



Standard Guide for Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses¹

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1. Scope

1.1 This guide recommends standards for the characterization of fly ash from the combustion of coal, fly ash from coal combusted in the presence of alkaline materials, and fly ash from combusted coal in which the flue gases have been treated with alkaline materials in the presence of the fly ash.

1.2 This guide provides recommended and optional test methods for fly ash evaluation. Acceptance criteria can be negotiated between the producer and the user according to the potential end use.

1.3 The coal fly ash and clean coal combustion fly ash of this guide do not include the following:

1.3.1 Dusts from kilns producing products such as lime, portland cement, activated clays, etc.;

1.3.2 By-products of flue gas desulfurization that are not collected with the primary fly ash removal equipment such as the baghouse or electrostatic precipitator; and

1.3.3 Fly ash or other combustion products derived from the burning of waste; municipal, industrial, or commercial garbage; sewage sludge or other refuse, or both; derived fuels; wood; wood waste products; rice hulls; agriculture waste; or other non-coal fuels or other such fuels blended with coal, or some combination thereof.

1.4 Fly ash may contain some trace elements that may affect performance or potential end use.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

¹ This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.03 on Treatment, Recovery and Reuse.

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2. Referenced Documents

2.1 ASTM Standards:²

- C22/C22M Specification for Gypsum
- C25 Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
- C51 Terminology Relating to Lime and Limestone (as used by the Industry)
- C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
- C110 Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone
- C114 Test Methods for Chemical Analysis of Hydraulic Cement
- C150 Specification for Portland Cement
- C191 Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle
- 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
- C593 Specification for Fly Ash and Other Pozzolans for Use With Lime for Soil Stabilization
- C595 Specification for Blended Hydraulic Cements
- C602 Specification for Agricultural Liming Materials
- C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- D546 Test Method for Sieve Analysis of Mineral Filler for Bituminous Paving Mixtures
- D1973 Guide for Design of a Liner System for Containment of Wastes (Withdrawn 2000)³
- D2795 Test Methods for Analysis of Coal and Coke Ash (Withdrawn 2001)³
- D3178 Test Methods for Carbon and Hydrogen in the Analysis Sample of Coal and Coke (Withdrawn 2007)³
- D3682 Test Method for Major and Minor Elements in

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

- Combustion Residues from Coal Utilization Processes
- D3683 Test Method for Trace Elements in Coal and Coke Ash by Atomic Absorption
- D4326 Test Method for Major and Minor Elements in Coal and Coke Ash By X-Ray Fluorescence
- D5239 Practice for Characterizing Fly Ash for Use in Soil Stabilization
- D5681 Terminology for Waste and Waste Management
- E1266 Practice for Processing Mixtures of Lime, Fly Ash, and Heavy Metal Wastes in Structural Fills and Other Construction Applications

2.2 Other Document:

- USEPA SW846 Method 9100 Saturated Hydraulic Conductivity, Saturated Leachate Conductivity and Intrinsic Permeability⁴

3. Terminology

3.1 Definitions—For definitions of terms used in this practice, refer to Terminology D5681.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 clean coal combustion—the burning of coal, coal culm, or coal fines in a furnace designed to operate to minimize emissions (that is, a fluidized bed or aerated fluidized bed, etc.) or coal burned in the presence of alkaline materials, which combine to reduce these emissions.

4. Significance and Use

4.1 This guide provides guidance for the characterization of coal fly ash or clean coal combustion fly ash for potential uses in which absorption, cementitious activity, pozzolanic activity, pH adjustment, heat rise, or stabilization and solidification properties may be desired.

5. Chemical Composition

5.1 Fly ash from coal and clean coal combustion can be characterized by the recommended chemical tests of Table 1 and may be characterized further by the optional chemical tests of Table 2. Limits may be specified by the purchaser if required for a specific application. The most recent limits established by the appropriate regulatory agency shall govern if no specific

⁴ Available online at <http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/9100.pdf> (last accessed Feb. 10, 2012).

TABLE 1 Recommended Chemical Tests

Test Method	Component(s)	Limit ^A
C114	sulfur trioxide (SO ₃), % ^B	
C311	moisture content, %	
C311	loss on ignition, %	
C114, D2795, D3682, or D4326	calcium oxide (CaO), %	
C114, D2795, D3682, or D4326	magnesium oxide (MgO), %	
C114, D2795, D3682, or D4326	silicon dioxide (SiO ₂) plus aluminum oxide (Al ₂ O ₃) plus iron oxide (Fe ₂ O ₃), %	

^A On specific projects, a minimum or maximum may be applicable.

^B Fly ash replaces hydraulic cement in method.

TABLE 2 Optional Chemical Tests^A (Limits to be Specified Only if Applicable, by the Purchaser)

Test Method	Component(s)	Limit ^B
C25	available lime index (ALI), % ^C	
C311	available alkalis as Na ₂ O, %	
C400	pH ^D	
C602	calcium carbonate equivalent (CaCO ₃), %	
D3178	carbon (C), %	
D3683	trace elements (totals) (for example, sulfide, sulfite, and sulfate)	

^A Individual requirements may be specified by the purchaser if applicable to the project for which fly ash is to be used.

^B On specific projects, a minimum or maximum may be applicable.

^C Fly ash replaces limestone in analysis.

^D Fly ash replaces quicklime in method.

parameters are required. See Appendix X1 for possible non-mandatory information for various end uses of fly ash.

6. Physical Tests

6.1 Fly ash from coal and clean coal combustion can be tested further in accordance with the optional physical tests of Table 3, if required by the purchaser.

7. Shipments for Delivery to Purchaser

7.1 Fly ash shipped for delivery to the purchaser should be from a single combustion unit or a blend from multiple combustion units, as agreed upon between the purchaser and the supplier, such that the delivered fly ash complies with the provisions of Sections 8 and 9 herein.

TABLE 3 Optional Physical Tests^A (To be Specified Only as Required by the Purchaser)

Test Method	Component(s)
C109/C109M	compressive strength of hydraulic cement mortars, psi ^B
C110	heat rise (slaking rate), °C ^C
C191	time of set, min ^B
C311	amount retained on No. 325 sieve, %
C311	strength activity index with portland cement 7 days, % of control
	28 days, % of control
C311	water requirement, % of control ^D
C311	specific gravity
C311	increase in drying shrinkage, %
C311	reactivity with cement alkali, mortar expansion, % of control
C311	soundness
C593	amount retained on No. 200 sieve, %
C593	amount retained on No. 30 sieve, %
C593	lime pozzolan strength 7 days, psi
	lime pozzolan strength 28 days, psi

USEPA SW846 Method 9100

^A Individual requirements may be specified by the purchaser if applicable to the project for which fly ash is to be used.

^B Modification of Test Method C109/C109M to approximate proportion(s) of fly ash instead of cement; or fly ash in combination with other materials to be used on the project (that is, cement, lime, etc.) should be used.

^C Modify Test Methods C110 to a proportion of fly ash instead of lime. The fly ash to water ratio may need to be modified further to obtain measurable results.

^D Comparisons of water requirements to a control material, used at an equal flow, may be useful to determine the relative water requirement.

8. Sampling and Testing

8.1 Take individual, representative samples of at least 0.5 lb (227 g) from each 100 tons (90 Mg) of fly ash delivered to the purchaser.

8.2 Composite samples are to be created by combining 0.5-lb (227-g) individual samples of fly ash taken from each 100 tons (90 Mg) shipped. The minimum composite sample size should not be less than 8 lb (3.6 kg). Composites are to consist of nearly equal amounts from individual samples and be mixed thoroughly.

8.2.1 If insufficient fly ash has been shipped to comply with the composite sample requirements as listed in this section, an individual sample, or samples, may be used if agreed upon between the purchaser and the supplier. These samples should be at least 1 lb (454 g) and may represent less than 100 tons (90 Mg) shipped.

8.3 The recommended tests of **Table 1** are performed on a sample of at least 1 lb (454 g) composited of individual shipment samples, at a frequency no less than semiannual when at least 100 tons (90 Mg) of fly ash have been shipped to a purchaser.

8.4 For limits as required by the purchaser from **Table 2** and **Table 3**, optional tests may be performed on the following frequency unless otherwise agreed upon between the supplier and the purchaser prior to shipment:

8.4.1 Every 2000 tons (1800 Mg) shipped,

8.4.2 A calendar month during which at least 100 tons (90 Mg) of fly ash have been shipped to a purchaser.

9. Test Method

9.1 Testing is conducted in accordance with the appropriate sections of the ASTM standards, or noted modifications,

indicated in **Table 1**, the optional **Table 2** and **Table 3**, and the nonmandatory information of **Appendix X1**, as specified by the purchaser. Individual tests may be selected from **Table 2** and **Table 3** and **Appendix X1** according to the need of the user.

10. Inspection and Rejection

10.1 Upon agreement with the supplier, the purchaser should establish the criteria for inspection and testing. The criteria for rejection should be based on the ability of the material to comply with the appropriate specifications as referenced by the purchaser.

11. Compliance and Certification

11.1 Fly ash sampling and testing pursuant to Section 8 may be performed as the fly ash is produced or shipped, or both. Certification of compliance should be provided by the supplier with shipments of fly ash shipped from the production site, at the purchaser's request. If requested by the purchaser, test results on samples of the fly ash shipped should be sent to the purchaser as soon as they are available.

12. Retention of Test Samples

12.1 Samples shall be retained in airtight containers. Sample retention times are permissible if agreed upon between the purchaser and the supplier prior to shipment.

12.2 It is suggested that test data records should be maintained for a period of three years.

13. Keywords

13.1 characterization of clean coal combustion fly ash; characterization of clean coal fly ash; characterization of coal fly ash; fly ash for potential use

APPENDIX

(Nonmandatory Information)

X1. POTENTIAL END USE

TABLE X1.1 Potential End Use^A

Suggested Referenced Documents ^B	Waste Treatment	Hazard Waste Treatment	Soil Amendment	Soil Stabilization	Mineral Filler	Pozzolanic Liners	Slurry Wall	Cement Product	Concrete Product	Gypsum Product
USEPA SW846 Method 9100						X	X			
Specification C22/C22M			X			X		X		X
Test Methods C25	X	X								
Test Method C109/C109M	X	X				X	X		X	
Test Methods C110	X	X			X	X				
Test Methods C114	X	X	X	X				X		
Specification C150								X		
Test Method C191							X		X	
Test Methods C311					X	X			X	
Test Method C400	X	X	X							
Specification C593						X				
Specification C595								X		
Specification C602			X							
Specification C618									X	
Test Method D546					X					
Guide D1973						X				
Method D2795	X	X						X		
Test Method D3178								X		
Test Method D3683	X	X						X		
Practice D5239				X						
Practice E1266	X	X				X				

^A The use of this table is meant to assist the purchaser in selecting applicable best procedures for a specified end use. It is suggestive only.

^B Suggested documents are to assist in characterizing fly ash as a substitute for the subject materials of these documents.

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