SLOVENSKI STANDARD
oSIST prEN 14702-3:2017

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Karakterizacija in ravnanje z blatom - Določevanje lastnosti usedanja - 3. del: Določevanje hitrosti usedanja

Characterization and management of sludge - Determination of settling properties - Part 3: Determination of zone settling velocity (ZSV)

Charakterisierung von Schlämmen - Absetzeigenschaften - Teil 3: Bestimmung der Sinkgeschwindigkeit

Caractérisation et management des boues - Détermination des propriétés de sédimentation - Partie 3: Détermination de la vitesse de sédimentation

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Characterization and management of sludge - Determination of settling properties - Part 3: Determination of zone settling velocity (ZSV)

Caractérisation et management des boues - Détermination des propriétés de sédimentation - Partie 3: Détermination de la vitesse de sédimentation

Charakterisierung von Schlämmen - Absetzeigenschaften - Teil 3: Bestimmung der Sinkgeschwindigkeit

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

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European foreword

This document (prEN 14702-3:2017) has been prepared by Technical Committee CEN/TC 308 "Characterization and management of sludge", the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

The EN 14702 series consists of the following parts:

— *Characterisation of sludges — Settling properties — Part 1: Determination of settleability (Determination of the proportion of sludge volume and sludge volume index)*;

— *Characterisation of sludges — Settling properties — Part 2: Determination of thickenability*;

— *Characterization and management of sludge — Determination of settling properties — Part 3: Determination of zone settling velocity (ZSV)*.

Introduction

In wastewater treatment plants sludge thickening occurs in the lower portions of clarifiers and in separate thickening tanks. Due to wide variation in sludge settling properties both final clarifiers and thickeners should, if possible, be designed on the basis of pilot plant data. Continuous-flow pilot units are expensive and difficult to operate so design criteria for the process are mostly based on batch thickening tests.

A number of parameters have been developed to obtain a quantitative measure of the settleability of sludge. All of these tests are based on one of two basic approaches.

The first approach uses the volume of the sludge occupied after a fixed period of settlement. In this approach laboratory tests [1 and 2] are conducted by allowing a sludge to thicken in a small graduated cylinder, without (SVI: Sludge Volume Index) or with stirring (SSVI: Stirred Sludge Volume Index) and evaluating the proportion of the sludge volume is recorded. These characterization tests are easily performed and have a widespread use in routine process control for sludge quality comparison in settling tanks or by scientists who tried to correlate these indexes to sludge velocity and to aid thickener design [3]. The use of these indexes for sizing/optimizing decanters and static thickeners should be done with care as they are influenced by laboratory artefacts (channeling and bridging effects, turbulences caused by filling, shallow depth by partial support through the solids from the bottom to the vessel, impact of stirring on sludge) [4].

The second approach uses the subsidence velocity of the solid/liquid interface of the sludge at its initial concentration calculated from the straight-line portion of the resulting curve. This parameter should be measured in large-diameter columns having a depth with the same order of magnitude as industrial thickener. Following the interface between the solid and liquid phase enables the determination of the (zone) settling (or sedimentation) velocity (SV) of the sludge (initial slope of the curve) and compression point (intersection of the linear sedimentation zone and the asymptotic falling zone). The use of sedimentation curve data after the compression point enables to calculate the required time and theoretical area of the thickener to obtain the desired sediment concentration [5].

The sedimentation velocity and compression point are basic parameter for decanters/static thickeners sizing [6] and are linked directly to phenomena occurring in the industrial devices. This measurement can evaluate the impact of sludge chemical conditioning on the size and design of the thickener or on the process productivity. A decanter/thickener well sized will enable further sludge treatment as lowest cost for its volume reduction.

1 Scope

This draft European Standard specifies a method for determining the zone settling velocity (ZSV) and the Compression point.

This draft European standard is applicable to sludge and sludge suspensions from:

— storm water handling;

— urban wastewater collecting systems;

— urban wastewater treatment plants;

— plants treating industrial wastewater similar 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 are referred to in the text 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.

EN 14742, *Characterization of sludges — Laboratory chemical conditioning procedure*

EN 16323, *Glossary of wastewater engineering terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 16323 and the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
settleability
ability of sludge solids to separate from water by sedimentation under gravity

3.2
zone settling (or sedimentation) velocity
ZSV
vertical distance covered by a group of particles per time unit

3.3
compression point
critical time in a gravity sedimentation where the sludge in the thickening zone begins to compress

3.4
theoretical thickener area
required area per unit of solids and time to concentrate sludge according a given factor

4 Principle

The principle of the measurement lies on the sludge introduction in a vertical cylinder and on the following of the interface between the free supernatant and the concentrated sediment versus time.

The introduction of suspension under vacuum in well adapted for sludge flocs as it limits the shearing action and consequently the flocs breakage.

ZSV is given by the slope of the straight line part of the interface height versus time curve. The ZSV decreases as the solids concentration increases. The zone settling curve is composed of two stages: a constant - rate period, when the interface height versus time curve is a linear function, and a compaction period when the interface plot is curved (corresponding settling velocity is a variable and is generally less that the initial zone settling velocity).

The interface height versus time curve gives not only the zone settling velocity but also the compression point by the graphical construction illustrated in Figure 1 and the theoretical surface unit (Annex A).

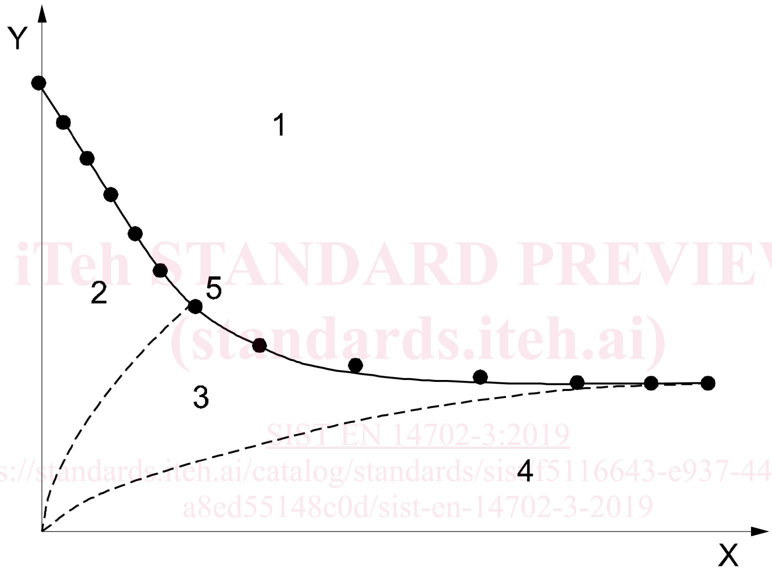

Figure 1 — Compression point in a gravity sedimentation (1) clear liquid, (2) uniform concentration (3) sediment in compression, (4) sediment deposit

5 Interferences

Initially, when following the interface height versus time, there is usually an induction period that is followed by the linear settling portion, which is supposed to be characteristic of the initial solids concentration in the column. It is attributed to the formation of the solids structure most appropriate for settling.

The settling velocity of flocculent suspension depends on the conditions under which the aggregates were formed. The flocculation step shall be carried out according to EN 14742.

The settling of particles in a fluid generally takes place in a container of finite dimensions that could be expected to have some effects on the sedimentation velocity. The effect is bound to be related to the size of the solids relative to the container d/D and it is likely to be more relevant for dilute systems where particle/particle and particle-wall hydrodynamic interaction effects could be of the same order. The diameter should be much greater than the particle diameter, generally at least 4 to 5 orders of magnitude greater.

6 Equipment

An example of the required device is illustrated in Annex A. It includes the following elements:

6.1 Storage/Flocculation tank.

It is used for sludge storage and flocculation according to EN 14742.

An example of appropriated dimensions is:

Height: 40 to 44 cm

Diameter: 25 to 26 cm

Exit pipe at the bottom of the tank, in the middle point, minimum diameter: 25 mm

6.2 Stirrer.

A mechanical stirrer with 3 or 4 horizontal perpendicular blades is set in the storage tank, allowing the modification and control of mixing speed.

NOTE In case of important sludge volumes, a 3 or 4 staged PVC blades (15 cm to 20 cm x 3cm x 0,5 cm) impeller could be used with a distance of 10 cm between each blade.

6.3 Feed/Draining valve.

6.4 Measurement cell.

Column in glass or plexiglass.

Internal diameter: 9 to 10 cm

Height: 120 cm for determination of settling velocity, 220 cm for determination of sludge thickening kinetics (after compression point)

The cylinder could be composed of one part or several parts, gathered by adapted devices. It is closed with PVC flanges with openings. It is recommended to set different sampling valves with a distance of 20 cm between each valve (the last set up at a distance between 100 mm to 120 mm from the bottom of the column) to facilitate recovery of the different phases (sediments and supernatants) at the end of the test.

— Inferior flange: central opening crossed by a pipe (diameter around 6 mm) for liquid feed

— Superior flange: central opening crossed by a pipe (diameter around 6 mm) for vacuum

A meter, set on the cylinder, enables to measure the interface level.

The death volume between the zero level and the draining vane.

6.5 Vacuum pump.

It allows the filling of the column until the required height with a time inferior to 1 min.

6.6 Vacuum trap.

6.7 Vent valve.

6.8 Chronometer.

7 Procedure

7.1 Put the sludge volume (minimal volume: 10 L) in the storage tank (6.1), start the stirrer (6.2) by adjusting the mixing speed in order to ensure a good homogenization without modifying particles size.

If the test requires the use of conditioners, add them in the storage tank according to EN 14742.

7.2 Check the connection between the vacuum pump, the vacuum trap and the column head and the vacuum after starting the pump

7.3 After sample homogenization and/or coagulation/flocculation steps, open the feed valve (6.3), start the vacuum pump (6.5), let the sludge going up in the column (6.4) until the required level (100 or 200 cm) then close the feed valve (6.3)

7.4 Open/close in a short time the 3 ways feed valve (6.3), allowing the entrance of one or two big air bubbles whose the rise sample homogenization of the sample in the column. As soon as bubbles achieve the surface level (in around 1 min), start a chronometer (6.8). Stop the vacuum pump and open the column to atmosphere by opening vent valve (6.7).

7.5 Record the height of interface between sediments and clear supernatant versus time, the data recording frequency is function of sludge velocity.

It is recommended to record data at least every minute during the 5 first minutes, every 5 min until 15 min, every 15 min until 1 h and every 30 min until 2 h. If sedimentation is slow, the recording can continue beyond 2 h.

NOTE 1 For sludge thickening kinetics (after compression point), stop the test when the interface height is stabilized (variation of height interface < 5 % after 1 h).

NOTE 2 If there is no interface formed, see Annex B.

7.6 Recover the supernatant with the closest sampling valve from the interface. Recover the sediment by opening the draining valve. If supernatant is recovered with sediment, pour the mixture in an Imhoff cone and measure accurately the sediments volume. Recover separately the supernatant and the sediments and measure the dry solids on the sediment.

The standard temperature condition of the test shall be (20 ± 0,5) °C. If any other temperature is used it shall be included in the test report.

8 Expression of the results

The zone settling velocity is measured by the slope of the linear part of the curve: Interface height versus time. Annex B presents different cases of measuring the slope, including case where there's no interface.

The compression point is determined by the intersection of the sedimentation curve with the bisector of the 2 linear parts of the sedimentation curve.

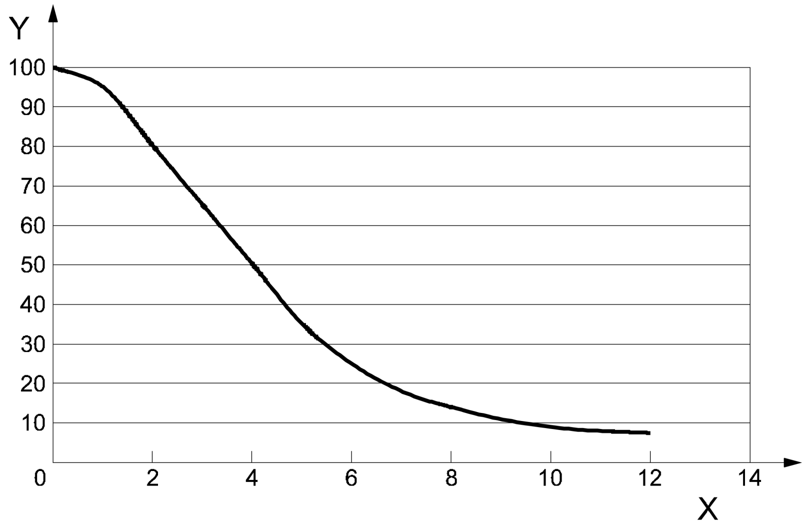

Figure 2 — Compression point

Annex C presents a geometric construction method developed by Talmage and Fitch [3] for using a single-batch settling curve to establish the area required for an arbitrarily selected rate-limiting layer.

9 Precision

Results of validation trials are summarized in Annex D.

Mean measured values of Zone settling velocity were 5,59 m/h for Kaolin sludge at 30 g/L solids concentration (sludge A), 12,93 m/h for Waterworks sludge at 0,41 g/L (sludge B), and 1,08 m/h for Inorganic sludge at 80 g/L (sludge C).

The Repeatability standard deviation ranged 2,169 % for sludge C to 11,760 % for sludge B. Mean value resulted 5,912 %.

The Reproducibility standard deviation ranged 4,855 % for sludge C to 15,862 % for sludge B. Mean value resulted 10,587 %.

As regards the Compression point, mean measured values were 0,260 % for Kaolin sludge at 30 g/L solids concentration (sludge A), 0,094 % for Waterworks sludge at 0,41 g/L (sludge B), and 0,190 % for Inorganic sludge at 80 g/L (sludge C).

The Repeatability standard deviation ranged 3,099 % for sludge C to 9,144 %) for sludge B. Mean value resulted 5,308 %.

The Reproducibility standard deviation ranged 9,774 % for sludge A to 18,088 %) for sludge B. Mean value resulted 12,580 %.

10 Test report

The test report shall contain at least the following information:

a) reference to this document;

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

c) details of sample preparation (e.g. dilution, flocculation conditions, temperature, etc.);

d) results of calculations according to Clause 8;