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Standard Guide for Use of Coal Combustion Products for Solidification/ Stabilization of Inorganic Wastes¹

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1. Scope

1.1 This guide covers methods for selection and application of coal combustion products (CCPs) for use in the chemical stabilization of trace elements in wastes and wastewater. These elements include, but are not limited to, arsenic, barium, boron, cadmium, chromium, cobalt, lead, molybdenum, nickel, selenium, vanadium, and zinc. Chemical stabilization may be accompanied by solidification of the waste treated. Solidification is not a requirement for the stabilization of many trace elements, but does offer advantages in waste handling and in reduced permeability of the stabilized waste.

1.1.1 Solidification is an important factor in treatment of wastes and especially wastewaters. Solidification/Stabilization (S/S) technology is often used to treat wastes containing free liquids. This guide addresses the use of CCPs as a stabilizing agent (with or without the addition of other materials. Stabilization may be achieved by using combinations of CCPs and other products such as lime, lime kiln dust, cement kiln dust, cement, and others. CCPs used alone or in combination with other reagents promote stabilization of many inorganic constituents through a variety of mechanisms. These mechanisms include precipitation as hydrates, carbonates, silicates, sulfates, and so forth; microencapsulation of the waste particles through pozzolanic reactions; formation of metal precipitates; and formation of hydrated phases (1-4).² Long-term performance of the stabilized waste is an issue that must be addressed in considering any S/S technology. In this guide, several tests are recommended to aid in evaluating the long-term performance of the stabilized wastes.

1.2 The CCPs that are suited for this application include fly ash, dry flue gas desulfurization (FGD) material, and fluidized-bed combustion (FBC) ash.

1.3 The wastes or wastewater, or both, containing the inorganic species may be highly variable, so the chemical

characteristics of the waste or wastewater to be treated must be determined and considered in the selection and application of any stabilizing agent, including CCPs. In any waste stabilization process, laboratory-scale tests for compatibility between the candidate waste or wastewater for stabilization with one or more selected CCPs and final waste stability are recommended prior to pilot-scale and full-scale application of the stabilizing agent.

1.4 This guide does not intend to recommend pilot-scale or full-scale processes or procedures for waste stabilization. Full-scale processes should be designed and carried out by qualified scientists, engineers, and environmental professionals. It is recommended that stabilized materials generated at the full-scale stabilization site be subjected to testing to verify laboratory test results.

1.5 The utilization of CCPs under this guide is a component of a pollution prevention program. Utilization of CCPs in this manner conserves land, natural resources, and energy.

1.6 This guide applies only to CCPs produced primarily from the combustion of coal. It does not apply to ash or other combustion products derived from the burning of waste; coal coking byproducts; municipal, industrial, or commercial garbage; sewage sludge or other refuse, or both; derived fuels; wood waste products; rice hulls; agricultural waste; or other noncoal fuels.

1.7 Regulations governing the use of CCPs vary by nation, state and locality. The user of this guide has the responsibility to determine and comply with applicable regulations.

1.8 It is recommended that work performed under this guide be designed and carried out by qualified scientists, engineers, and environmental professionals.

1.9 *This standard 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

¹ This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.03 on Beneficial Use.

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² The boldface numbers in parentheses refer to the list of references at the end of the text.

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:³

- C114** Test Methods for Chemical Analysis of Hydraulic Cement
- C311** Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
- C400** Test Methods for Quicklime and Hydrated Lime for Neutralization of Waste Acid
- D75** Practice for Sampling Aggregates
- D558** Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
- D1556** Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
- D1633** Test Methods for Compressive Strength of Molded Soil-Cement Cylinders
- D1635** Test Method for Flexural Strength of Soil-Cement Using Simple Beam with Third-Point Loading
- D2166** Test Method for Unconfined Compressive Strength of Cohesive Soil
- D2216** Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D2937** Test Method for Density of Soil in Place by the Drive-Cylinder Method
- D3441** Test Method for Mechanical Cone Penetration Testing of Soils
- D3877** Test Methods for One-Dimensional Expansion, Shrinkage, and Uplift Pressure of Soil-Lime Mixtures (Withdrawn 2017)⁴
- D3987** Practice for Shake Extraction of Solid Waste with Water
- D4318** Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- D4832** Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
- D4843** Test Method for Wetting and Drying Test of Solid Wastes
- D4972** Test Methods for pH of Soils
- D5084** Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
- D5907** Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water
- D6913** Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
- D6938** Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

- D7928** Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis
- E2201** Terminology for Coal Combustion Products

3. Terminology

3.1 Definitions:

3.1.1 Definitions are in accordance with Terminology **E2201**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 **BDAT**—best demonstrated available technology.

3.2.1.1 *Discussion*—The treatment technology that best minimizes the mobility or toxicity (or both) of the hazardous constituents for a particular waste.

3.2.2 *ettringite*—a mineral with the nominal composition $\text{Ca}_6\text{Al}_2(\text{SO}_4)_3(\text{OH})_{12} \cdot 26\text{H}_2\text{O}$ (**1**)

3.2.3 **S/S**—solidification/stabilization.

3.2.4 **XRD**—x-ray diffraction.

4. Significance and Use

4.1 *General*—CCPs can have chemical and mineralogical compositions that are conducive to use in the chemical stabilization of trace elements in wastes and wastewater. These elements include, but are not limited to, arsenic, barium, boron, cadmium, chromium, cobalt, lead, molybdenum, nickel, selenium, vanadium, and zinc. Chemical stabilization may be accompanied by solidification of the waste treated. Solidification is not a requirement for the stabilization of many trace elements, but does offer advantages in waste handling and in reduced permeability of the stabilized waste. This guide addresses the use of CCPs as a stabilizing agent with or without addition of other materials.

NOTE 1—In the United States, S/S is considered the BDAT for the disposal of some wastes that contain metals since they cannot be destroyed by other means (**2**).

4.1.1 *Advantages of Using CCPs*—Advantages of using CCPs for waste stabilization include their availability in high volumes, and generally good product consistency from a single source. In addition, in some instances certain CCPs can partly or entirely replace other expensive stabilization materials such as Portland cement. CCPs vary depending on the combustion or emission control process and the coal or sorbents used, or both, and CCPs contain trace elements, although usually at very low concentrations. CCPs are generally an environmentally suitable materials option for waste stabilization, but the compatibility of a specific CCP must be evaluated with individual wastes or wastewater through laboratory-scale tests followed by full-scale demonstration and verification. CCPs suitable for the chemical stabilization have the ability to incorporate large amounts of free water via hydration reactions. These same hydration reactions frequently result in the formation of mineral phases that stabilize or chemically immobilize the trace elements of concern. CCPs that exhibit high pHs (>11.5) offer advantages in stabilizing trace elements that exist as oxyanions in nature (such as arsenic, boron, chromium, molybdenum, selenium, and vanadium) and trace

³ 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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.