Designation: D5341/D5341M – 19

Standard Test Method for Measuring Coke Reactivity Index (CRI) and Coke Strength After Reaction (CSR)[1]

This standard is issued under the fixed designation D5341/D5341M; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method, patterned after the Nippon Steel test procedure (see Carbonization Research Report 91 and Nishi et al.[2]), describes the equipment and techniques used for determining lump coke reactivity in carbon dioxide (CO_2) gas at elevated temperatures and its strength after reaction in CO_2 gas by tumbling in a cylindrical chamber referred to as an I-tester.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

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

D346 Practice for Collection and Preparation of Coke Samples for Laboratory Analysis

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *British Carbonization Research Association Report:*[4]

Carbonization Research Report 91, "The Evaluation of the Nippon Steel Corporation Reactivity and Post-Reaction-Strength Test for Coke."

2.3 *ISO Standard:*[5]

ISO 5725 - 6: 1994 Accuracy of Measurement Methods and Results – Part 6: Use in Practice of Accuracy Values

3. Summary of Test Method

3.1 A sample of dried coke of designated origin and size is reacted with CO_2 gas in a retort at a specified elevated temperature for a specified length of time. Two indices, coke reactivity index (CRI) and coke strength after reaction (CSR), are determined using the reacted coke residue. The mass or weight loss after reaction determines the CRI. The mass or weight retained after sieving the tumbled reacted coke in a designated number of revolutions over a designated turning rate determines the CSR.

4. Significance and Use

4.1 When coke lumps descend in the blast furnace, they are subjected to reaction with countercurrent CO_2 and to abrasion as they rub together and against the walls of the furnace. These concurrent processes physically weaken and chemically react with the coke lumps, producing an excess of fines that can decrease burden permeability and result in increased coke rates and lost hot metal production. This test method is designed to measure indirectly this behavior of coke in the blast furnace.

5. Reagents

5.1 *Nitrogen,* with purity greater than 99.9 % by volume, dry and with total oxygen and carbon dioxide concentrations of less than 100 mg/kg.

[1] This test method is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.15 on Metallurgical Properties of Coal and Coke.

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[2] Nishi, T., et al., *Journal of the Fuel Society of Japan*, Vol 61, No. 668, 1982, pp. 1066-1073.

[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] Available from British Carbonization Research Association, Chesterfield, Derbyshire, England.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

5.2 *Carbon Dioxide,* with purity of greater than 99.5 % by volume, dry with an oxygen concentration less than 100 mg/kg.

6. Apparatus

6.1 *Electric Furnace* (Fig. 1), capable of housing the reaction vessel assembly containing the coke sample and providing a uniform temperature of 1100 °C ± 5 °C in the assembly. The position of the coke sample contained in the vessel assembly when housed in the furnace shall be in the center of the controlled temperature zone. It is preferable that the furnace have independently controlled heating in three zones to achieve uniformity of heating in the retort and that this control be achieved with a programmable controller.

6.2 *Reaction Vessel* (Fig. 1), constructed of a heat-resistant steel or nickel alloy (see Note 1) with an internal diameter of 78 mm ± 1 mm [3.07 in. ± 0.039 in.] and designed to fit snugly inside the electric furnace selected for use. The coke to be tested sits on a perforated plate in the reaction vessel. Below this perforated plate, a gas preheater, such as a bed of ceramic Al_2O_3 balls sitting on a second perforated plate, is used to diffuse the nitrogen (N_2) and carbon dioxide (CO_2) introduced into the vessel up through the coke bed during the course of the test. The gas enters through inlets positioned at the bottom of the reaction vessel and exits through outlets at the top of the reaction vessel varying from 6 mm to 15 mm [¼ in. to ⅝ in.] in inside diameter. During the test, it is important that no backpressure be detected when gas enters or exits through these inlets or outlets. The reaction vessel is positioned such that the coke sample contained in the vessel on top of the ceramic Al_2O_3 balls is in the center of the controlled temperature zone in the furnace. The reaction vessel shall be inspected prior to each use for wear, cracks, or deterioration. Clean and remove scale that could contaminate the test sample if present. The vessel should also be checked for leaks prior to initial use and at specified intervals. See 9.3.

NOTE 1—Inconel 601 is recommended over stainless steel. Inconel 601 does not leave scale, that, if not properly removed, can alter a coke sample mass or weight after the test.

6.3 *Flowmeters*—Rotometers or, preferably, mass flowmeters shall be used to monitor the amount of N_2 and CO_2 gases used in the test. The accuracy of measuring gas flowrates should be ±1 % of full scale since varying gas flow can cause variability in the test results. Gas pressures through the flowmeters should be maintained at the manufacturer's calibration specification. Flowmeters shall be calibrated for the gas being used, or the flow rate shall be corrected to account for the difference in the density of the gas used for calibration.

6.4 *Thermocouple* (Fig. 1), of the K, S, or R type normalized at 20 °C to 21 °C and enclosed in a heat-resistant steel or nickel alloy or ceramic protection tube placed in the center of the coke sample in the reaction vessel. A centering guide also made of heat-resistant material, ideally extended from the center of vessel lid and open on the opposite end to allow the thermocouple and protection tube to protrude is used to guide the thermocouple into its proper location in the coke bed.

6.5 *Sieves,* used for sieving the coke during its preparation for reactivity testing and after tumbling for strength after reaction testing. Square mesh sieves having 22.4 mm [⅞ in.], 19.0 mm [¾ in.], and 9.5 mm [⅜ in.] actual openings between the wires are to be used. Standard test sieves that conform to Specification E11 should always be used.

6.6 *Balance,* capable of weighing up to 25 kg [55.1 lb] and sensitive to 0.1 g [0.000 22 lb].

6.7 *Coke Strength After Reaction Tumbler* (Fig. 2), consisting of a cylindrical chamber with an internal length of 700 mm ± 10 mm [27 ⅝ in. ± ⅜ in.] and an internal diameter 130 mm ± 5 mm [5 ⅛ in. ± ½ in.], with end caps of 10 mm thickness or more (Note 2). This cylindrical chamber is attached to its longitudinal center to an electric motor fitted with a direct drive fixed gearbox, a drive belt, or, preferably, a hydraulic drive set for a revolving rate of 20 r/min ± 1 r/min (Note 3). A revolution counter is fitted so that the power is cut off when the cylinder has revolved 600 times in 30 min.

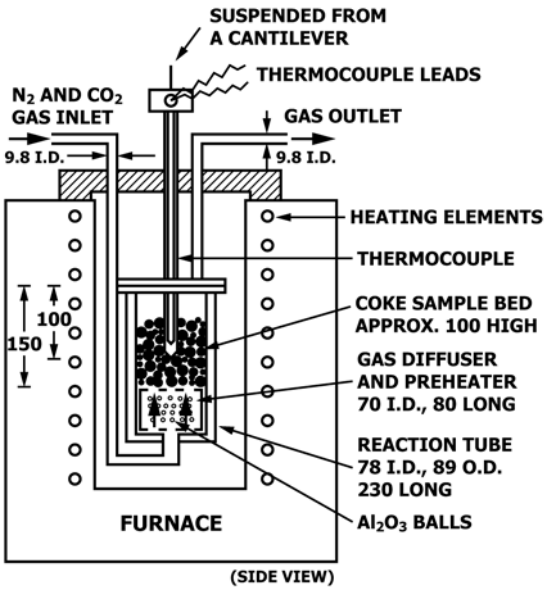

FIG. 1 Example of Reactivity Test Apparatus (Dimensions in mm)

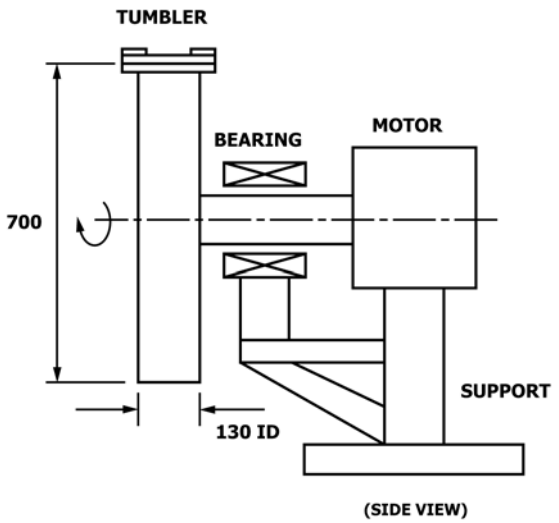

FIG. 2 Example of I-Type Coke Tumbler (Dimensions in mm)