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Characterization of sludges - Physical consistency - Part 1: Determination of flowability - Method by extrusion tube apparatus

Charakterisierung von Schlämmen - Physikalische Beschaffenheit - Teil 1: Bestimmung des Fließverhaltens - Verfahren mit Gerät mit Extrusionsrohr

Caractérisation des boues - Consistance physique - Partie 1: Détermination de l'aptitude à l'écoulement - Méthode utilisant un appareil à tube d'extrusion

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Characterization of sludges - Physical consistency - Part 1: Determination of flowability - Method by extrusion tube apparatus

Caractérisation des boues - Consistance physique - Partie 1: Détermination de l'aptitude à l'écoulement - Méthode utilisant un appareil à tube d'extrusion

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European foreword

This document (EN 16720-1:2016) has been prepared by Technical Committee CEN/TC 308 "Characterization and management of sludge", 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of an identical text or by endorsement, at the latest by November 2016 and conflicting national standards shall be withdrawn at the latest by November 2016.

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 16720, *Characterization of sludges - Physical consistency* consists of the following two parts:

— *Part 1: Determination of flowability - Method by extrusion tube apparatus*

— *Part 2: Determination of solidity* (in preparation)

According to the CEN-CENELEC Internal Regulations, the national standards organizations 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 evaluation of physical consistency is recognized to be very important since it affects almost all treatment, utilization and disposal operations, such as storage, pumping, transportation, handling, land spreading, de-watering, drying, landfilling. It is also to be pointed out that in many analytical methods for sludge characterization (e.g. pH, dry matter, leachability, etc.), different procedures are required depending on whether the sample to be examined is liquid or not. No standardized procedures have previously been available for the evaluation of this sludge property.

Physical consistency is a characteristic strictly linked to the rheological properties of fluids. Details on flow behaviour of fluids are available in Annex A (informative).

Flowability represents the boundary area between the liquid and the paste-like physical state, i.e. the state in which a sludge is able to “flow” under the effect of gravity or pressure below a certain threshold (CEN/TR 15463).

This document defines a method for determining the flowability of sludge (Flowability index, F_{i}) by means of an extrusion tube apparatus.

1 Scope

This part of the European Standard specifies a method for determining the flowability, as defined in CEN/TR 15463, of sludge by means of the extrusion tube apparatus.

This part of this 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, 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 16323:2014, *Glossary of wastewater engineering terms*

CEN/TR 15463:2007, *Characterization of sludges - Physical consistency - Thixotropic behaviour and piling behaviour*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 16323:2014 and the following apply.

3.1
dynamic viscosity
ratio of the applied shear stress to the shear rate (velocity gradient) in a rotating viscometer

Note 1 to entry: Dynamic viscosity is the measure of the resistance to flow of a liquid.

3.2
flowability index
F_i
parameter indicating whether a sludge is in the “liquid” physical state or not, i.e. is able to flow under the effect of gravity or pressure below a certain threshold

3.3
non-Newtonian fluid
fluid having a non-constant shear stress to shear rate ratio

3.4
shear rate
measure of the spatial change in speed at which the intermediate layers move with respect to each other

3.5
shear stress
force per unit area required to produce the shearing action

3.6
yield stress
minimum shear stress to initiate flow

4 Principle

The flowability of sludge can be evaluated through several procedures using different devices (see CEN/TR 15463). A simple way, at both the laboratory and field scale, consists of measuring the Flowability index F_i by means of an extrusion tube apparatus (cylindrical container equipped with standardized discharge pipes at its bottom, 5.1). The flowability index is related to the yield stress and is expressed in the same units (see Clause 8).

F_i is determined by measuring the height of the sludge remaining in the cylinder above the discharge pipe fitted at its bottom when the flow through the pipe becomes discontinuous. The measured height value allows the corresponding value of F_i to be calculated through the simplified flow equation in straight pipes, often referred to as the Bingham model.

NOTE Theoretically, the liquid physical state can be defined in the absence of yield stress. However, sludge can be considered a liquid when yield stress is below a certain level.

5 Equipment

5.1 Extrusion tube apparatus

The standard extrusion tube apparatus is shown in Figure B.1. It consists of a cylindrical transparent container, 100 mm internal diameter and 350 mm deep, to which pipes (in PVC or similar material) 200 mm long and with internal diameter of 5 mm, 10 mm and 20 mm can be fitted at its bottom. The apparatus shall be provided with a scale graduated in millimetres to measure the height of the sludge remaining in the cylinder above the discharge pipes at the end of the test.

To avoid additional errors, each pipe of different diameter shall have its upper side at the same height from the bottom of the vessel (see Figure B.2).

The apparatus shall be vertically mounted on a stable support, free of vibrations.

5.2 Beakers/containers, pouring beakers/containers of appropriate capacity.

5.3 Thermometer, with a precision of 0,5 °C.

5.4 Sieve, mesh size maximum 2,5 mm.

6 Test sample

Sufficient volume of the test sample to fill up the apparatus (about 3 l) is required.

The presence of coarse particles or lumps of aggregate in the suspension can cause clogging phenomena. If necessary, the sample shall be sieved to exclude particles larger than 2,5 mm (see 5.4).

Furthermore, test could be negatively affected by fast-settling particles, clogging phenomena and presence of air bubbles, especially in the discharge pipes. Pour carefully the sludge in the cylinder along the wall to minimize bubbles. If necessary, homogenization at adequate stirring speed in the cylinder should be guaranteed to limit settling. Pre-sieving could limit clogging, but if it appears during test appropriate de-clogging actions could be adopted.

7 Procedure

7.1 Level the apparatus to assure verticality.

7.2 Fill up the cylinder with the sample by keeping closed the end side of the pipe(s) fitted at the bottom and while avoiding the presence of air bubbles. Make the transfer in such a manner that the sample will be manipulated as little as possible.

7.3 Let the flow start from the discharge pipe with diameter of 20 mm until flow becomes clearly discontinuous or intermittent, i.e. when the flow is reduced to one drop falling per second. At this time stop the flow and measure the height of the sludge remaining in the cylinder above the upper side, not the center, of the discharge pipe.

7.4 Repeat steps 7.1 to 7.3 with the 20 mm diameter pipe.

7.5 If the above measured 2 values differ by more than 1 cm from their mean value when it is ≤5 cm or 20 % from their mean value when it is >5 cm, repeat steps 7.1 to 7.3 in order to have at least two significant values.

7.6 Repeat steps 7.1 to 7.5 with the 10 mm diameter pipe.

7.7 Repeat steps 7.1 to 7.5 with the 5 mm diameter pipe.

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

By measuring the height of the sludge remaining in the cylinder at the end of the test above the discharge pipe, the flowability index (F_i) can be calculated through Formula (1):

$$F_i = 3/8 \times \rho \times g \times h \times r / l \qquad (1)$$

where

F_i is the flowability index, in Pa;

3/8 is the hydraulic equation ratio for laminar flow (this is generally the case of sludge having yield stress);

ρ is the sludge density, in kg/m^3;

g is the gravity acceleration, in m/s^2;