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Karakterizacija blata - Smernica za dobro prakso toplotnih procesov

Characterization of sludges - Guideline of good practice for thermal processes

Charakterisierung von Schlämmen - Anleitung für die gute fachliche Praxis thermischer Prozesse

Caractérisation des boues - Lignes directrices relatives aux bonnes pratiques pour les procédés thermiques

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This Technical Report was approved by CEN on 25 November 2014. It has been drawn up by the Technical Committee CEN/TC 308.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (CEN/TR 16788:2014) has been prepared by Technical Committee CEN/TC 308 “Characterization of sludge”, the secretariat of which is held by AFNOR.

This document supersedes CEN/TR 13767:2004 and CEN/TR 13768:2004.

Introduction

It is recognized that wastewater sludge is a potential source of valuable resources. Material recycling is higher in the waste hierarchy (ref. 2008/98/EC Directive) than recovery (energy and material). Sludge incineration and other organic matter treatments by thermal processes (gasification, pyrolysis and wet oxidation) should deal with materials which do not meet beneficial use requirements. They represent a consistent year round solution. To decide which type of solution is appropriate for a particular sludge, Figure 1 should be consulted.

Thermal processes involve, among others, reduction of volume and weight, highest destruction of toxic organic compounds, possible recovery of phosphorus and other useful materials. Drawbacks include high costs and complexity of plant operation.

In all cases, the energy balance (including energy for removing water etc.) and carbon footprint of the processes should be calculated to verify the environmental benefit of the process.

A good performance of a thermal processing plant also depends upon the provision of proper auxiliary equipment and devices, which include receiving and storage systems, pre-treatments equipment, feeding system, flue gas cleaning, heat recovery, ash handling, wastewater disposal and process monitoring.

The purpose of this Technical Report is to describe good practice for sludge incineration and other organic matter treatments by thermal processes in order to ensure a safe and economical operation. The main goals are to:

— describe the principal design parameters relevant to different process schemes;

— assess the operating procedures able to perform optimal energy balance, emissions control and equipment durability;

— provide the responsible authorities with well-established and easily applicable protocols for control purposes;

— promote the diffusion of good practice;

— contribute to taking appropriate decisions.

Priority should be given to reduction of pollutants at the origin and to recover, if technically and economically feasible, valuable substances (e.g. phosphorus) from sludge and derived products.

As part of a process and company quality approach, the relevant issues are therefore:

— exploiting the operating data and the statutory inspections carried out;

— rendering the process reliable, optimizing and of perpetuating it, as well as guaranteeing a permanent development;

— maintaining a climate of confidence between the authorities, the sludge producers, the transporters, the incineration plant and waste disposal site operators and allowing the services to be provided on a contractual basis.

The local considerations to be taken into account are:

— the adoption of a more convenient solution with respect to other options;

— the geographical context, the client population and therefore the potential input material as well as the expected developments;

— the proximity of the sewage treatment plant and the local transportation network;

— the capacity of treatment plants.

All of the recommendations of this document constitute a framework within which the thermal processes can be proposed in addition to and/or as a substitution for land utilization, landfilling when allowed, or any other process when relevant situations occur and appropriate conditions are met.

The management of sludges both upstream and downstream of the treatment process to ensure that it is suitable for the outlets available is outlined in CEN/TS 13714:2013.

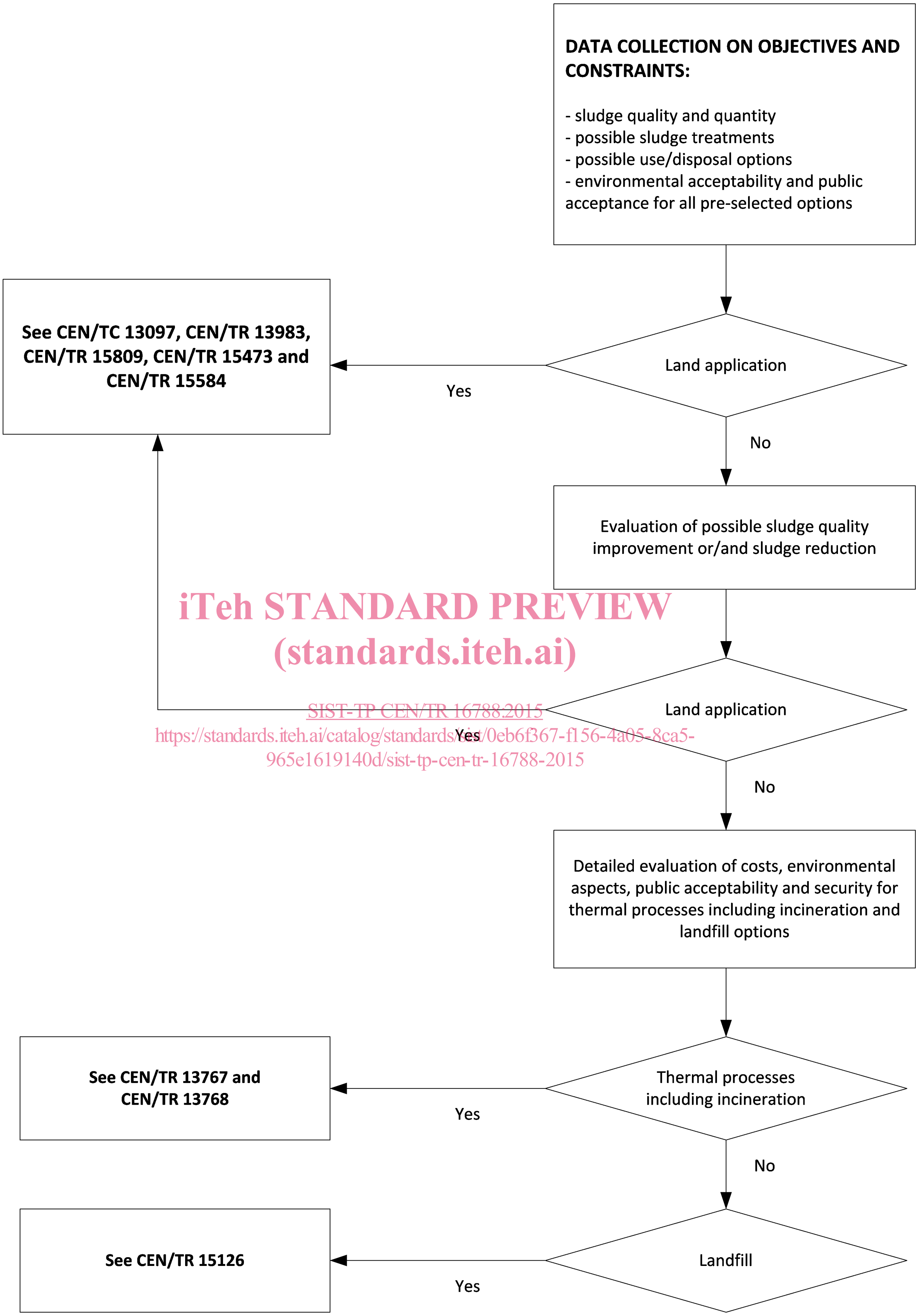

Figure 1 — A basic scheme for deciding on sewage sludge use/disposal options and the relevant CEN/TC 308 guidance documents

1 Scope

This Technical Report describes good practice for the incineration and other organic matter treatment by thermal processes of sludges.

Thermal drying, thermal conditioning and thermal hydrolysis are excluded.

This Technical Report is applicable for sludges described in the scope of CEN/TC 308 specifically derived from:

— storm water handling;

— night soil;

— urban wastewater collecting systems;

— urban wastewater treatment plants;

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

but excluding hazardous sludges from industry.

2 Normative references

Not applicable.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
thermal treatment
reduction of organic matter by incineration, gasification, pyrolysis and wet air oxidation

3.2
thermal process
technique for the application of thermal treatment

3.3
combined thermal treatment
thermal treatment of sludge and other waste in the same device

3.4
pyrolysis
thermal treatment without supply of oxygen

3.5
gasification
thermal treatment with less than the stoichiometric supply of oxygen or air (partial combustion)

3.6
furnace
enclosed chamber where combustion of organic matter takes place

3.7
boiler
specific part of the thermal treatment plant where heat exchange takes place in view of recovering heat and energy

3.8
flue gas treatment
any physical or chemical process aimed at cleaning the gas emission resulting from the thermal treatment with the regard to their discharge into the atmosphere

3.9
bottom ash
combustion residue collected at the bottom of combustion furnaces

3.10
fly ash
solid material that is entrained in a flue gas stream

3.11
energy recovery
activity to use combustible waste as a means to generate energy through thermal treatment with recovery of heat

3.12
recycling
activity in a production process to process waste materials for the original purpose or for other purposes, excluding energy recovery

3.13
slag
partially glassy by-product obtained by cooling a mineral liquid phase

3.14
energy efficiency
amount of energy and/or heat recovery in relation to the energy content of input material

3.15
wet air oxidation
aqueous-phase oxidation of organics under pressure, using either air or oxygen as the oxidant

3.16
syngas
mixture of gases (including carbon monoxide, hydrogen, methane, etc.) produced from gasification or pyrolysis process

3.17
char
combination of non-combustible materials and carbon produced from devolatization, gasification or pyrolysis process

3.18
combustion
chemical and exothermical reaction with full oxidation of combustible materials

4 Abbreviations

For the purposes of this document, the following abbreviations apply.

BAT	Best Available Techniques
COD	Chemical oxygen demand
DM	Dry Matter
ELV	Emission Limit Values
GCV	Greater (or gross) Calorific Value
HTFB	High Temperature Fluidized Bed
LCV	Lower (or net) Calorific Value
LOI	Loss On Ignition
LPO	Low pressure oxidation
MHF	Multiple Hearth Furnace
MHV	Medium heating value
MSW	Municipal solid waste
NO_x	Nitrogen oxides
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PCDD	Polychlorodibenzodioxins
PCDF	Polychlorodibenzofurans
RKF	Rotary Kiln Furnace
SCR	Selective catalytic reduction
SNCR	Selective non-catalytic reduction
TOC	Total organic carbon
UDG	Up-draught or Counter-current gasifier
WWTP	Wastewater treatment plant

5 Regulatory aspects

European regulations on thermal treatment of waste have been merged in Directive 2010/75/EU on industrial emissions. This text merges seven previous European directives concerning the main industrial sectors and especially the directives on the incineration of wastes (Directive 2000/76/CE) and on integrated pollution prevention and control (Directive 2008/1/CE).

For the European regulation, an incineration plant is dedicated to the thermal treatment of wastes with or without recovery of the combustion heat generated. This includes the incineration by oxidation of waste as well as other thermal treatment processes such as pyrolysis, gasification or plasma processes in so far as the substances resulting from the treatment are subsequently incinerated (this is not applicable if the gases resulting from the thermal treatment of waste (pyrolysis or gasification) are purified to such extent that they are no longer a waste and they cause emission no higher than those resulting from the burning of natural gas).

Incineration plant shall operate with a permit including provisions related to operating condition and emission limit values. Best Available Techniques shall be considered for all stages of the life cycle of the thermal treatment plant: conception, operation and closure.

Some of the operating conditions are, among others the following:

— a level of incineration, such that the slag and bottom ashes TOC content, shall be less than 3 % or their loss on ignition less than 5 % of the dry weight of the material shall be achieved;

— the gas resulting from the process shall reach, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, the temperature of 850 °C. If hazardous waste with a content of more than 1 % of halogenated organic substances is incinerated the temperature shall be at least 1 100 °C. These temperatures shall be measured near the inner wall or at another representative point of the combustion chamber as authorized by the competent authority and kept for 2 s;

— an automatic system to prevent waste feed shall be operated when temperatures are below prescribed values;

— any heat generated by the incineration process shall be recovered as far as practicable.

Limits are also given for (i) water discharges from the cleaning of exhaust gases, (ii) flue gas emission and (iii) residues which shall be recycled, where appropriate, directly in the plant or outside in accordance with relevant legislation.

The Emission Limit Values (ELV) are fixed in accordance with the emission values which are reachable with the implementation of the Best Available Techniques (BAT). With the revision of the integrated pollution prevention and control directive (2008/1/EC) and the publication of the Industrial Emission Directive (2010/75/EU), the ELV cannot exceed the Best Available Technique associated emission level.

The emission limit values are reported in Annex A. It can be seen that the main difference from the previous directives is the half-hourly average emission limit values.

6 Sludge properties

6.1 General

Sludge characterization for the assessment of thermochemical processes involves the evaluation of both technical and economic parameters. The main technical characteristics to evaluate the suitability of thermochemical processing are dry matter or moisture content, calorific value, ash content. The main economic parameters are cost of processing, collection and transport, and the characteristics of the recovered materials and by-products.

6.2 Physico-chemical characteristics

6.2.1 General

The main physico-chemical characteristics to be taken into account are:

— dry matter (or moisture content);

— loss on ignition;

— calorific value;

— amount of grease, scum and screenings.

Physical consistency, together with rheological properties, also play an important role, especially as far as the design of feeding system is concerned.

6.2.2 Dry matter

The dry matter (DM), or moisture content, is of primary importance for thermal processes because it strongly affects the Lower Calorific Value (LCV) of organic material which decreases when the moisture content increases.

In thermal processing of sewage sludge dry matter is a parameter affecting both fuel requirement and exhaust gas production. Generally speaking, any increase in dry matter is believed to be beneficial in the combustion for the reduction in fuel requirement. When the condition for autogenous combustion, at a given temperature, is reached the increase in dry matter corresponds also to a decrease in combustion gases production. It should be pointed out that any further increase of dry matter beyond the limit of autogenous combustion involves a more abundant gas production, due to dilution air or water needed for the control of the combustion chamber temperature depending on design of incineration plant. However, the use of water, reduces the quantity of recoverable heat in the boiler.

Moreover, if after-burning of combustion gases should be accomplished, the feeding of too dry a sludge to the furnace implies also very abundant fuel requirements in the after-burning chamber due to high gas production.

6.2.3 Loss on ignition

The loss on ignition represents the portion mass escaping as gas as a result of the ignition of the dry mass of sludge.

The loss of ignition is generally used as a measure of the volatile matter content but it should be noted that inorganic substances or decomposition products (e.g. H_2O, CO_2, SO_2, O_2) are released or absorbed and some inorganic substances are volatile under the reaction conditions.

It is measured by heating sludge in a furnace at (550 ± 25) °C and expressed as percent of the dry mass. The loss on ignition can be used as an assessment of the organic part of the sludge, and is therefore related to its heat value.

The presence in the sludge of iron with oxidation during ignition from iron (II) to iron (III), and of calcium hydroxide or calcium oxide, when sludge is conditioned with lime, can involve decreasing of the loss on ignition value (EN 12879).

6.2.4 Calorific value

Calorific value of sludge is a very important parameter for the evaluation of thermal processes, as it represents the heat quantity developed in the combustion process by the unit mass of material in standard conditions.

The Calorific Value can be expressed as (see EN 15170):

— Greater (or Gross) calorific value (GCV) at constant volume with both the water of the combustion products and the moisture of the sludge as liquid water;

— Lower (or Net) calorific value (LCV) obtained by calculation from the Gross calorific value provided that either the hydrogen content of the sludge or the amount of water found in the combustion test has to be determined.

Sludge usually contains much water, combustible and incombustible solids. Therefore their calorific value, especially on the “as received” basis – is quite low.

The calculation of calorific value of sludge is based on LOI (loss on ignition or organic matter content).

Typical calorific values of municipal wastewater sludge range from 22 100 kJ/kg *LOI* to 24 400 kJ/kg *LOI* (anaerobically digested primary) to 23 300 to 27 900 (raw primary). Secondary sludge display values between 20 700 kJ/kg *LOI* and 24 400 kJ/kg *LOI*.

GCV and LCV values can be calculated according to the standard method EN 15170, while the procedures for the theoretical calculation of GCV and LCV are reported in Annex B.

6.2.5 Grease, scum and screening

Grease, scum and screenings can be thermally treated together with sludge but generally they pose several problems.

Screenings clog feed mechanisms for certain types of furnace and therefore grinding or shredding is advisable before feeding. Screenings also contain bulky and incombustible materials, which create problems in the ash disposal system.

Skimmed material generally contains more than 95 % moisture and therefore it should be dewatered to at least 25 % solids before treatment. Skimming is difficult to handle in the dewatered state due to its viscosity and a heating process to 70 °C - 80 °C is generally requested to get skimming pumpable. After dewatering, scum solids should be ground to a size not exceeding 6 mm. *GCV* of skimming and screenings are in the range 37 000 to 44 000 kJ/kg DM and 23 000 to 25 600 kJ/kg DM, respectively.

Quantities of screenings are strictly dependent on the screen openings: they can vary in the range of $3x10^{-6}$ m^3/m^3 to $40x10^{-6}$ $m^3/m^3$of sewage for openings of 12 mm to 25 mm (the upper limits apply to the reduced openings). As dewatered sludge production can be approximately evaluated in 1 l/m^3 of sewage the screenings production can be accounted in approximately 0,2 % to 4 % in mass of sludge production, considering that the density of wet screenings is 640 kg/m^3 to 1 000 kg/ m^3.

Quantities of scum are very much dependent on the quality of the sewage and on the collecting system in the wastewater treatment plant: the highest values can be as high as 17 g of DM/m^3 of sewage which means up to 1,7 % of sludge production. At a concentration of 25 % this value increases to 6,8 %.

The quantity of any added material, especially grease, scum and screening, is limited by the capacity and the efficiency of the gas treatment.

6.2.6 Physical consistency and others

The physical consistency of the sludge will influence the selection and design of thermal processes.

Therefore, the evaluation of specific parameters giving information on this aspect (e.g. flowability, solidity, piling behaviour) appears useful in this designing step.

Other characteristics influencing thermal processes are particle size, bulk density and morphology.

6.3 Chemical characteristics

6.3.1 General

The main chemical characteristics to be taken into account are:

— sulphur;

— phosphorus;

— nitrogen;

— chlorine and other halogens;

— organic micro pollutants;

— trace elements (especially mercury).

The presence of the above mentioned chemicals has to be known in order to prevent or minimize toxic emissions (gaseous, liquid, solid) from thermal processes.