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BSI Standards Publication

Characterization of sludges — Filtration properties

Part 4: Determination of the drainability of flocculated sludges

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National foreword

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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.

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Foreword

This document (EN 14701-4:2010) 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of an identical text or by endorsement, at the latest by July 2010, and conflicting national standards shall be withdrawn at the latest by July 2010.

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.

EN 14701, *Characterisation of sludges — Filtration properties*, consists of the following parts:

— *Part 1: Capillary suction time (CST)*

— *Part 2: Determination of the specific resistance to filtration*

— *Part 3: Determination of the compressibility*

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Introduction

The determination of drainability of flocculated sludges is an important parameter for evaluating their suitability to be thickened by means of a draining process. It also gives indications for the choice of flocculant or their dosage in view of the thickening of the sludge through a filtering medium. These easy and quick tests are the best means to narrow the number of products to be tested in full scale experiments and to adapt the pre-treatment to the sludge variability.

The results obtained are the mass of filtrate collected in a standard time or the time required to recover a given volume of filtrate (commonly 50 % of the water content of the sludge), the maximum volume of filtrate and the corresponding wet and dry mass of the sludge, the undissolved solids remaining in the filtrate and the best flocculant and its optimum dose in the case of comparative tests.

1 Scope

This European Standard specifies a method for the determination of drainability of flocculated sludges. It is applicable to sludge and sludge suspensions from:

a) storm water handling;

b) urban wastewater collecting systems;

c) urban wastewater treatment plants;

d) treating industrial wastewater similar to urban wastewater (as defined in Directive 91/271/EEC);

e) water supply treatment plants.

This method is also applicable to sludge suspensions from other origin.

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.

EN 872, *Water quality — Determination of suspended solids — Method by filtration through glass fibre filters*

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
drainability
ability of treated sludge to separate from sludge liquor by gravity filtration

3.2
flocculation
coagulation by means of inorganic or organic flocculants (polyelectrolytes)

4 Sludge conditioning

For flocculation, the sludge shall be sampled already flocculated or mixed with flocculant in repeatable and quantified conditions according to CEN/TR 14742 for a laboratory preparation.

5 Principle

A given volume of flocculated sludge is poured in a filter cell equipped with a known filtering medium, the mass of filtrate collected is recorded versus time and the corresponding wet and dry mass of the sludge retained on the filtering medium and the undissolved solids remaining in the filtrate are measured.

6 Apparatus

Ordinary laboratory apparatus and the following (see informative Annex A):

6.1 Transparent tube (e.g. glass, polyethylene) of 150 mm diameter and of about 200 mm height, supported by a system composed of a filtering medium tightened in a device equipped with an appropriate sealing joint.

6.2 Filtering medium whose characteristics shall be the same as that used in the full scale drainage device and in comparative tests.

6.3 Filtrate draining device fixed under the filtering medium.

6.4 Beaker for the filtrate collection.

6.5 Weighing balance with an accuracy of at least 0,1 g connected to a computer to continuously record the cumulative mass of filtrate collected over time. The software shall be able to record data every 0,5 s.

6.6 Apparatus for the determination of dry solids content of the sludge retained on the filtering medium.

6.7 Apparatus for the determination of suspended solids in the filtrate.

NOTE To allow a correct interpretation of data, the comparison of flocculation conditions should be made with the same test equipment.

7 Procedure

a) Prepare the balance and the software to record the mass of filtrate as soon as the first drops of filtrate are collected.

b) Measure the water content of the flocculated sludge.

c) Gently pour (without shaking) (1 ± 0,2) l of flocculated sludge (record the exact mass) in the centre of the cell for the sludge to recover the whole surface of the filtering medium.

d) Record the cumulative mass of filtrate collected over time every 0,5 s at least during the first 30 s.

e) Stop the test when the mass of filtrate to initial mass of sludge ratio is constant to within 0,1 g or after 10 min.

f) Measure the concentration of suspended solids in the filtrate (see EN 872) and the wet and dry mass of the sludge retained on the filter medium (see EN 12880).

g) Repeat steps a) to f) for at least twice if repeatability measurements are needed.

8 Expression of results

Plot adimensional mass versus time:

$$\frac{M}{M_0} = f(t)$$

where

M is the mass of filtrate, in grams (g);

M_0 is the initial mass of sludge, in grams (g);

t is the time of experiment, in seconds (s).

Record the following data obtained for each test:

a) Adimensional mass of filtrate recovered at t = 30 s, t = 90 s and at the end of the test;

b) Time necessary to collect a volume of filtrate corresponding to 50 % of the water content of the sludge;

c) Dryness of the cake retained on the filtering medium;

d) Dry mass of suspended solids per unit volume of filtrate.

NOTE The optimal operating conditions of the drainage process are those for which the drainage is the fastest to remove the maximal drainable quantity of water, the mass of wet and dry solids retained on the filter medium is the highest, and the mass of suspended solids in the filtrate is the lowest.

9 Test report

The test report shall contain at least the following information:

a) Reference to this document;

b) Identification of the sludge (origin, type, identification, concentration, method of sampling and storage);

c) Identification of the flocculation conditions and preparation;

d) Characteristics of sludge and filtering medium (initial mass and water content of sludge, reference and supplier of the filtering medium);

e) Adimensional mass recovered versus time with at least the volume of filtrate collected at t = 30 s, at t = 90 s and at the end of the test;

f) Time, in seconds (s), corresponding to the collection of 50 % of the initial water content of the sludge;

g) Dry mass of the suspended solids per unit volume of filtrate (in milligrams per litre (mg/l));

h) Dryness (mass fraction in percent (%)) of sludge cake retained on the filtering medium;

i) Any detail not specified in this document or which are optional and any other factor which may have affected the results.

10 Precision

Full results of validation trials, which three types of sludge (i.e. digested sewage sludge, raw sewage sludge, and waterworks sludge) were used for, are reported in informative Annex C .

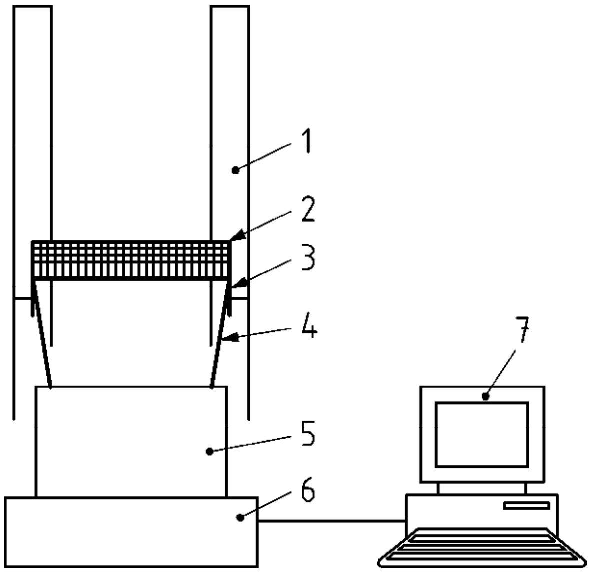
All sludge types considered, average values of relative repeatability standard deviation were 4,6 % for adimensional mass of filtrate at 30 s, 3,5 % for adimensional mass of filtrate at 90 s, 2,0 % for adimensional mass of filtrate at test end, 20 % for the time to collect 5/10 of sludge water content, 1,8 % for dryness of cake, and 14 % for suspended matter in the filtrate. Minimum value was 1,4 % for dryness of cake of both digested sewage sludge and waterworks sludge, while maximum one was 22 % for the time to collect 5/10 of water content of digested sewage sludge.

All sludge types considered, average values of relative reproducibility standard deviation were 4,3 % for adimensional mass of filtrate at 30 s, 3,2 % for adimensional mass of filtrate at 90 s, 2,6 % for adimensional mass of filtrate at test end, 20 % for the time to collect 5/10 of sludge water content, 2,3 % for dryness of cake, and 31 % for suspended matter in the filtrate. Minimum value was 1,0 % for adimensional mass of filtrate at test end of digested sewage sludge, while maximum one was 37 % for suspended matter in the filtrate of raw sewage sludge.

At least the precision data given as averages should be reached in the analysis of sludges.

Annex A
(informative)

Typical gravity drainage cell



Key

1 Cylindrical tube in transparent material
2 Filtering medium
3 Tightening device with sealing joint
4 Filtrate draining device
5 Filtrate collector (beaker)
6 Weighing balance
7 Computer

Figure A.1 — Gravity drainage cell

Annex B
(informative)

Quantity of sludge in a gravity belt filtration

The ratio of the mass of sludge to be deposited per unit surface area of the filter cloth $\left(\frac{M_0}{A}\right)$ can be calculated from the characteristics of the industrial equipment, using Equation (A.1):

$$\frac{M_0}{A} = \left(\frac{Q_b + Q_p}{L \times S_b}\right) \quad \text{(A.1)}$$

where

M_0 is the mass of sludge poured in the cell, in kilograms (kg);

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

Q_b is the sludge flow rate feeding the industrial equipment, in kilograms per second (kg/s);

Q_p is the polymer flow rate feeding the industrial equipment, in kilograms per second (kg/s);

L is the belt width, in metres (m);

S_b is the belt velocity, in metres per second (m/s).

If the characteristics of the industrial equipment are unknown, the quantity of sludge poured shall be able to build a cake whose height ranges from 1 cm to 3 cm.

Annex C
(informative)

Results of validation trials

Because the circulation of samples of real sludge high in organic content is not possible due to problems associated to 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 doc CEN/TC 308 N 822, was followed. With this procedure, the round robin tests are carried out through "circulation of analysts", i. e. operators coming from the laboratories participating to the exercise meet in a common location, close to the place where samples are collected, and work there on same samples, each using own apparatus.

Validation trials were carried out at IFTS (Institute of Filtration and Techniques of Separation) at Foulayronnes (near Agen, France), on 12-13 February 2009.

Trials involved a total of 15 operators from the following ten laboratories/institutions in five countries: Andritz (France), Cemagref (France), CNR (Italy), Cutec (Germany), DIN (Germany), IFTS (France), University of Bordeaux (France), University of León (Spain), University of Liège (Belgium), University of Pau (France).

The following three different sludge types were tested:

— Sample 1: Conditioned digested sewage sludge (initial sludge solids concentration: 2 %, flocculated with polymer KB 606[1)] prepared at 3 g/l and used at 9,4 kg/t (dry mass));

— Sample 2: Conditioned biological sewage raw sludge (initial sludge solids concentration: 3 %, flocculated with polymer EM 540 BD[2)] prepared at 3 g/l and used at 14,2 kg/t (dry mass));

— Sample 3: Conditioned sludge from drinking water treatment plant (waterworks) (initial sludge solids concentration: 9 %, flocculated with polymer EM 440 MBL[3)] prepared at 3 g/l and used at 3,2 kg/t (dry mass)).

The sludges were sampled on three different plants at proximity of Agen, already flocculated (just after the feed pump for biological and waterworks sludge and at the entrance of belt press for digested sludges), the day of the trials (the day before for waterworks sludge).

Drainage tests were carried out with filter cloth reference Si030904 from Rai-Tillières[4)] manufacturer.

All analyses for measuring solids concentration and/or dry residue were carried out at the laboratories of IFTS at Foulayronnes.

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1) KB 606 is the trade name of a product supplied by SNF Floerger, France. This information is given for the convenience of users of this European Standard 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.

2) EM 540 BD is the trade name of a product supplied by SNF Floerger, France. This information is given for the convenience of users of this European Standard 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.

3) EM 440 MBL is the trade name of a product supplied by SNF Floerger, France. This information is given for the convenience of users of this European Standard 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.

4) Si030904 is the trade name of a product supplied by Rai-Tillières, France. This information is given for the convenience of users of this European Standard 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.

Test results have been statistically analysed for the evaluation of precision according to ISO 5725-2. In particular, the repeatability standard deviation, and the reproducibility standard deviation were calculated. After compilation of data potential outliers were identified using Mandel's statistic (ISO 5725-2). All outlier-free data were then used for calculation.

Results are presented in the following six tables.

Table C.1 — Results for adimensional mass of filtrate, in grams (g), at t = 30 s

	Digested sludge	Biological raw sludge	Sludge from waterworks
Total number of participants	14	15	14
Number of participants (outliers removed)	12	14	10
Outliers	2	1	4
Average adimensional mass of filtrate, in grams (g), at t = 30 s	0,548	0,561	0,189
Repeatability adimensional mass of filtrate, in grams (g), at t = 30 s	0,029	0,016	0,011
Reproducibility adimensional mass of filtrate, in grams (g), at t = 30 s	0,035	0,012	0,008
Relative repeatability, in percent (%)	5,25	2,86	5,56
Relative reproducibility, in percent (%)	6,30	2,22	4,26

Table C.2 — Results for adimensional mass of filtrate, in grams (g), at t = 90 s

	Digested sludge	Biological raw sludge	Sludge from waterworks
Total number of participants	14	15	15
Number of participants (outliers removed)	13	12	13
Outliers	1	3	2
Average adimensional mass of filtrate, in grams (g), at t = 90 s	0,659	0,592	0,213
Repeatability adimensional mass of filtrate, in grams (g), at t = 90 s	0,020	0,012	0,012
Reproducibility adimensional mass of filtrate, in grams (g), at t = 90 s	0,018	0,014	0,009
Relative repeatability, in percent (%)	3,1	2,03	5,51
Relative reproducibility, in percent (%)	2,68	2,31	4,46

Table C.3 — Results for adimensional mass of filtrate, in grams (g), at the end of the test

	Digested sludge	Biological raw sludge	Sludge from waterworks
Total number of participants	14	15	15
Number of participants (outliers removed)	11	10	11
Outliers	3	5	4
Average adimensional mass of filtrate, in grams (g), at the end of the test	0,728	0,619	0,294
Repeatability adimensional mass of filtrate, in grams (g), at the end of the test	0,008	0,010	0,010
Reproducibility adimensional mass of filtrate, in grams (g), at the end of the test	0,007	0,012	0,015
Relative repeatability, in percent (%)	1,16	1,56	3,23
Relative reproducibility, in percent (%)	0,99	1,96	4,98

Table C.4 — Results for time, in seconds (s), to collect 5/10 of the sludge water content

	Digested sludge	Biological raw sludge	Sludge from waterworks
Total number of participants	14	15	[a]
Number of participants (outliers removed)	12	13	
Outliers	2	2	
Average time, in seconds (s), to collect 5/10 of the sludge water content	20,4	11,5	
Repeatability time, in seconds (s), to collect 5/10 of the sludge water content	4,5	2,0	
Reproducibility time, in seconds (s), to collect 5/10 of the sludge water content	5,4	1,6	
Relative repeatability, in percent (%)	22,0	17,8	
Relative reproducibility, in percent (%)	26,7	13,7	

[a] Filtration of sludges from waterworks was very slow, for all participants this time was > 600 s. Therefore the exact time was not recorded.

Table C.5 — Results for dryness of cake, in percent (%)

	Digested sludge	Biological raw sludge	Sludge from waterworks
Total number of participants	14	15	15
Number of participants (outliers removed)	11	12	11
Outliers	3	3	4
Average dryness of cake, in percent (%)	6,6	6,5	12,4
Repeatability dryness of cake, in percent (%)	0,09	0,16	0,18
Reproducibility dryness of cake, in percent (%)	0,10	0,24	0,23
Relative repeatability, in percent (%)	1,35	2,49	1,41
Relative reproducibility, in percent (%)	1,50	3,59	1,89

Table C.6 — Results of suspended matters in filtrate, in milligrams per litre (mg/l)

	Digested sludge	Biological raw sludge	Sludge from waterworks
Total number of participants	14	15	15
Number of participants (outliers removed)	12	10	11
Outliers	2	5	4
Average suspended matters in filtrate, in milligrams per litre (mg/l)	1 074	104	9 014
Repeatability suspended matters in filtrate, in milligrams per litre (mg/l)	153	20	703
Reproducibility suspended matters in filtrate, in milligrams per litre (mg/l)	258	39	2 889
Relative repeatability, in percent (%)	14	19	8
Relative reproducibility, in percent (%)	24	37	32

Bibliography

[1] 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*

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