SLOVENSKI STANDARD
SIST-TP CEN/TR 15473:2008

01-julij-2008

Karakterizacija blata - Dobra praksa pri sušenju blata

Characterization of sludges - Good practice for sludges drying

Charakterisierung von Schlämmen - Gute fachliche Praxis zur Schlammtrocknung

Caractérisation des boues - Bonne pratique pour le séchage des boues

Ta slovenski standard je istoveten z: CEN/TR 15473:2007

ICS:
13.030.20 Tekoļ i odpadki. Blato Liquid wastes. Sludge

SIST-TP CEN/TR 15473:2008 en,fr

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 15473

March 2007

ICS 13.030.20

English Version

Characterization of sludges - Good practice for sludges drying

Caractérisation des boues - Bonne pratique pour le séchage des boues

Charakterisierung von Schlämmen - Gute fachliche Praxis zur Schlammtrocknung

This Technical Report was approved by CEN on 27 August 2006. It has been drawn up by the Technical Committee CEN/TC 308.

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Ref. No. CEN/TR 15473:2007: E

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Foreword

This document (CEN/TR 15473:2007) has been prepared by Technical Committee CEN/TC 308 "Characterization of sludges", the secretariat of which is held by AFNOR.

The status of this document as CEN/TR has been chosen because much of its content is not completely in line with practice and regulations in each member state. This document gives recommendations for good practice concerning the drying of sludges, but existing national regulations remain in force.

Introduction

All the information of this CEN Technical report constitutes a framework for the process of drying sludges.

Various Directives will apply to thermally dried sludge products depending on the use to which they are to be put. These Directives include Directive 86/278/EEC(see [1]) for recycling to land, Directive1999/31/EC (see [2]) for disposal to landfill and Directive 2000/76/EC (see [3]) for incineration and energy recovery and Directive 94/9 for equipment intended for use in potentially explosive atmospheres (see [4]).

This document should be read in the context of the requirements of these Directives and any other relevant regulations, standards and codes of practice, which may prevail locally within Member States.

1 Scope

This CEN Technical report describes good practices for sludge drying and it is one of a series on sludge management options. It gives guidance on

- drying processes;
- characteristics of dried sludge products;
- recycling or disposal of dried sludge products.

from **urban wastewater treatment** plants.

Sludges of other origin, like sludge from water supply or industrial treatment plants are not in the exact scope of this CEN Technical Report, however the handling of most of these sludges will comply to a large extent with the leads given in this CEN Technical Report.

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 1085, *Wastewater treatment – Vocabulary*

EN 12832, *Characterisation of sludges – Utilisation and disposal of sludges –Vocabulary*

CR 13714, *Characterisation of sludges – Sludge management in relation to use or disposal*

CEN/TR 13767, *Characterisation of sludges – Good practice for sludges incineration with and without grease and screenings*

CEN/TR 13768, *Characterisation of sludges – Good practice for combined incineration of sludges and household wastes*

CEN/TR 15126, *Characterisation of sludges – Good practice for landfilling of sludges and sludge treatment residues*

3 Terms , definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document the terms and definitions given in EN 1085, EN 12832 and CR 13714 apply and also those given in:

Directive 91/271/EC (see [5]) concerning urban wastewater treatment;

Directive 75/442/EC (see [6]) the waste framework directive as amended by Directive 91/156/EC (see [7]);

Directive 99/31/EC (see [2]) on the landfill of waste;

Directive 86/278/EEC (see [1]) on the protection of the environment, and in particular the soil, when sewage sludge is used in agriculture;

Directive 2000/76/EC (see [3]) on incineration;

Directive 94/9 (see [4]) for equipment intended for use in potentially explosive atmospheres;

Directive 99/92/EC (see [8]) on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres;

and the following terms and definitions apply:

3.1.1
adhesion or shearing phase

phase, which exists in a range of some 40 % to 60% dry residue content, where the sewage sludge changes its rheological behaviour. Within this phase there is a "sticky mass" whose treatment and transportation is to be given special attention. Above the adhesion phase the sewage sludge has, in many cases, depending on the drying equipment, a more crumbly/lumpy structure that makes it easier to handle

3.1.2

fully dried / partly dried sludge
sludge dried above 85% dry residue content is defined as “fully dried” and sludge of dry residue content below 85% as “partly dried”

3.1.3

convection dryer
drying system where the heat is transferred to the product by a gaseous medium which is in intimate and direct contact with the product

NOTE The evaporated water is thus mixed with the drying medium and the exhaust gases from the dryer consist of the drying gas including leakage air plus the evaporated water. Convection dryer can operate with direct or indirect heating.

3.1.4
conduction dryer
drying system where the heat is transferred through an intermediate heat transfer surface to the product

NOTE The medium, which supplies the heat to the product, is never in direct contact with it. The total exhaust gas amount leaving the dryer is the evaporated water plus some leakage air. Therefore a conduction dryer is always operated with indirect heating.

3.1.5
solar dryer
drying system where the heat is transferred to the product by solar radiation

3.1.6
combined drying system
system, which uses both principles, convection and conduction in the same dryer

3.1.7
hybrid drying system
system that consists of a combination of a conduction dryer and a convection dryer

3.1.8
direct heating
off gas from the burner is in contact with the drying product

3.1.9
indirect heating
heating loop is crossing a heat exchanger

3.2 Abbreviated terms

BOD Biological Oxygen Demand

COD Chemical Oxygen Demand

HAZOP Hazard and Operability Studies

LCV Lower Calorific Value

LIT Layer Ignition Temperature

LOC Limiting Oxygen Concentration

MEC Minimum Explosion Concentration

MIE Minimum Ignition Energy

MIT Minimum Ignition Temperature

MPOC Maximum Permissible Oxygen Concentration

PLC Programmable Logic Controller

RTO Regenerative Thermal Oxydizer

SCADA System Control, Alarm and Data Acquisition

VOC Volatile Organic Carbon

WWTP Waste Water Treatment Plant

4 General

The drying of sewage sludge is a complex process but it can contribute to the need for increased disposal security for sewage sludge. With dried sewage sludge, a wider potential customer market can be approached than for liquid or dewatered products. It can be recorded that the range of those willing to accept sewage sludge can be expanded if one offers dried sewage sludge. In any case, the opportunity for marketing sewage sludge can be extended considerably which, in turn, represents an additional security for disposal and/or utilisation. The overview of thermal dryer types is given in Figure 1.

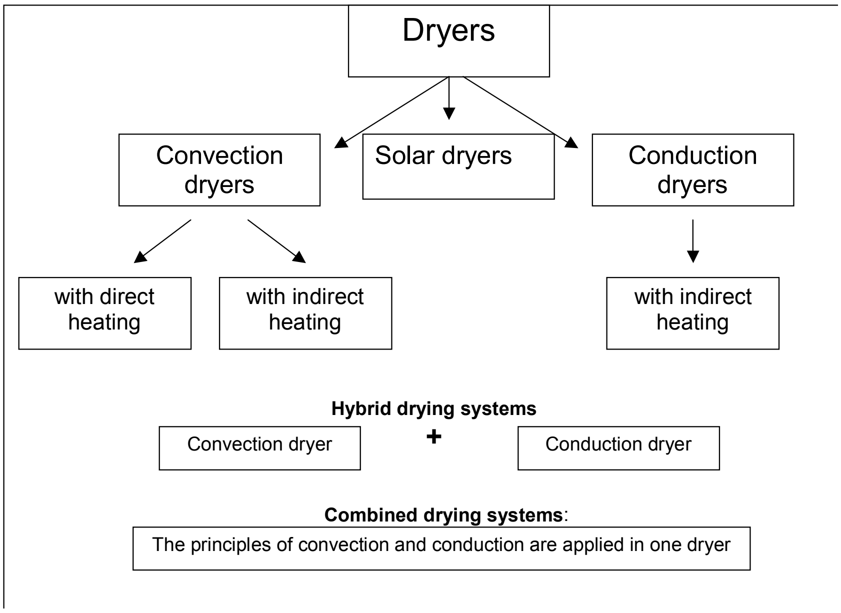


Figure 1: Overview on thermal dryer types

Thermal drying of sludge can result in the following advantages for almost all outlet routes:

- Substantial minimisation of the bulk of sludge for disposal. Thus 1 t dry residue of sludge at 90% represents 1,1 t actual or wet mass of sludge for disposal, but 1 t dry residue of sludge at 5% represents 20 t wet mass of sludge for disposal. Minimisation of sludge mass and volume by thermal drying results in savings in transport costs, which can be a major component of disposal costs.

- The removal of water leaves a thermally dried sludge product with a lower calorific value (LCV) (about 10 MJ/kg to 15 MJ/kg, depending e.g. upon the extent of pre-treatment), which can be used for thermal recycling.

- The thermally dried sludge product has favourable properties, as it is usually handable and storable, which lends flexibility to operations.

- For recycling to agriculture, in particular, there is the advantage that thermal drying is an ‘advanced treatment process whereby the dried sludge product gets sanitised and effectively free of pathogens at the end of the process.

Whilst the thermally dried product has definite advantages over other types of sewage sludge, there are some reservations (Brown and Jacobs, 2001 (see [9])) about the thermal drying process as follows:

- High capital cost (see 7.2.1);

- High operating cost, mainly energy consumption (see 7.2.1);

- Safety issues, particularly risk of fire and explosion (see clause 8);

- Technology can be complex and needs some well trained operators (see 7.3);

- The thermally dried product can be re-infected by micro-organisms and as a result of rewetting odour can be released after storage dependent upon the conditions of storage.

The thermally dried sludge product can reach a dry residue content up to about 95% mass fraction. In most instances thermal drying of sludge will aim to achieve a dry residue content of more than 50% in order to avoid the adhesion or shearing phase.

5 Treatment process description

5.1 General

There are numerous designs of thermal drying equipment available on the market and many of these have been adapted from other industries and used for sewage sludge drying. Few have been designed specifically for sewage sludge.

The equipment can be classified into four main groups defined by the drying process:

- Conduction dryers;
- Convection dryers;
- Combined or hybrid drying system;
- Solar dryers (radiation dryers).

5.2 Conduction dryers

5.2.1 General

A conduction dryer is a drying system where the heat is transferred through an intermediate heat transfer surface to the product.

The medium, which supplies the heat to the product, is never in direct contact with it. The total exhaust gas volume leaving the dryer is the evaporated water plus some leakage air. Therefore conduction dryers are always operated with indirect heating.

5.2.2 Disc dryers

Disc drying plants are - dependent on their shape - in a position to dry sewage sludge, both partially and completely. With this, complete drying is made possible using a mixing machine placed before the dryer. Here, a part of the already dried product is mixed with the dewatered sludge and thus overcoming of the adhesion phase is achieved outside the dryer. Plants for full drying, as special structures, are also used by which the return admixture takes place in the input area of the dryer.

Wear problems and dried sludge behaviour (fines and dust) have contributed to the decline in use of disc dryers for full drying. In the majority of cases, disc dryers are used to dry sludge up to a dry residue content below the shearing phase (for an auto thermal incineration).

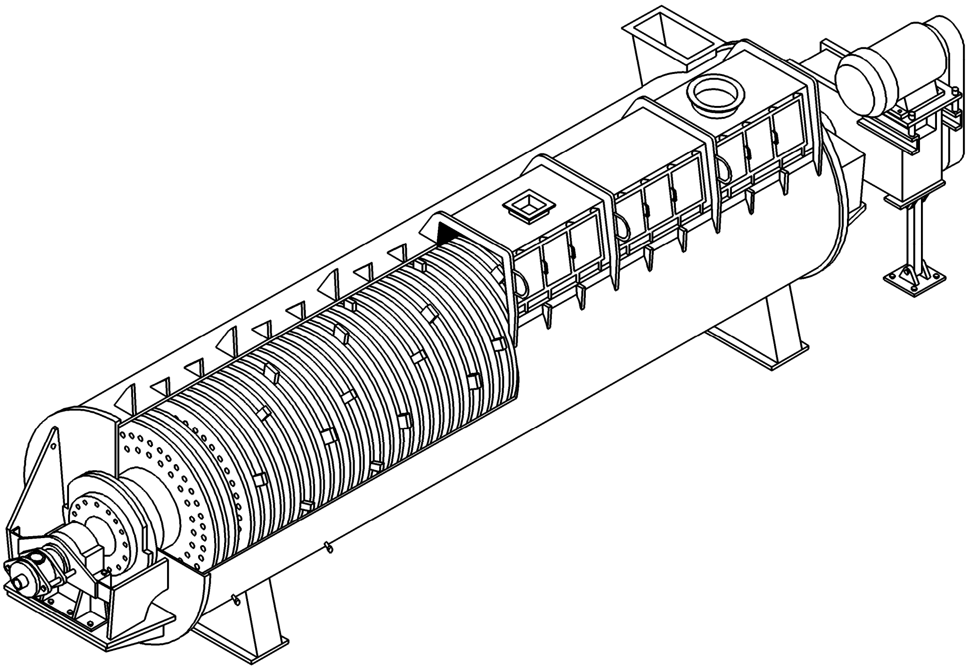


Figure 2: Disc dryer[1)]

The disc dryers (see Figures 2 and 3) are constituted of:

- A stator or body
- A rotor composed of a hollow shaft with hollow discs shaped as plates and welded on it.

A heating fluid crosses the rotor, either saturated steam up to approximately 1 MPa (10 bar) or thermal oil, which transfer thermal energy to the dewatered sludge, through the disc's surface. A process variant can additionally have the stator heated. The thermal oil (or steam) is heated in a boiler, usually fired with fossil fuel or biogas.

Vapours exhaust from the superior dome of the dryer, which should be correctly designed for effective transfer to a cyclone or a scrubber (partial drying at 45 %). As the residence time of the sludge in this type of dryer is rather large (around 1h), the vapours are usually highly polluted. However, one advantage of an indirect conduction dryer is that the volume of polluted vapours is small and kept separated from the flue gases of the energy source.

Due to the slow rotation of the rotor (circumferential velocity approximately 1 m/s) the sewage sludge is well mixed and a new interface for drying is continuously created. The requirements of the start-up condition are, met with the design of the drive.

Transport paddles, by which the sewage sludge is transported axially in the dryer, are additionally mounted on the rotor discs. However, in order to dry past the sticky phase, it is necessary to recycle some dry product upstream.

1) This dryer is an example of a suitable design of thermal drying equipment available commercially. This information is given for the convenience of users of this CEN Technical Report and does not constitute an endorsement by CEN of this equipment. The manufacturer has given the authorisation to reproduce the scheme included in SIL documentation.

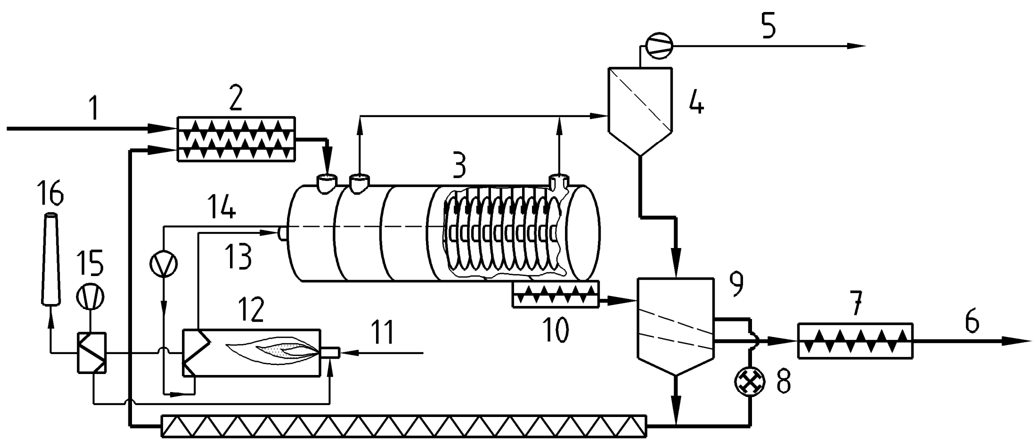
The dryer discs are subjected to high wear and corrosion loads, which should be taken into account through the selection of suitable materials or appropriate wear reserves, and in terms of maintenance and life time. Particularly stressed areas can additionally be armoured. The rotor has a considerable mass so that reverse-bending stresses also need to be accounted for.

Through the small separation of the discs it is possible to create a large surface area for heat transfer- related to the dryer volume. This means that disc dryers can be made very compact. The following specific evaporation performances have been documented (ATV-DVWK 2001 see [10]):

- With full drying plants of approximately 7 kg to 10 kg H_2O evaporated / (m^2.h) and
- With partial drying plants of greater than 11 kg H_2O evaporated / (m^2.h)

The degree of drying of the product is, as a rule, set via the input sludge quantity, which is proportional to the filling level of the sludge in the dryer and to the ratio of return, mixed dried material. To control the filling level and maximise the contact surface with the sludge, either pressure pick-up cells or gamma radiation level detectors are used.

In practice, for a daily start up and shut down, the operational flexibility of disc dryers is difficult to manage because of the high energy heat stored in the heating medium. As there are permanently large sewage sludge quantities with varying degrees of dryness in disc dryers, a quick shutdown of the plant is not possible. Consequently, there is a danger that sewage sludge can bake on to the discs (particularly with a sudden removal from service and extended standstill periods). Therefore several hours are to be allowed for start-up and closedown procedures so that disc-drying plants are best operated continuously.



Key

1 Dewatered sludge
2 Mixer
3 Disc dryer
4 Solids separator
5 Exhaust vapour treatment
6 Dry material
7 Cooler
8 Grinder
9 Sieving plant
10 Feed screw
11 Oil/gas
12 Burner
13 Steam
14 Condensate
15 Air feed
16 Exhaust gas

Figure 3: Disc drying plant for full drying[2)]

5.2.3 Paddle dryers

These dryers are composed of a horizontal body, in which two shafts are rotating in opposite directions. Each shaft bears special paddles, of wedge-shaped type. The paddles of the first shaft are staggered, in relation to the second one.

The main difference with a disc dryer is in the design of the paddles and the high torque, which allow complete drying without dry sludge feedback.

2) This is an example of a suitable design of thermal drying equipment available commercially. This information is given for the convenience of users of this CEN Technical Report….and does not constitute an endorsement by CEN of this equipment. The ATV-DVWK has given the authorisation to reproduce this scheme included in document ATV-DVWK 2004, see [11].

The dewatered sludge to be dried is fed at one extremity of the dryer and flows out to the other extremity, carried in part by the rotation of shafts and inclination of the dryer.

The heating medium (steam or thermal oil from the boiler) is fed simultaneously to the dryer shell, the shafts and the paddles.

The vapours escape to a lateral condenser. There is a little control air swept in.

The body, shafts and paddles are manufactured with special and resistant steel. The surface of the paddles and body are quite smooth.

Typical features of a paddle dryer are:

- Low shaft rotation speed (about 10 tr/min), in order to limit the risks of wear;
- Good homogeneity of temperature in the sludge bulk, which allows a good control and avoids a local overheating;
- The paddle construction and the smooth surface enables self cleaning and an excellent thermal transfer (up to 20 kg H_2O evaporated /(m^2.h);
- For full drying, there is no need for any back mixing of dried sludge; the shearing phase is overcome by kneading action;
- It can accommodate possible variations of sludge dry residue content;
- The high residence time (up to 4 h) is effective for pathogen reduction.

The operation of paddle dryers is similar to disc dryers, but special attention is required to control the plastic phase, which can move along the dryer when different sludges are processed.

5.2.4 Thin film dryers

Thin film dryers consist of a horizontal stator with double walled cylinder and an internal rotor. The heat energy in the form of saturated steam or thermal oil is fed to the dryer via the double jacket of the cylinder.

Two kinds of thin film dryers can be differentiated:

- Total indirect dryer;
- Mixed dryer with an internal fluidised effect for sludge transportation.

a) **Thin film dryer with mechanical transportation of sludge** (see Figures 4 and 5)

The function of the internal rotor, with its welded-on distributor and transport elements, is to build up and spread the dewatered sewage sludge in a 5 mm to 15 mm thick layer on the inner circumference of the stator. In this manner a continuously renewed contact interface is ensured and sludge is exchanged very intensively at the heated wall.

The design of the rotor provides a spiral shaped carrier for the dried material along the heating surfaces as far as the discharge side. A continuous blending and breakdown of agglomerates, which could possibly form in the adhesion phase, is achieved through the freely moving pivoted flaps of the rotor. The rotor can be matched to various sludges by changes to the paddles (rotor design) during stoppages.

By using a special blade configuration fitted on the rotor, sludge is exchanged very intensively at the heated wall. These blades have different functions as:

- Feed transfer elements. These pieces transport the sludge from the feed point into the heated area, they are located at the dryer inlet;
- Twisted transportation elements. They have the function of conveying the sludge through the dryer at slow or high speed;