



# Standard Test Method for Disintegration of Refractories in an Atmosphere of Carbon Monoxide<sup>1</sup>

This standard is issued under the fixed designation C 288; 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.

## 1. Scope

1.1 This test method covers the comparative behavior of refractories under the disintegrating action of carbon monoxide (CO). The test method is an accelerated exposure to CO to determine potential material behavior in a relatively short time.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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.*

## 2. Significance and Use

2.1 This test method is used to determine the relative resistance of various refractories to disintegration caused by exposure to a CO atmosphere. The results obtained by this method can be used to select refractories that are resistant to CO disintegration.

2.2 This test method is suitable for research and development and for establishing CO disintegration criteria for specification acceptance.

2.3 The disintegration of test specimens is accelerated by providing a higher concentration of CO than anticipated in most service environments. The effects on the test specimens may be different than those found for refractories in actual service conditions.

## 3. Apparatus

3.1 *Heated Chamber*—The chamber shall be gastight and of a suitable size, made of stainless steel, brass, aluminum, or unoxidized Monel metal. A suggested size is 18 in. (460 mm) in diameter and 36 in. (914 mm) long. The unit may be heated by resistance wire or other means, provided that at the temperature of operation the difference in temperature between any two points within the chamber shall not be greater than

20°F (11°C). The chamber may be provided with a thermocouple well and shall have a gas inlet and outlet, with a provision for gas sampling at the outlet.

3.2 *Temperature-Control Instrument*—The temperature of the test chamber shall be controlled and recorded by a suitable instrument having the required accuracy.

3.3 *Atmosphere Control*—The CO shall be supplied from a tank, or of the gas, or manufactured by the conversion of carbon dioxide (CO<sub>2</sub>). The pressure from a tank supply (**Caution**, see Note 1) shall be reduced by a regulator made for that purpose, and the flow of gas adjusted by means of a sensitive needle or regulating valve. A flowmeter shall be used in the line as an aid for regulating the flow. When CO is used from a tank, iron carbonyl is present in the gas and may cause clogging of the inlet tube, in which case the carbonyl may be removed before the gas enters the chamber. A soda-asbestos (the Ascarite) tower in the inlet line will remove the carbonyl, but this should be preceded by a drying tower to prevent moisture from getting into the soda-asbestos.

NOTE 1—**Caution:** As a precaution against the possibility of tank explosions, the tanks should be stored and used outdoors or in a separate building designed to reduce the explosion hazard.

3.4 *Furnace Pressure Control*—The unit shall be equipped with a bubbling bottle or a sensitive gage to control the pressure of the exhaust gas. A positive pressure shall be maintained throughout the test.

3.5 *Gas Analyzer*—Any conventional gas analyzer can be used to periodically determine the CO content of the exhaust gas.

## 4. Test Specimens

4.1 Ten specimens shall constitute a specimen set.

4.2 The specimens shall be 9 in. (228 mm) long and 2½ or 3 in. (64 or 76 mm) square in cross section. Only one specimen shall be cut from a shape so that as many original surfaces as possible remain intact. The specimen shall be cut lengthwise from the original shape.

## 5. Unfired Samples

5.1 Unfired refractories shall be prepared for testing by firing for 5 h under oxidizing conditions at one of the following temperatures:

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5.1.1 1000°F (540°C), to remove combined water.

5.1.2 2000°F (1095°C), to remove combined water and compounds that inhibit the deposition of carbon.

## 6. Procedure

6.1 Bring the heating chamber containing the dried specimens to an operating temperature of 925 to 940°F (495 to 505°C) in a nitrogen atmosphere. After the specimens have attained test temperature, change the atmosphere of the chamber so that it shall contain at least 95 % (CO).

NOTE 2—This may be done in one of the following ways: A vacuum pump may be used to evacuate the nitrogen from the chamber to a pressure of about 100 mm Hg. Then introduce the CO, and repeat the evacuation process three times. Time the test from the last evacuation. A second method consists of flushing the nitrogen from the system with a fast flow of CO.

NOTE 3—*Carbon Dioxide Absorbent*—A sufficient quantity of burned lime or calcium oxide (CaO) may be placed in the furnace or in the circulating system of the CO to absorb the CO<sub>2</sub> as it is produced. A commercial CO<sub>2</sub> absorbent can be used outside the test chamber for the absorption of CO<sub>2</sub> from the circulating gas. This granular material, probably calcium hydroxide, is very efficient, but does have the advantage of giving water vapor, which must be taken out of the circulating gas with a calcium chloride tower. (Five pounds (2.3 kg) of CaO theoretically will absorb the CO<sub>2</sub> from a gas mixture containing 1 % CO<sub>2</sub>, flowing at the rate of ½ ft<sup>3</sup> (14.2 dm<sup>3</sup>)/h for 7000 h.)

6.2 Regulate the CO to a flow of not less than 2 in.<sup>3</sup>/h·in.<sup>3</sup> (32.8 cm<sup>3</sup>/h·16.4 cm<sup>3</sup>) of specimen volume. Analyze the chamber atmosphere at least twice a day and maintain the CO content of the exit gas above 95 %. If a recirculating system is used, the CO flow may be greater.

6.3 Inspect the specimens at the end of each selected time period. Before each inspection, pass a fast flow of nitrogen through the furnace to flush out the CO, and then maintain a slow flow of nitrogen during cooling. If half the specimens in

any set of ten show complete disintegration at the end of any test period, consider the test for that specimen set complete.

## 7. Report

7.1 Report any prefring temperature of the specimens and the condition of each specimen at each inspection by photographing the most affected face(s), and by describing the extent of any spotting and the degree of disintegration, according to the following classifications (see Fig. 1).

7.1.1 *Unaffected*, when no particles spall and no cracking occurs.

7.1.2 *Affected—Surface Popouts*, when destructive action is confined to spalls or surface popouts of ½ in. (13 mm) or less in diameter.

7.1.3 *Affected—Cracked*, when destructive action produces spalls or popouts greater than ½ in. (13 mm) in diameter, or cracking, or both.

7.1.4 *Destructive Condition*, when the specimen breaks into two or more pieces, or when hand pressure can cause breaking.

NOTE 4—Spalls or popouts that have not separated from the specimen are to be considered as if separation had occurred.

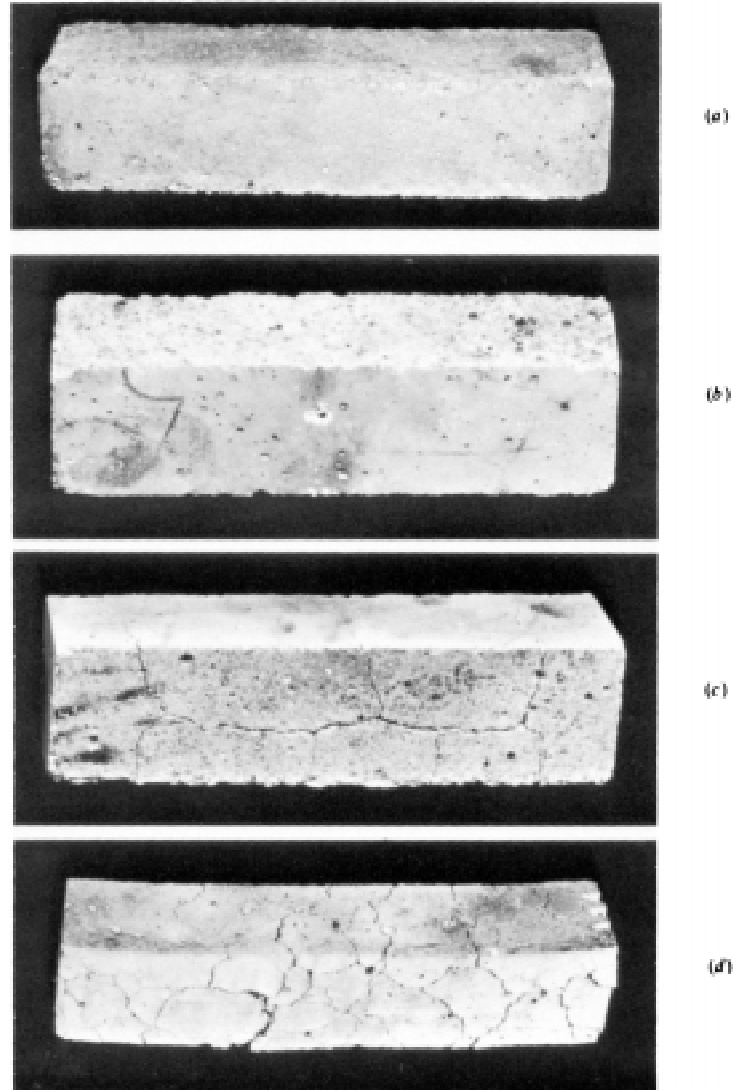
## 8. Precision and Bias

8.1 *Precision*—No justifiable statement of precision is possible since the results of the test are word descriptions rather than numerical values.

8.2 *Bias*—No justifiable statement of accuracy is possible since a true value of refractory disintegration by carbon monoxide cannot be established by an accepted reference sample.

## 9. Keywords

9.1 carbon monoxide; CO atmosphere; disintegration; refractories



(a) Unaffected.  
(b) Affected—Surface popouts.  
(c) Affected—Cracked.  
(d) Destructive condition.  
(Hand pressure can break this into pieces.)

**FIG. 1 Guide to Degrees of Disintegration**

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