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Standard Guide for Alkaline Stabilization of Wastewater Treatment Plant Residuals[1]

This standard is issued under the fixed designation D6249; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This document provides guidance for use of reactive alkaline materials (quicklime, hydrated lime, high lime fly ash, or other byproducts) for treating wastewater solids (biosolids) to reduce pathogen levels and achieve compliance with regulatory requirements. Federal (40 CFR, Part 503) regulations for use or disposal of biosolids became effective on March 22, 1993; refer to USEPA regulations and guidance documents for information on other treatment processes or for specific requirements for use or disposal of biosolids.

1.2 Additional requirements may be imposed by individual states, and these are available through state regulatory agencies that issue permits for treatment and use or disposal, or both, of biosolids.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This guide does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C25 Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime

C110 Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone

2.2 *USEPA Publication:*

Title 40, Code of Federal Regulations (CFR), Part 503, Standards for the Use or Disposal of Sewage Sludge; Final Rules, 58 FR 9248-9404[3]

3. Terminology

3.1 *Acronyms*—These are defined by operating parameters (for example, time, temperature) whose values must be met in order for biosolids to be used in various ways as a nutrient source/soil conditioner. Ref. 40 CFR Part 257.

3.1.1 *PFRP*—Processes to Further Reduce Pathogens (equivalent to 503 Class A).

3.1.2 *PSRP*—Processes to Significantly Reduce Pathogens (equivalent to 503 Class B).

4. Significance and Use

4.1 Operators of power and other plants producing alkaline by-products and wastewater treatment plant operators needing to treat and manage wastewater solids will find this guide helpful in dealing with their materials.

[1] This guide is under the jurisdiction of ASTM Committee C07 on Lime and Limestone and is the direct responsibility of Subcommittee C07.02 on Specifications and Guidelines.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

***A Summary of Changes section appears at the end of this standard**

4.2 This guide provides the tests, procedures, and parameters that should be considered to significantly reduce pathogens in wastewater treatment plant solids by the addition of manufactured or by-product alkaline materials(**1**).[4]

5. Alkaline Materials Characteristics

5.1 *Chemical Composition:* Alkaline materials may be tested for Available Lime Index (ALI) in accordance with the optional chemical test of Table 1. Other chemical components, if required, may be determined in accordance with the appropriate procedure when requested by the purchaser.

5.2 *Reactivity:*

5.2.1 Alkaline materials should be tested for pH and heat of hydration (heat rise or slaking rate) in accordance with the recommended tests of Table 2.

5.3 *Physical Characteristics:*

5.3.1 Alkaline materials should be tested to determine the particle size in accordance with the recommended physical tests of Table 3.

6. Process Performance

6.1 *PFRP (Class A) Alkaline Treatment of Biosolids:*

6.1.1 *Mixing*—Thorough mixing of the biosolids and stabilization reagent must be provided to ensure uniform pH distribution and pathogen reduction throughout the biosolids mass (**2**). Effective mixing depends upon achieving the appropriate ratio of alkaline material to biosolids cake uniformly distributed throughout the treated biosolids.

6.1.1.1 Biosolids with a high moisture content will require less mixing energy than high-solids biosolids cake.

6.1.1.2 Biosolids characteristics will determine the proper type of equipment or system required for adequate mixing. Incomplete mixing can cause odor release during product storage or application and may lead to failure to meet regulatory requirements for pathogen and vector control.

6.1.2 *Particle Size:*

6.1.2.1 Given an adequate moisture supply using alkaline agents (for example, CaO) with smaller particle sizes will facilitate rapid and efficient mixing of agents with biosolids and increase reaction rates and pH, resulting in higher temperatures and greater pathogen reduction.

6.1.2.2 Since dusts are more easily generated from finely divided particles, precautions should be taken to prevent exposure to eyes and mucous membranes, which may result in irritation.

6.1.2.3 Reactivity and particle size also affect the rate of dust and mist emissions from reactors or mixing devices, or both. Particulate release may require scrubbing, water spray, or other emission controls on reactors or mixing devices for aesthetic reasons or to meet regulatory requirements.

6.1.2.4 Very small particle size may also lead to "air slaking" or recarbonation of active lime particles if the material is exposed to high humidity. Air slaked/recarbonated materials will not achieve the pH necessary to meet regulatory requirements.

6.1.3 *Reactivity (Heat and pH Elevation):*

6.1.3.1 Reactivity is dependent upon the interaction between the alkaline reagent and the material to be treated. Reactions occur as the alkaline material contacts the biosolids. The finer the alkaline product, the greater the potential for a more rapid pH/temperature elevation.

6.1.3.2 Reagent reactivity affects mixing time and dosage rate and must be considered in process design.

6.1.4 *Moisture Content:*

6.1.4.1 Adequate moisture must be present to react with the free CaO (as measured by Available Lime Index, ALI, ~~as per~~ in accordance with Test Methods C25) to generate heat and elevate pH. Generally, dry biosolids cakes (18 to ~~30 %)~~ 30 % solids) require a more intimate mix to ensure proper penetration and reaction than is required by wet biosolids (less than ~~18 %).~~ 18 % solids).

6.1.4.2 The calcium oxide in the reagent must react with the moisture in biosolids (hydration) producing calcium hydroxide and heat. The moisture content in the biosolids mass must be sufficient to allow the hydration reaction to occur between the selected reagent (CaO concentration and fineness) and biosolids mass.

6.1.4.3 Biosolids cakes with a high moisture content will tend to react faster than biosolids with a low moisture content.

6.1.5 *Biosolids Type:*

TABLE 1 Optional Chemical Test

Test Method	Component	Specification
C25	Available Lime Index (ALI), %	[A]

[A] To be specified only as required by purchaser.

[4] The boldface numbers in parentheses refer to the list of references at the end of this guide.

TABLE 2 Recommended Reactivity Tests

ASTM Test Method	Component	Specification
C25	pH	≥ 12.0[A]
C110[B]	Heat rise, C	[C]

[A] Based on 40 CFR Part 503 for pH >12 for 2 h or more.
[B] Modify Test Method C110 to proportion alkaline reagent ~~in lieu~~ instead of quicklime. Alkaline material and water ratio may need to be modified to obtain measurable results. Any modification of Test Method C110 must be clearly stated on the analysis report.
[C] To be specified only as required by purchaser.

TABLE 3 Recommended Physical Test

ASTM Test Method	Component	Specification
C110	Amount retained on 600 µm (No. 30 mesh), %	[A]
C110	Amount retained on 75 µm (No. 200 mesh), %	[A]

[A] To be specified only as required by purchaser.

6.1.5.1 Case-by-case alkaline material demand should be determined for each biosolids type through pilot testing using the actual biosolids cake and proposed reagents for each project. Develop process guidelines for alkaline additions by biosolids type and alkaline additive characteristics.

6.1.5.2 Biosolids with a high moisture content may require a higher dose ratio than drier dewatered biosolids cake when dosage ratios are expressed on a dry weight basis.

6.1.6 *Reaction Time and Curing Time:*

6.1.6.1 Heat will be generated as hydration of calcium oxide occurs. The reaction time will vary depending on reagent composition moisture content of the biosolids mass, and mixer efficiency.

6.1.6.2 Reaction times to effect pathogen reduction are established by applicable federal and state regulations. Reaction/cure times depend upon a number of variables and should be pilot-tested using the actual biosolids cake, alkaline admixture, mix unit, cure vessel, and testing protocol and acceptance criteria to assure compliance with regulatory standards.

6.1.6.3 For alkaline treatment processes, one of the three performance criteria is required:

(1) The time-temperature relation established in 40 CFR 503.32 (a) (3) (Alternative 1). Selected time-temperature values are as follows:

Biosolids	Temp, °C	50	55	60	65	70	75	80
Moisture >7 %	Time, hours	316	63	13	2.5	0.5	0.10	0.020
Moisture <7 %	Time, hours	120	24	4.8	0.95	0.19	0.04	0.008

(2) The pH-time, temperature-time, drying procedure in 40 CFR 503.32 (a) (4) (Alternative 2). Basically, the biosolids are held at a pH above 12 for 72 hours with a 12-hour period in which the temperature exceeds ~~52°C,~~ 52 °C, followed by air drying to a solids content exceeding 50 %.

(3) Pasteurization (40 CFR 503, App. B, Part B—PFRP Option 7) in which the biosolids are maintained at a minimum temperature of ~~70°C~~ 70 °C for 30 minutes.

6.1.6.4 Ammonia or other odors released may require water spray, scrubbing, gas capture, or control of emission.

6.1.7 *Reaction/Cure Vessels or Containers:*

6.1.7.1 Consideration should be given to minimize heat losses through materials management, configuration, and materials of construction for processes that require extended curing times.

6.1.7.2 Proper temperatures can be maintained without an insulated vessel by adding adequate alkaline reagent to compensate for heat loss. However, some situations may benefit from an insulated vessel to efficiently retain the heat to meet PFRP temperature requirements.

6.1.7.3 For processes using a windrow, at a minimum, the mixture should be at least 18 inches thick at all locations in the pile to ensure heat retention throughout the entire mass for the applicable curing time. Thin areas at the pile extremities should be avoided as they will not retain adequate heat and can lead to potential regrowth and recontamination of the entire mass.

6.1.8 *Process Testing Requirements:*

6.1.8.1 Process testing requirements vary with the specific alkaline process selected.

6.1.8.2 Temperature and pH measurements for the requisite time periods should be recorded to comply with pathogen reduction (and vector attraction reduction). Daily testing may include monitoring and documenting the elevated temperature and pH for a predetermined period of time (see 6.2.6 for details). Some methods also require documentation of reduced moisture content and mixing.

6.1.8.3 Procedures to monitor or collect samples for analysis are developed for each project based upon site-specific conditions considering the process selected, equipment utilized, volumes of materials to be processed, local state and federal regulatory requirements, and local conditions (**3**).

6.1.9 *Process Testing Schedule:*

6.1.9.1 Testing must be conducted in accordance with federal, state, and local regulations. Product testing, to meet end-use requirements, will be site-specific. Under 40 CFR Part 503 regulations, pathogen (salmonella, virus, protozoan, and helminth egg) or indicator organism testing and pollutant concentration (metals) testing requirements are:

Amount of Biosolids (dry metric tons/365 days)	Frequency
> 0 and < 290	Once per year
≥ 290 and < 1500	Once per quarter
≥ 1500 and < 15 000	Once per 60 days
≥ 15 000	Once per month

6.1.9.2 In addition, at a minimum, daily operating records should be maintained documenting compliance with applicable requirements (for example, process time/temperature, pH, solids concentrations, and fecal coliform levels) (**4**).

6.1.10 *Product Solids Content:*

6.1.10.1 Product utilization may be affected by solids content to aid in control of microbial regrowth during storage to minimize odor potential at application sites and during storage or to improve end-product marketability and physical handling characteristics.

6.1.11 *~~On-Site~~On-site Storage:*

6.1.11.1 On-site storage may be required for a land application or marketing program of the tested product. Programs that produce an end-product for sale should consider on-site storage capacity to meet the seasonal fluctuations in market demand, the scheduling needs of the consumer, and production rates of the generator.

6.1.11.2 On-site storage may require odor control for end-products with high moisture content or a low alkaline reagent dosage rate.

6.2 *PSRP (Class B) Alkaline Treatment of Biosolids:*

6.2.1 *Mixing*—Thorough mixing of the biosolids and chemical reagent must be provided to ensure uniform pH distribution and pathogen reduction (**2**). Mechanical mixing to achieve a homogeneous blend of reagent throughout the biosolids mass depends upon a number of factors, including achieving the proper ratio of alkaline reagent to biosolids, and sufficient moisture to enable the reaction to occur.

6.2.1.1 Incomplete mixing or an inadequate reagent dosage rate can cause odor generation and release during product storage or application and failure to meet regulatory pathogen or vector control requirements.

6.2.2 *Alkaline Reagent Particle Size:*

6.2.2.1 Reactions occur as the alkaline reagents contact the moist biosolids particles. The rate of reaction of the alkaline reagent tends to increase with: (1) finer reagent particle size, and (2) increased free moisture content. Reagents with a finer (smaller) particle size distribution generally are more easily and uniformly blended into the biosolids.

6.2.2.2 When using an alkaline slurry, or treating liquid biosolids, particle size may not be as critical as long as sufficient mixing and reaction time are provided.

6.2.3 *Reactivity (pH ~~elevation):~~Elevation):*

6.2.3.1 Care must be taken to ensure moisture will not come into contact with the reagent prior to entering the mixer. Air slaking of the alkaline reagent can be a problem in long-term storage or pneumatic transfer systems. Guidance for proper storage of reactive alkaline materials can be found in Lime—Handling, Application and Storage, National Lime Association Bulletin 213.

6.2.3.2 Increasing the alkaline reagent oxide concentration may increase potential for reactivity.

6.2.4 *Moisture Content:*

6.2.4.1 Moisture content affects the pH by permitting the alkaline reagents to dissociate, releasing hydroxide ions, increasing the pH. As moisture increases, it is easier for the alkaline material to disperse, penetrate, react, and dissociate, thus generating hydroxide ions throughout the mixture.

6.2.4.2 Care should be exercised when working with biosolids cakes with greater than 30 % solids content to ensure a complete uniform reaction is achievable.

6.2.5 *Biosolids Type*—Biosolids characteristics will impact on the required dosage rates for specific alkaline reagents. Therefore, site-specific process guidelines should be developed through actual pilot studies for alkaline additions by biosolids type and alkaline additive characteristics. Liquid biosolids require less mixing energy to achieve a uniform distribution of alkaline reagent (and therefore uniform pH) throughout the mixture than do cake biosolids.

6.2.6 *Reaction Time:*

6.2.6.1 For dry reagents, after uniform mixing with biosolids is complete, the alkaline metal oxides must hydrate to hydroxides and penetrate the biosolids mass. The presence of hydroxides will increase biosolids pH.

6.2.6.2 When working with biosolids cake with low moisture content or reagents with low reactivity due to particle size or oxide content, longer curing time (contact period) may be required to allow the hydration reaction to occur.