

# Standard Specification for **REFRACTORIES FOR INCINERATORS AND BOILERS**<sup>1</sup>

This Standard is issued under the fixed designation C 64; 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.

<sup>e</sup> NOTE-Tables 3 and 6 were editorially changed in February 1973.

## 1. Scope

1.1 This specification covers the requirements for refractories that may be used in the construction or repair of incinerators and boilers.

1.2 It is beyond the scope of this specification to prescribe the form or class of refractories to be applied in the particular areas of incinerators or boilers.

NOTE 1-This specification combines and supersedes the following ASTM standards:

- C 64 Specification for Fireclay Brick Refractories for Heavy Duty Stationary Boiler Service<sup>2</sup>
- C 106 Specification for Fireclay Brick and Silicon Carbide Brick for Incinerator Service<sup>2</sup>
- C 153 Specification for Fireclay Brick Refractories for Moderate Duty Stationary Boiler Service<sup>2</sup>
- C 176 Specification for Fireclay Plastic Refractories for Boiler and Incinerator Services<sup>2</sup>
- C178 Specification for Air-Setting Refractory Mortar (Wet Type) for Boiler and Incinerator Services<sup>2</sup>
- C 213 Specification for Alumina-Silica-Base Castable Refractories for Boiler Service<sup>2</sup>

NOTE 2-The values stated in U.S. customary units are to be regarded as the standard.

## 2. Applicable Documents

#### 2.1 ASTM Standards:

- C 16 Load Test for Refractory Brick at High Temperatures<sup>2</sup>
- C 20 Test for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick<sup>2</sup>
- C 24 Test for Pyrometric Cone Equivalent (PCE) of Refractory Materials<sup>2</sup>
- C 71 Definitions of Terms Relating to Refractories<sup>2</sup>
- C 92 Test for Sieve Analysis and Water Content of Refractory Materials<sup>2</sup>
- C 107 Panel Spalling Test for High Duty Fireclay Brick<sup>2</sup>

- C 113 Test for Reheat Change of Refractory Brick<sup>2</sup>
- C 122 Panel Spalling Test for Super Duty Fireclay Brick<sup>2</sup> C 133 Test for Cold Crushing Strength and
- Modulus of Rupture of Refractory Brick and Shapes<sup>2</sup>
- C 134 Test for Size and Bulk Density of Refractory Brick and Insulating Fire Brick<sup>2</sup>
- C 154 Test for Warpage of Refractory Brick and Tile<sup>2</sup>
- C 155 Classification of Insulating Fire Brick<sup>2</sup>
- C 179 Test for Drying and Firing Shrinkage of Fireclay Plastic Refractories<sup>2</sup>
- C 180 Panel Spalling Test for Fireclay Plastic Refractories<sup>2</sup>
- C 181 Test for Workability Index of Fireclay Plastic Refractories<sup>2</sup>
- C 198 Test for Cold Bonding Strength of Air-Setting Refractory Mortar (Wet Type)<sup>2</sup>
- C 199 Test for Refractoriness of Air-Setting Refractory Mortar (Wet Type)<sup>2</sup>
- C 210 Test for Reheat Change of Insulating Fire Brick<sup>2</sup>
- C 268 Test for Modulus of Rupture of Castable Refractories<sup>2</sup>
- C 269 Test for Permanent Linear Change on Firing of Castable Refractories<sup>2</sup>
- C 491 Test for Modulus of Rupture of Air-Setting Plastic Refractories<sup>4</sup>
- C 571 Chemical Analysis of Carbon and Carbon-Ceramic Refractories<sup>2</sup>
- C 573 Chemical Analysis of Fireclay and High-Alumina Refractories<sup>2</sup>

# 3. Classification

3.1 Five forms of refractories are classified according to their mode of installation or use.

<sup>1</sup>This specification is under the jurisdiction of ASTM Committee C-8 on Refractories

Current edition approved March 13, 1972. Published April 1972. Originally published as C 64 - 27 T. Last previous edition C 64 - 61.

This specification combines and supersedes C 64 – 61, C 106 - 67, C 153 - 61, C 176 - 67, C 178 - 47 (1958), and C 213 - 66. <sup>2</sup> 1974 Annual Book of ASTM Standards, Part 17.

Each form of refractory is further classified in relation to the service environment with which it may be used. The class and type of refractory should be carefully selected on the basis of service conditions.

3.2 The five forms of refractories classified are as follows, and appear in the following Sections:

	Sections
Refractory Brick and Shapes	5 to 8
Insulating Fire Brick	9 to 12
Refractory Mortar	13 to 17
Plastic Refractories	18 to 21
Castable Refractories	22 to 26
Retests	27

## 4. Definitions

4.1 Definitions C 71, shall apply to the terms used in this specification.

# **REFRACTORY BRICK AND SHAPES**

# 5. Physical Requirements

5.1 Fireclay refractory brick and shapes shall meet the applicable requirements given in Table 1.

5.2 High-alumina and mullite refractory brick and shapes shall meet the applicable requirements given in Table 2.

5.3 Silicon carbide refractory brick shall meet the requirements given in Table 3.

#### 6. Dimension Tolerance and Warpage

6.1 The following permissible variations in size and warpage shall apply to all refractory brick and shapes listed in this specification:

6.1.1 Size Variation of 9 by  $4\frac{1}{2}$  by  $2\frac{1}{2}$  or 3-in. (230 by 115 by 65 or 76-mm) brick— The permissible size variation shall be not more than 2 percent from the intended or specified dimensions.

6.1.2 Size Variation of Rectangular Tile and Shapes—The permissible size variation from the intended or specified size shall be not more than 2 percent on dimensions of 4 in. (102 mm) or over, nor more than 3 percent on dimensions smaller than 4 in.

6.1.3 Warpage of Tile and Shapes— Ninety-five percent of the tile or shapes shall not show a warpage greater than 1 percent of the diagonal used in making the measurement.

# 7. Sampling

7.1 The number of brick required for testing the various categories and classes of refractory brick is given in Table 1, 2, or 3. The samples shall be selected at random from each lot of 50,000 brick or less.

#### 8. Methods of Test

8.1 The properties enumerated in this specification for refractory brick shall be determined in accordance with the following ASTM methods:

8.1.1 Size—Method C 134.

8.1.2 Warpage-Method C 154.

8.1.3 Pyrometric Cone Equivalent— Method C 24.

8.1.4 *Load Test*—Applicable schedules of Method C 16, as follows:

Semi-silica class of fireclay brick	Schedule No. 2
Mullite brick	Schedule No. 6
Silicon carbide brick	Schedule No. 6, except that
	the 90-min holding period
	shall start at 2730 F (1500
	C).

8.1.5 *Reheat Shrinkage*—Applicable schedules of Method C 113 as follows:

Super-duty fireclay brick Schedule C

8.1.6 Panel Spalling Loss:

8.1.6.1 *High-Duty Fireclay Brick*—Method C 107.

8.1.6.2 Super-Duty Fireclay Brick— Method C 122.

8.1.7 Bulk Density and Apparent Porosity —Method C 20.

8.1.8 Modulus of Rupture-Method C 133.

8.1.9 Silica Content and Alumina Content -- Method C 573.

8.1.10 Chemical Analysis of Silicon Carbide Brick—Method C 571.

# **INSULATING FIRE BRICK**

## 9. Physical Requirements

9.1 Insulating fire brick are classified under groups identified in accordance with Classification C 155. Insulating fire brick shall meet the applicable requirements given in Table 4.

# **10. Dimension Tolerance**

10.1 The permissible variation from intended or specified size shall be not more than 2 percent on dimensions of 4 in. (102 mm) or over, nor more than 3 percent on dimensions smaller than 4 in.

# 11. Sampling

11.1 A sample of 20 brick shall be selected at random from each lot of 50,000 brick or less. Ten of these brick shall be taken as a primary sample and the remaining ten brick shall be retained for retesting if required.

# 12. Methods of Test

12.1 The dimensions and properties specified for insulating fire brick shall be determined in accordance with the following ASTM methods:

12.1.1 Size and Bulk Density—Method C 134.

12.1.2 Reheat Change-Method C 210.

# **REFRACTORY MORTARS**

# 13. Classification

13.1 Refractory mortars are classified according to the service and type of brick or shapes with which they will be used. The several classes of mortar are distinguished by their refractoriness test temperatures.

## 14. Workability Requirements

14.1 Wet Type, Air-Setting Mortar shall be of such consistency and plasticity that it will spread easily with a trowel, either as it comes from the container or after a moderate amount of tempering with water. At any time within a 6-month period after purchase, the mortar in a newly opened container shall not have stiffened or hardened to such an extent as to prevent its easy removal and mixing.

14.2 Dry Type, Air-Setting or Heat-Setting Mortar shall develop satisfactory working properties when tempered with water to a trowelling consistency.

14.3 The mortar shall be convertible from a troweling consistency to a dipping consistency by mixing with additional water.

# **15. Physical Requirements**

15.1 Refractory mortar shall meet the applicable requirements given in Table 5.

#### 16. Sampling

16.1 One container of the refractory

mortar shall be selected from each shipment of a carload or less of each class or type of mortar specified. The contents of each container selected shall be thoroughly mixed before withdrawing a portion of the contents for testing.

# 17. Methods of Test

17.1 The properties enumerated in this specification shall be determined in accordance with the following ASTM methods (dry-type mortars shall be thoroughly mixed with water and allowed to stand from 20 to 30 min, or longer, before preparation of specimens for bonding strength and refractoriness tests):

17.1.1 *Particle Size*—Method C 92, using the procedure for wet sieve analysis described in 5.2 of those methods.

17.1.2 Bonding Strength-Method C 198.<sup>3</sup>

17.1.3 Refractoriness-Method C 199.3

17.1.4 Alumina Content-Method C 573.

# PLASTIC REFRACTORIES

## 18. Classification

18.1 Five classes of plastic refractory are covered as follows:

High-duty fireclay Super-duty fireclay 60 percent alumina 70 percent alumina 80 percent alumina

18.2 High-duty fireclay and super-dry fireclay plastic refractories are available as airsetting as well as heat-setting types.

#### **19. Physical Requirements**

19.1 Plastic refractories shall conform to the applicable requirements given in Table 6.

## 20. Sampling

20.1 A 200-lb (90-kg) sample shall be taken at random from each carload shipment, or fraction thereof. If packed in moistureproof cartons of about 1-ft<sup>3</sup> (28-dm<sup>3</sup>) capacity, two cartons will suffice; if packed in steel drums, one drum of 200 lb shall be selected.

<sup>&</sup>lt;sup>a</sup>Although Methods C 198 and C 199 pertain to wettype mortars, they may be used for testing dry-type mortars mixed in accordance with 17.1, pending possible revision of Methods C 198 and C 199.

# 21. Methods of Test

21.1 The properties enumerated in this specification for plastic refractories shall be determined in accordance with the following ASTM methods:

21.1.1 Workability Index-Method C 181.

21.1.2 Pyrometric Cone Equivalent— Method C 24.

21.1.3 Drying and Firing Shrinkage— Method C 179.

21.1.4 Panel Spalling Loss—Method C 180.

21.1.5 *Modulus of Rupture*—Method C 491.

21.1.6 Alumina Content-Method C 573.

# CASTABLE REFRACTORIES

## 22. Classification

22.1 Alumina-Silica-Base Castable Refractories are classified on the basis of dimensional stability when heated at the temperature prescribed in Table 7. Each class of alumina-silica-base castable refractory is available in normal strength and high-strength types.

22.2 Insulating Castable Refractories are classified on the basis of bulk density of dried cast test brick and dimensional stability when heated at the temperatures prescribed in Table 8.

NOTE 3—Castable refractories are furnished with relatively coarse and fine particle sizing. The particle size should be determined by the dry method of Method C 92, using a 500-g sample obtained by carefully quartering a 100-lb (45-kg) bag sample. Ordinarily, the finer sized product will have not more than 0.5 percent retained on a ¼-in. (6.3mm) ASTM sieve.

Castable refractories of either the coarse or fine particle sizing may be used for making shapes having a thick section, but when the thickness of the shape or wall is 2 in. (51 mm) or less, a product with the finer particle sizing should be used.

#### 23. Physical Requirements

23.1 Alumina-Silica-Base Castable Refractories shall conform to the applicable requirements given in Table 7.

23.2 Insulating Castable Refractories shall

conform to the applicable requirements given in Table 8.

# 24. Sampling

24.1 One bag of the castable refractory shall be selected from each shipment of a carload, or less, of each class of castable refractory specified.

#### 25. Methods of Test

25.1 The properties enumerated in this specification for castable refractories shall be determined in accordance with the following ASTM methods:

25.1.1 *Permanent Linear Change*—Method C 269.

25.1.2 Modulus of Rupture—Method C 268.

25.1.3 Bulk Density—Method C 134, on test brick prepared in accordance with Method C 269, and after the 220 to 230 F (105 to 110 C) oven-drying of Section 7 of Method C 269.

# 26. Packing and Labeling

26.1 The castable refractories shall be shipped in moistureproof bags that shall be labeled to show the brand name and the manufacturer or seller.

#### RETESTS

#### 27. Retests

27.1 Because of variables resulting from sampling and the lack of perfect reproducibility in tests conducted by different laboratories, the various types of material may be resampled and retested when requested by either the manufacturer or the purchaser. This may apply in instances when the first test results do not conform to the requirements prescribed in this specification. The final results to be used shall be the average of two sets of results, each of which has been obtained by following in detail the specified testing procedures.

NOTE 4—Retest provisions for variation in size of fireclay brick and of insulating fire brick are provided for in the indicated test methods.

					High-D	uty		Super-Du	ity
Tests	Low- Duty	Medium- Duty	Semi- Silica	Reg- ular	Spall- Resis- tant	Slag- Resis- tant	Reg- ular	Spall- Resis- tant	Slag- Resis- tant
Pyrometric cone equiva- lent, min	15	29		31½	31½	31 1/2	33	33	33
Panel spalling loss, max, percent									
2910 F (1599 C) pre- heat	•••		•••	• • •	10		• • •		•••
3000 F (1649 C) pre- heat	•••	•••	•••	•••		•••	8	4	
Hot load subsidence, max, percent at 2460 F (1349 C)		••••	1.5			••••	•••	•••	•••
Reheat shrinkage, max, percent at 2910 F (1599 C)				÷••		••••	1.0	1.0	
Modulus of rupture, min. psi (MPa)	600 (4)	500 (3.4)	300 (2)	•••	500 (3.4)	1200 (8,3)	600 (4)	600 (4)	1000 (7)
Bulk density, <sup>a</sup> min, lb/ft <sup>3</sup> Mg/m <sup>3</sup> )		•••	•••			137 (2.19)	•••	•••	140 (2,24)
Apparent porosity,"		•••	•••			15	•••		
Chemical composition: Silica, min, percent	• • •	••••	72		•••		•••	••••	,
Number of brick re- quired to conduct tests <sup>6</sup>	7	7	9	1	21	7	24	24	7

TABLE 1	Physical Red	uirements for	Fireclay	Refractory	Brick
			,		

 $^{a}$  For slag-resistant, high-duty brick, only one of the two conditions (apparent porosity or bulk density) need be satisfied.

<sup>b</sup> Two extra brick are included (except high-duty regular brick) to provide for possible damage in shipment. If size variation is to be measured, a minimum of 22 brick are required.

TABLE 2	Physical Red	quirements for	<b>High-Alumina</b>	and Mullite	Refractory	Brick
			8			

	Classes of High-Alumina Brick					
	50	60	70	80	90	
Pyrometric cone equivalent, min	34	35	36	37		
Chemical composition, Alumina, percent	$50 \pm 2.5$	$60 \pm 2.5$	70 ± 2.5	$80 \pm 2.5$	$90 \pm 2.0$	
Modulus of rupture, min, psi (MPa)	600 (4)	600 (4)	600 (4)	600 (4)	600 (4)	
Number of 9-in. brick required for tests <sup>a</sup>	7	7	7	7	7	
·····			Mu	llite Brick		
Hot load subsidence, max, percent at 2900 F	(1595 C)		5.	0	ana tana ing panan	
Chemical composition:						
Alumina, percent	•		50	5 to 79		
Impurities, <sup>b</sup> max, percent			5.	0		
Number of 9-in, brick required for tests <sup>a</sup>	1		5			

<sup>a</sup> Two extra brick are included to provide for possible damage in shipment. If size variation is to be measured, a total of 22 are required.

<sup>b</sup> Impurities refer to metal oxides other than those of aluminum and silicon.

#### TABLE 3 Physical Requirements for Silicon Carbide **Refractory Brick**

#### TABLE 4 Physical Requirements for Insulating Fire Brick

Mg/m<sup>3</sup>

Hot load subsidence at 2730 F (1500 C), max, percent	0.2	Group	Reheat Change, 2 percent max when	Bulk Der	nsity, max
Bulk density, min, lb/ft <sup>3</sup> (Mg/m <sup>3</sup> )	155 (2.48)		tested at	Ib/It*	Mg/m
Apparent porosity, max, percent Chemical analysis: SIC, min, percent CaO, max, percent Alkalies, max, percent	18 85 0.6 0.25	16 20 23 26	1550 F (845 C) 1950 F (1065 C) 2250 F (1230 C) 2550 F (1400 C)	34 40 48 54	0.54 0.64 0.77 0.86
MgO, max, percent	0.1	_			
Number of 9-in. brick required to con- duct tests <sup>a</sup>	9				

"Two extra brick are included to provide for possible damage in shipment. If size variation is to be measured, a total of 22 brick are required.

TABLE 5 Physical Requirements for Refractory Mortar

Class	Medium-Duty Fireclay	High-Duty Fireclay	Super-Duty Fireclay	High- Alumina
Refractoriness—no flow when tested at Particle size	2550 F (1400 C) all classes—at lea sieve and not m (850-μm) sieve.	2730 F (1500 C) st 95 percent shall p nore than 0.5 percen	2910 F (1600 C) ass through a No. 4 t shall be retained o	2910 F (1600 C) 0 ASTM (425-μm) n a No. 20 ASTM
Alumina content, min, percent (calcined basis)			••••	47.5
Bonding strength (air-setting type only)	all classes—modu be not less than	lus of rupture of drie 200 psi (1.4 MPa)	ed brick-mortar join	ts shall

## TABLE 6 Physical Requirements for Plastic Refractories

	High-Duty Fireclay	Super-Duty Fireclay	60 percent Alumina	70 percent Alumina	80 percent Alumina
Workability index, deformation, per- cent			All classes—1	15 to 35	
Pyrometric cone equivalent, min Drying and firing shrinkage, max, percent at:	31	32 1/2	35	36	37
2550 F (1400 C) 2910 F (1600 C)	3	2.5	2.5	2.5	2.5
Panel spalling loss, max, percent, preheated at:					
2910 F (1600 C)	15				••••
3000 F (1650 C)		5	(0 . 25	70 . 25	
(calcined basis) percent	•••	•••	60 ± 2.5	$70 \pm 2.5$	80 ± 2.5
Modulus of rupture, <sup>a</sup> after 1000 F (540 C), min	200 psi (	1.4 MPa)	<b></b>	•••	····

" Modulus of rupture requirement applicable to air-setting type only.

#### TABLE 7 Physical Requirements for Alumina-Silica-Base Castable Refractories

	Class A	Class B	Class C	Class D	Class E	Class F
Linear shrinkage, 1.5 percent max when fired for 5 h at Modulus of rupture after drying, min psi (MPa)	2000 F (1095 C)	2300 F (1260 C)	2500 F (1370 C)	2700 F (1480 C)	2900 F (1595 C)	3100 F (1705 C)
Normal strength, psi (MPa) High strength, psi (MPa)			all classes all classes	s—300 (2) s—600 (4)		

45	M	С	64
----	---	---	----

	Class N	Class O	Class P	Class Q
Linear shrinkage, 1.5 percent max when fired for 5 h at Bulk density, dried, max, lb/ft <sup>3</sup> (Mg/m <sup>3</sup> )	1700 F (925 C) 55 (0.88)	1900 F (1040 C) 65 (1.04)	2100 F (1150 C) 75 (1.20)	2300 F (1260 C) 95 (1.52)

TABLE 8 Physical Requirements for Insulating Castable Refractories

By publication of this standard no position is taken with respect to the validity of any patent rights in connection therewith, and the American Society for Testing and Materials does not undertake to insure anyone utilizing the standard against liability for infringement of any Letters Patent nor assume any such liability.