_m, and Δp leads to the following practical, linearised form of Darcy's law:

$$\frac{t}{V} = \frac{\mu \cdot m \cdot r}{2 \cdot \Delta p \cdot A^2} \cdot V + \frac{\mu \cdot R_\mathrm{m}}{\Delta p \cdot A} \tag{A.4}$$

The plot of $t/V = f(V)$ with experimental results, as illustrated in Figure A.1 is theoretically a line whose slope enables the calculation of the average specific resistance.



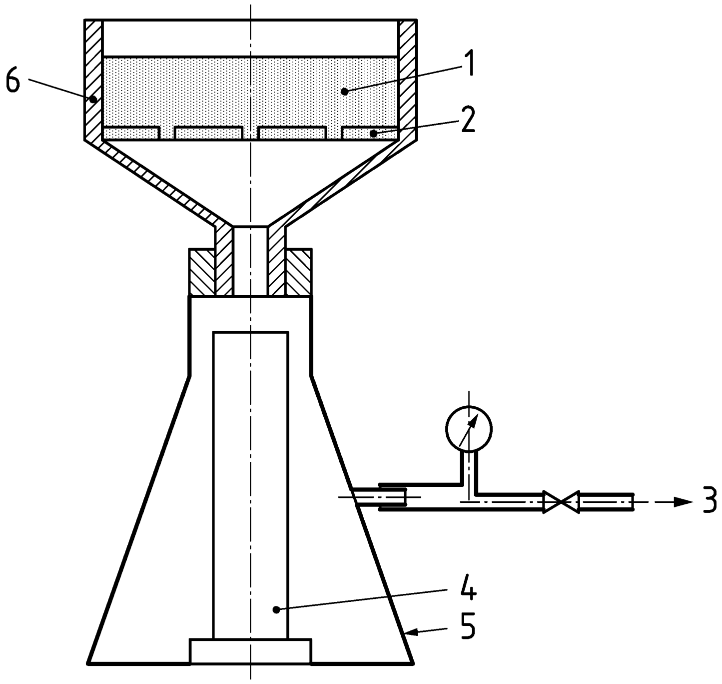
Key

1 poor experimental technique or equipment design, or prevalence of blocking over bridging
2 intercept used to calculate medium resistance
3 linear part used to calculate cake resistance
4 test depleted of feed (cake deliquored)
5 permeation through a sedimented cake
X filtrate volume
Y filtration time/Filtrate volume

Figure A.1 — Graphical interpretation of Darcy's law: Characteristic plot for constant pressure filtration

Annex B
(informative)

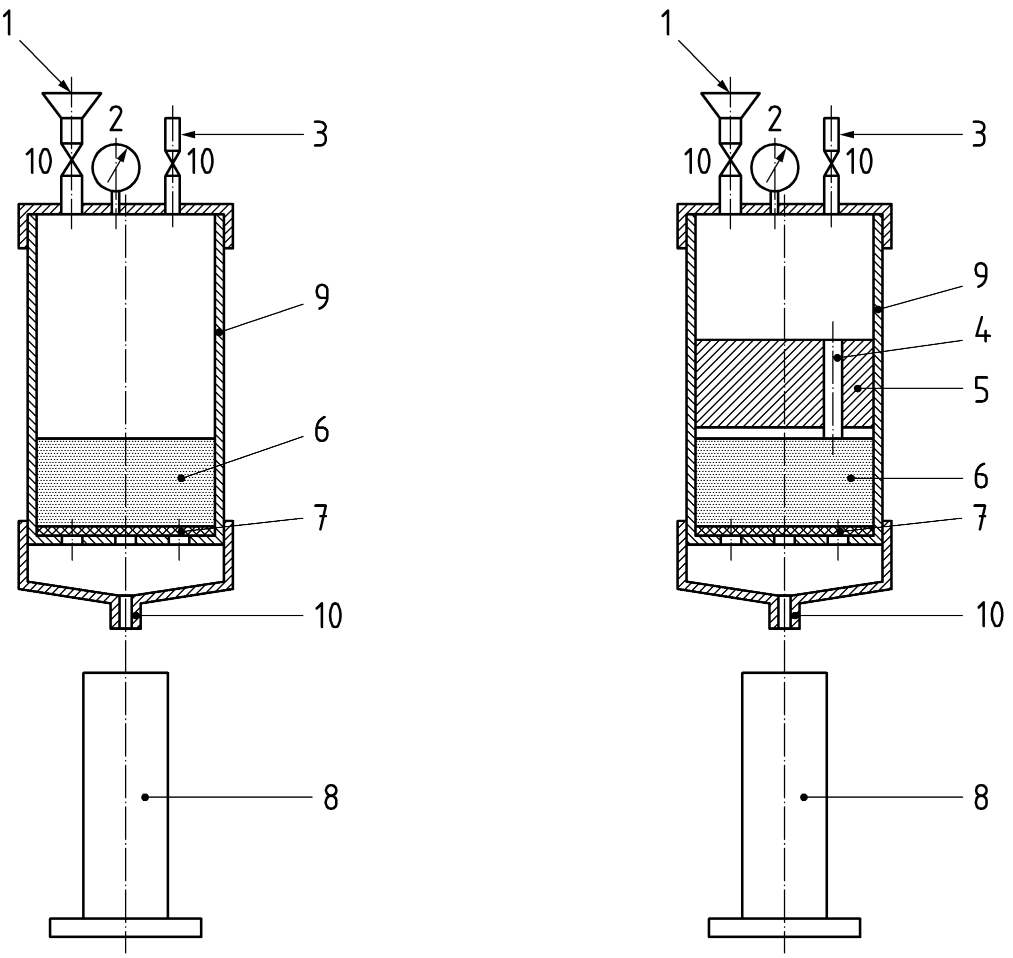
Filtration apparatus



Key

1 sludge
2 filtering medium
3 reduced pressure
4 graduated cylinder
5 flask
6 buchner funnel

Figure B.1 — Reduced pressure laboratory filter



Key

1 sludge inlet
2 manometer
3 air pressure
4 air outlet
5 piston
6 sludge
7 filter medium
8 graduated cylinder
9 filtration cell
10 valve

a) Pressure laboratory filter without piston **b) Pressure laboratory filter with piston**

Figure B.2 — Pressure laboratory filter

Annex C
(informative)

Table of viscosity

Table C.1 — Viscosity of water from 0° C to 40° C (10^{-3} Pa · s)

T (°C)	Viscosity (10^{-3} Pa · s)	*T* (°C)	Viscosity (10^{-3} Pa · s)
0	1,792 1	20,2	1,000 0
1	1,731 3	21	0,981 0
2	1,672 8	22	0,957 9
3	1,619 1	23	0,935 8
4	1,567 4	24	0,914 2
5	1,518 8	25	0,893 7
6	1,472 8	26	0,873 7
7	1,428 4	27	0,854 5
8	1,386 0	28	0,836 0
9	1,346 2	29	0,818 0
10	1,307 7	30	0,800 7
11	1,271 3	31	0,784 0
12	1,266 3	32	0,767 9
13	1,202 8	33	0,752 3
14	1,170 9	34	0,737 1
15	1,140 4	35	0,722 5
16	1,111 1	36	0,708 5
17	1,082 8	37	0,694 7
18	1,055 9	38	0,681 4
19	1,029 9	39	0,668 5
20	1,005 0	40	0,656 0
NOTE 10^{-3} Pa × s = 10^{-2} g/cm × s = 1 centipoise.			

Annex D
(informative)

Result of validation trial

Because the circulation of samples of real sludge high in organic content was not possible due to potential changes in their physical characteristics during handling and transportation, the "Modified Round Robin Tests" procedure, developed by TG 3 of CEN/TC 308/WG 1, and reported in CEN/TR 15175, was followed.

During this procedure, operators from participating laboratories meet at a laboratory close to the location of sampling and work on these same samples, each using their own apparatus.

In validation trials at Lab Instruments facilities, Turi (Bari, Italy), in 2005, the following 3 different sludge types were tested.

- **Sample 1**: Waterworks sludge
  Solids concentration (g/l): 2,840
- **Sample 2**: Sewage sludge – thickened
  Solids concentration (g/l): 23,181
- **Sample 3**: Sewage sludge – activated
  Solids concentration (g/l): 3,074

Analysis for measuring solids concentration was carried out at the Analytical Laboratory of Acquedotto Pugliese, Bari, Italy.

Test results have been statistically analysed for the evaluation of precision according to ISO 5725-2 and the reproducibility standard deviation s_R was calculated.

The following tables of results show the values of b (s/cm^6), the slope of the linear part of the curve obtained by plotting t/V vs V (see Clause 7). They contain the following symbols:

i is the operator number;

j is the sample number;

k is the test number;

s_R is the reproducibility standard deviation;

$\bar{u}_{ij}$ is the mean value of measurements of the operators;

y is the value of measurement;

y_{ijk} is the result of measurements of operator, i at sample, j.

Table D.1 — Readings of b (s/cm^6) at Δp = 50 kPa

Operator number (i)	Sample 1 (j)		Sample 2		Sample 3	
	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6
1	0,012 7 0,012 4	0,012 6	1,326	1,326	0,113	0,113
2	0,010 9 0,010 0	0,010 5	1,474	1,474	0,119 0,108	0,114
3	0,011 5	0,011 5	1,418	1,418	0,151	0,151
4	0,010 8 0,011 5	0,011 2	1,540	1,540	0,116	0,116
5	0,008 7 0,010 3	0,009 5	1,529	1,529	0,105	0,105
6	0,011 8 0,011 5	0,011 7	1,495	1,495	0,127	0,127
7	0,011 6 0,011 0	0,011 3	1,640	1,640	0,123	0,123
8	0,011 3 0,012 2	0,011 8	1,487	1,487	0,108	0,108
9	0,011 8 0,011 6	0,011 7	—	—	—	—
10	0,012 4	0,012 4	—	—	—	—
11	—	—	1,492	1,492	0,114	0,114
Mean at level (j)		0,011 4	—	1,489	—	0,119
NOTE Different orders of magnitude for *b* values have been obtained for the 3 samples. A range of 1 to 100 orders of magnitude have been covered by the tests.						

Table D.2 — Readings of b (s/cm^6) at Δp = 150 kPa

Operator number (i)	Sample 1 (j)		Sample 2		Sample 3	
	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6
1	0,009 9 0,009 6	0,009 8	1,274	1,274	0,132	0,132
2	0,007 1 0,007 0	0,007 1	1,107	1,107	0,103	0,103
3	0,009 9 0,010 2	0,010 1	1,380	1,380	0,129	0,129
4	0,009 8 0,010 0	0,009 9	1,344	1,344	0,128	0,128
5	0,007 0 0,008 3	0,007 7	1,303	1,303	0,108	0,108
6	0,010 2 0,009 9	0,010 1	1,349	1,349	0,075	0,075
7	0,007 0 0,009 8	0,008 4	1,262	1,262	0,079	0,079
8	0,008 9 0,009 6	0,009 3	1,189	1,189	0,098	0,098
9	0,009 8 0,009 7	0,009 8	—	—	—	—
10	0,007 1 0,008 0	0,007 6	—	—	—	—
11	—	—	1,347	1,347	0,146	0,146
Mean at level (j)		0,009 0	—	1,284	—	0,111

NOTE 1 Different orders of magnitude for b values have been obtained for the 3 samples. A range of 1 to 100 orders of magnitude have been covered by the tests.

NOTE 2 Statistical analysis was carried out not considering b values of tests 6 and 11 at sample 3 because they were exceeding 30 % from the relevant mean value.

Table D.3 — Readings of b (s/cm^6) at Δp = 300 kPa

Operator number (i)	Sample 1 (j)		Sample 2		Sample 3	
	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6	values (y_{ijk}) s/cm^6	mean ($\bar{u}_{ij}$) s/cm^6
1	0,005 1 0,005 2	0,005 2	1,112	1,112	0,110	0,110
2	0,005 1 0,005 6	0,005 4	0,848	0,848	0,087	0,087
3	0,008 3 0,006 5	0,007 4	1,072	1,072	0,114	0,114
4	0,006 5 0,006 0	0,006 3	0,916	0,916	0,122	0,122
5	0,006 6 0,006 5	0,006 6	0,884	0,884	0,074	0,074
6	0,006 3 0,006 7	0,006 5	0,823	0,823	0,070	0,070
7	0,006 9 0,006 5	0,006 7	1,190	1,190	0,079	0,079
8	0,005 7 0,007 9	0,006 8	0,912	0,912	0,083	0,083
9	0,005 7 0,005 5	0,005 6	—	—	—	—
10	0,006 1 0,006 8	0,006 5	—	—	—	—
11	—	—	0,994	0,994	0,129	0,129
Mean at level (j)		0,006 3	—	0,972	—	0,096

NOTE 1 Different orders of magnitude for b values have been obtained for the 3 samples. A range of 1 to 100 orders of magnitude have been covered by the tests.

NOTE 2 Statistical analysis was carried out not considering b values of test 11 at sample 3 because it was exceeding 30 % from the relevant mean value.

Table D.4 — Reproducibility standard deviation, s_R

Sample	s_R (10^{-3} s/cm^6) at (50; 150; 300) kPa	s_R (%) at (50; 150; 300) kPa
1) Waterworks sludge	0,872; 1,165; 0,691	7,6; 12,9; 11,0
Mean value	0,91	10,5
2) Sewage sludge, thickened	85,8; 88,2; 127,3	5,8; 6,9; 13,1
Mean value	100,4	8,6
3) Sewage sludge, activated	13,8; 19,7; 19,9	11,6; 17,7; 20,7
Mean value	17,8	16,7

Bibliography

[1] EN 14701-4, *Characterization of sludges — Filtration properties — Part 4: Determination of the drainability of flocculated sludges*

[2] CEN/TR 15175, *Characterization of sludges — Protocol for organizing and conducting inter-laboratory tests of methods for chemical and microbiological analysis of sludges*

[3] ISO 565, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of opening*s

[4] ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

[5] 91/271/EEC, COUNCIL DIRECTIVE of 21 May 1991 concerning urban waste water treatment

[6] BASKERVILLE, R. C. and GALE R. S., *A simple automatic instrument for determination of the filterability of sewage sludges, Journal of the Institute of Water Pollution Control,* Vol. 67, No 2 (1968), 233-241

[7] BOCKSTAL, F., FOUARGE, L., HERMIA, J., *Constant pressure cake filtration with simultaneous sedimentation, Filtration and Separation, July/August, 255-257 (1985)*

[8] RAYNAUD, M., BAUDEZ, J. C, VAXELAIRE, J., HERITIER, P., *Activated sludge dewatering in filtration compression cell: Deviations in comparison to classical theory, Asia Pacific Journal of Chemical Engineering (2009)*

[9] SPINOSA L., LOTITO V. and INFUSINO E., *Relationships between sludge rheology and dewaterability parameters, Fluid/Particle Sep. J., 4,3,176 (1991)*

[10] TILLER, F. M., *Theory and practice of solid-liquid separation, University of Houston, A 72, 544 pp., Houston Texas (1975)*

[11] YETIS, J., WILLIS, M. S., CHASE, G., *Specific cake resistance: Myth or reality, Wat. Sci. Tech. 28, 1, 91-101. (1993)*

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK