



# Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete<sup>1</sup>

This standard is issued under the fixed designation C618; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification covers coal fly ash and raw or calcined natural pozzolan for use in concrete where cementitious or pozzolanic action, or both, is desired, or where other properties normally attributed to fly ash or pozzolans may be desired, or where both objectives are to be achieved.

NOTE 1—Finely divided materials may tend to reduce the entrained air content of concrete. Hence, if a fly ash or natural pozzolan is added to any concrete for which entrainment of air is specified, provision should be made to ensure that the specified air content is maintained by air content tests and by use of additional air-entraining admixture or use of an air-entraining admixture in combination with air-entraining hydraulic cement.

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

1.3 The text of this standard references notes and footnotes, which provide explanatory information. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

**C125 Terminology Relating to Concrete and Concrete Aggregates**

**C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete**

## 3. Terminology

3.1 *Definitions*:

3.1.1 The terms used in this specification are defined in Terminology **C125**.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee **C09** on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee **C09.24** on Supplementary Cementitious Materials.

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

3.1.2 *fly ash*—the finely divided residue that results from the process of combustion of ground or powdered coal and that is transported by flue gasses.

NOTE 2—This definition of fly ash does not include, among other things, the residue resulting from: (1) fluidized bed combustion ash, (2) the burning of municipal solid waste or any other refuse with coal, or (3) the burning of industrial or municipal solid waste in incinerators commonly known as “incinerator ash.”

## 4. Classification

4.1 *Class N*—Raw or calcined natural pozzolans that comply with the applicable requirements for the class as given herein, such as some diatomaceous earths; opaline cherts and shales; tuffs and volcanic ashes or pumicites, calcined or uncalcined; and various materials requiring calcination to induce satisfactory properties, such as some clays and shales.

4.2 *Class F*—Fly ash that meets the applicable requirements for this class as given herein. This class of fly ash has pozzolanic properties.

4.3 *Class C*—Fly ash that meets the applicable requirements for this class as given herein. This class of fly ash, in addition to having pozzolanic properties, also has some cementitious properties.

NOTE 3—Class F fly ash is typically produced from burning anthracite or bituminous coal, but may also be produced from subbituminous coal and from lignite. Class C fly ash is typically produced from burning lignite or subbituminous coal, and may also be produced from anthracite or bituminous coal. Class C fly ashes typically have total calcium contents, expressed as calcium oxide (CaO), that are higher than Class F fly ashes.

## 5. Ordering Information

5.1 The purchaser shall specify any supplementary optional physical requirements.

5.2 The purchaser shall indicate which procedure, A or B, shall be used when specifying requirements for effectiveness in contribution to sulfate resistance under **Table 3**.

## 6. Chemical Composition

6.1 Fly ash and natural pozzolans shall conform to the requirements as to chemical composition prescribed in **Table 1**.

NOTE 4—The chemical component determinations and the limits placed

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

**TABLE 1 Chemical Requirements**

	Class		
	N	F	C
Silicon dioxide (SiO <sub>2</sub> ) plus aluminum oxide (Al <sub>2</sub> O <sub>3</sub> ) plus iron oxide (Fe <sub>2</sub> O <sub>3</sub> ), min, %	70.0	70.0	50.0
Sulfur trioxide (SO <sub>3</sub> ), max, %	4.0	5.0	5.0
Moisture content, max, %	3.0	3.0	3.0
Loss on ignition, max, %	10.0	6.0 <sup>A</sup>	6.0

<sup>A</sup>The use of Class F pozzolan containing up to 12.0 % loss on ignition may be approved by the user if either acceptable performance records or laboratory test results are made available.

**TABLE 2 Physical Requirements**

	Class		
	N	F	C
<i>Fineness:</i>			
Amount retained when wet-sieved on 45 µm (No. 325) sieve, max, %	34	34	34
<i>Strength activity index:</i> <sup>A</sup>			
With portland cement, at 7 days, min, percent of control	75 <sup>B</sup>	75 <sup>B</sup>	75 <sup>B</sup>
With portland cement, at 28 days, min, percent of control	75 <sup>B</sup>	75 <sup>B</sup>	75 <sup>B</sup>
Water requirement, max, percent of control	115	105	105
<i>Soundness:</i> <sup>C</sup>			
Autoclave expansion or contraction, max, %	0.8	0.8	0.8
<i>Uniformity requirements:</i>			
The density and fineness of individual samples shall not vary from the average established by the ten preceding tests, or by all preceding tests if the number is less than ten, by more than:			
Density, max variation from average, %	5	5	5
Percent retained on 45-µm (No. 325), max variation, percentage points from average	5	5	5

<sup>A</sup> The *strength* activity index with portland cement is not to be considered a measure of the compressive strength of concrete containing the fly ash or natural pozzolan. The mass of fly ash or natural pozzolan specified for the test to determine the *strength* activity index with portland cement is not considered to be the proportion recommended for the concrete to be used in the work. The optimum amount of fly ash or natural pozzolan for any specific project is determined by the required properties of the concrete and other constituents of the concrete and is to be established by testing. *Strength* activity index with portland cement is a measure of reactivity with a given cement and is subject to variation depending on the source of both the fly ash or natural pozzolan and the cement.

<sup>B</sup> Meeting the 7 day or 28 day *strength* activity index will indicate specification compliance.

<sup>C</sup> If the fly ash or natural pozzolan will constitute more than 20 % by mass of the cementitious material in the project mixture, the test specimens for autoclave expansion shall contain that anticipated percentage. Excessive autoclave expansion is highly significant in cases where water to cementitious material ratios are low, for example, in block or shotcrete mixtures.

on each do not predict the performance of the fly ash or natural pozzolan with hydraulic cement in concrete, but collectively help describe composition and uniformity of the material.

## 7. Physical Properties

7.1 Fly ash and natural pozzolans shall conform to the physical requirements prescribed in **Table 2**. Supplementary optional physical requirements are shown in **Table 3**.

## 8. Methods of Sampling and Testing

8.1 Sample and test the fly ash or natural pozzolan in accordance with the requirements of Test Methods **C311**.

8.2 Use cement of the type proposed for use in the work and, if available, from the mill proposed as the source of the cement, in all tests requiring the use of hydraulic cement.

## 9. Storage and Inspection

9.1 The fly ash or natural pozzolan shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

9.2 Inspection of the material shall be made as agreed upon by the purchaser and the seller as part of the purchase contract.

## 10. Rejection

10.1 The purchaser has the right to reject material that fails to conform to the requirements of this specification. Rejection shall be reported to the producer or supplier promptly and in writing.

10.2 The purchaser has the right to reject packages varying more than 5 % from the stated weight. The purchaser also has the right to reject the entire shipment if the average weight of the packages in any shipment, as shown by weighing 50 packages taken at random, is less than that specified.

10.3 The purchaser has the right to require that material in storage prior to shipment for a period longer than 6 months after testing be retested. The purchaser has the right to reject such material if it fails to meet the fineness requirements.

## 11. Packaging and Package Marking

11.1 When the fly ash or natural pozzolan is delivered in packages, the class, name, and brand of the producer, and the weight of the material contained therein, shall be plainly marked on each package. Similar information shall be provided

**TABLE 3 Supplementary Optional Physical Requirements**

NOTE 1—These optional requirements apply only when specifically requested.

	Class		
	N	F	C
Increase of drying shrinkage of mortar bars at 28 days, max, difference, in %, over control <sup>A</sup>	0.03	0.03	0.03
Uniformity Requirements: In addition, when air-entraining concrete is specified, the quantity of air-entraining agent required to produce an air content of 18.0 vol % of mortar shall not vary from the average established by the ten preceding tests or by all preceding tests if less than ten, by more than, %	20	20	20
Effectiveness in Controlling Alkali-Silica Reaction: <sup>B</sup> Expansion of test mixture as percentage of low-alkali cement control, at 14 days, max, %	100	100	100
Effectiveness in Contributing to Sulfate Resistance: <sup>C</sup> Procedure A: Expansion of test mixture: For moderate sulfate exposure after 6 months exposure, max, % For high sulfate exposure after 6 months exposure, max, %	0.10 0.05	0.10 0.05	0.10 0.05
Procedure B: Expansion of test mixture as a percentage of sulfate resistance cement control after at least 6 months exposure, max, %	100	100	100

<sup>A</sup> Determination of compliance or noncompliance with the requirement relating to increase in drying shrinkage will be made only at the request of the purchaser.

<sup>B</sup> Fly ash or natural pozzolans meeting this requirement are considered as effective in controlling alkali silica reactions as the use of the low-alkali control cement used in the evaluation. However, the fly ash or natural pozzolan shall be considered effective only when used at percentages by mass of the total cementitious material equal to or exceeding that used in the tests and when the alkali content of the cement to be used does not exceed that used in the tests by more than 0.05 %. See Appendix XI, Test Methods **C311**.

<sup>C</sup> Fly ash or natural pozzolan shall be considered effective only when the fly ash or natural pozzolan is used at percentages, by mass, of the total cementitious material within 2 % of those that are successful in the test mixtures or between two percentages that are successful, and when the C<sub>3</sub>A content of the project cement is less than, or equal to, that which was used in the test mixtures. See Appendix X2 of Test Method **C311**.

in the shipping invoices accompanying the shipment of packaged or bulk material.

## 12. Supplier's Certification

12.1 Upon request of the purchaser, in the contract or the order, a supplier's report shall be furnished stating the results of tests made on samples of the material and certifying the product conforms to all applicable requirements of this specification. In addition, the report shall include the percentages of magnesium oxide (MgO), sodium oxide (Na<sub>2</sub>O), potassium

oxide (K<sub>2</sub>O), and calcium oxide (CaO), all determined as described in Test Methods **C311**. The report shall also include the total alkali content of the material, expressed as equivalent percentage of sodium oxide (Na<sub>2</sub>Oe).

NOTE 5—Guidance on preparing the supplier's report is provided in **Appendix X1**.

## 13. Keywords

13.1 fly ash; natural pozzolan; pozzolans

## APPENDIX

### (Nonmandatory Information)

#### X1. SUPPLIER'S CERTIFICATION REPORT

X1.1 To provide uniformity for reporting the results of tests performed on pozzolans under this specification, and affirming

compliance to the applicable limits of this standard, an example report of analysis is shown in **Fig. X1.1**.

## REPORT OF POZZOLAN ANALYSIS

**Plant:** XYZ Power Station **Date:** March 10, 20XX  
**Supplier:** ABC Materials Company  
**Product Class:** CLASS F  
**Sampling Period:** January 10, 20XX to February 10, 20XX **Type:** Composite

### STANDARD REQUIREMENTS (ASTM C618 Tables 1 and 2)

Chemical Composition (mass %)	Result	ASTM C618 Limits		
		Class N	Class F	Class C
Silicon Oxide (SiO <sub>2</sub> )	61			
Aluminum Oxide (Al <sub>2</sub> O <sub>3</sub> )	18			
Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> (T))	5.2			
SUM (SiO <sub>2</sub> +Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub> (T))	84.2	70.0 min.	70.0 min.	50.0 min.
Sulfur Trioxide (SO <sub>3</sub> )	2.3	4.0 max.	5.0 max.	5.0 max.
Calcium Oxide (CaO)	6			
Magnesium Oxide (MgO)	1			
Sodium Oxide (Na <sub>2</sub> O)	0.7			
Potassium Oxide (K <sub>2</sub> O)	0.8			
Sodium Oxide Equilivant (Na <sub>2</sub> O+0.658K <sub>2</sub> O)	1.2			
Moisture Content	0.5	3.0 max.	3.0 max.	3.0 max.
Loss on Ignition	0.2	10.0 max.	6.0 max.	6.0 max.
<b>Physical Tests</b>				
Fineness				
Retained on a 45-µm sieve (%)	12.0	34 max.	34 max.	34 max.
Strength Activity Index				
Ratio to Control @ 7 days	94	75 min.	75 min.	75 min.
Ratio to Control @ 28 days	103	75 min.	75 min.	75 min.
Water Requirement (% of Control)	98	115 max.	105 max.	105 max.
Soundness				
Autoclave Expansion (%)	0.05	0.8 max.	0.8 max.	0.8 max.
Density (grams per cubic cm)	2.45			
Uniformity (average established from ten preceding tests or all tests if less than 10 values are available)				
Fineness (percentage points from avg.)	-1.1	±5 max.	±5 max.	±5 max.
Density (percentage points from avg.)	+1.5	±5 max.	±5 max.	±5 max.

### SUPPLEMENTARY OPTIONAL PHYSICAL REQUIREMENTS (ASTM C618 Table 3)

No tests requested

Signature: \_\_\_\_\_ Title: \_\_\_\_\_

FIG. X1.1 Example of a Supplier's Report

### SUMMARY OF CHANGES

Committee C09 has identified the location of selected changes to this specification since the last issue, C618 – 12a, that may impact the use of this specification. (Approved Aug. 1, 2015)

(1) Revised 3.1.2 and Note 2.



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