Designation: E1515 – 14 (Reapproved 2022)

Standard Test Method for Minimum Explosible Concentration of Combustible Dusts[1]

INTRODUCTION

This test method describes procedures for measuring the minimum concentration of a combustible dust (dispersed in air) that is capable of propagating a deflagration. The tests are made in laboratory chambers that have volumes of 20 L or larger.

1. Scope

1.1 This test method covers the determination of the minimum concentration of a dust-air mixture that will propagate a deflagration in a near-spherical closed vessel of 20 L or greater volume.

NOTE 1—The minimum explosible concentration (MEC) is also referred to as the lower explosibility limit (LEL) or lean flammability limit (LFL).

1.2 Data obtained from this test method provide a relative measure of the deflagration characteristics of dust clouds.

1.3 This test method should be used to measure and describe the properties of materials in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment that takes into account all of the factors that are pertinent to an assessment of the fire hazard of a particular end use.

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

1.5 *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.* Specific precautionary statements are given in Section 8.

1.6 *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:*[2]

D3173 Test Method for Moisture in the Analysis Sample of Coal and Coke

D3175 Test Method for Volatile Matter in the Analysis Sample of Coal and Coke

E681 Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)

E1226 Test Method for Explosibility of Dust Clouds

2.2 *CEN/CENELEC Publications:*[3]

EN 14034–3 Determination of Explosion Characteristics of Dust Clouds – Part 3: Determination of the Lower Explosion Limit LEL of Dust Clouds

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *dust concentration, n*—the mass of dust divided by the internal volume of the test chamber.

3.1.2 $(dP/dt)_{ex}$, *n*—the maximum rate of pressure rise during the course of a single deflagration test.

3.1.3 *minimum explosible concentration (MEC), n*—the minimum concentration of a combustible dust cloud that is capable of propagating a deflagration through a well dispersed mixture of the dust and air under the specified conditions of test.

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[1] This test method is under the jurisdiction of ASTM Committee E27 on Hazard Potential of Chemicals and is the direct responsibility of Subcommittee E27.05 on Explosibility and Ignitability of Dust Clouds.

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[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] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

3.1.4 $P_{ignition}$, *n*—the absolute pressure at the time the ignitor is activated, see Fig. 1.

3.1.5 $\Delta P_{ignitor}$, *n*—the pressure rise in the chamber due to the ignitor by itself in air at atmospheric pressure

3.1.6 $P_{ex,a}$, *n*—the maximum explosion pressure (absolute) reached during the course of a single deflagration test (see Figs. 1 and 2).

3.1.7 P_m, *n*—maximum pressure rise produced during the course of a single deflagration test that is corrected for the effects of ignitor pressure and cooling in the 20-L vessel (see Test Method E1226, Sections X1.8 and X1.9).

3.1.7.1 *Discussion*—When testing in the Siwek 20-L vessel (see Test Method E1226, Appendix X1) PR may be calculated using the corrected explosion pressure:

$$PR = (P_m + P_{ignition})/P_{ignition} \quad (1)$$

3.1.8 *pressure ratio (PR), n*—defined as:

$$PR = (P_{ex,a} + \Delta P_{ignitor})/P_{ignition} \quad (2)$$

4. Summary of Test Method

4.1 A dust cloud is formed in a closed combustion chamber by an introduction of the material with air. The test is normally made at atmospheric pressure.

4.2 Ignition of this dust-air mixture is then attempted after a specified delay time by an ignition source located near the center of the chamber.

4.3 The pressure time curve is recorded on a suitable piece of equipment.

5. Significance and Use

5.1 This test method provides a procedure for performing laboratory tests to evaluate relative deflagration parameters of dusts.

5.2 The MEC as measured by this test method provides a relative measure of the concentration of a dust cloud necessary for an explosion.

5.3 Since the MEC as measured by this test method may vary with the uniformity of the dust dispersion, energy of the ignitor, and propagation criteria, the MEC should be considered a relative rather than absolute measurement.

5.4 If too weak an ignition source is used, the measured MEC would be higher than the "true" value. This is an ignitability limit rather than a flammability limit, and the test could be described as "underdriven." Ideally, the ignition energy is increased until the measured MEC is independent of ignition energy. However, at some point the ignition energy may become too strong for the size of the test chamber, and the system becomes "overdriven." When the ignitor flame becomes too large relative to the chamber volume, a test could appear to result in an explosion, while it is actually just dust burning in the ignitor flame with no real propagation beyond the ignitor.

5.5 The recommended ignition source for measuring the MEC of dusts in 20-L chambers is a 2500 or 5000 J pyrotechnic ignitor.[4] Measuring the MEC at both ignition energies will provide information on the possible overdriving of the system.[5] To evaluate the effect of possible overdriving in a 20-L chamber, comparison tests may also be made in a larger chamber, such as a 1 m^3-chamber.

5.6 If a dust ignites with a 5000 J ignitor but not with a 2500 J ignitor in a 20-L chamber, this may be an overdriven system.[5] In this case, it is recommended that the dust be tested with a 10 000 J ignitor in a larger chamber, such as a 1 m^3-chamber, to determine if it is actually explosible.

5.7 The values obtained by this test method are specific to the sample tested (particularly the particle size distribution) and the method used and are not to be considered intrinsic material constants.

[4] The pyrotechnic ignitors are available commercially from Cesana Corp., PO Box 182, Verona, NY 13478, or from Fr. Sobbe, GmbH, Beylingstrasse 59, Postfach 140128, D-4600 Dortmund-Derne, Germany.

[5] Cashdollar, K. L., and Chatrathi, K., "Minimum Explosible Dust Concentrations Measured in 20-L and 1-m^3 Chambers," *Combustion Science and Technology*, Vol 87, 1993, pp. 157–171.

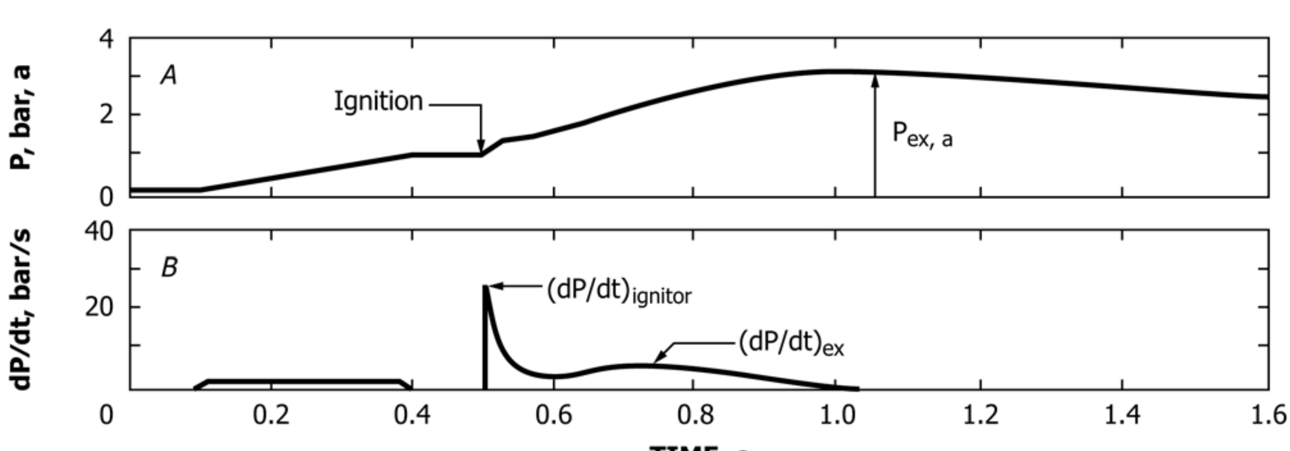

FIG. 1 Typical Recorder Tracings for a Weak Dust Deflagration in a 20-L Chamber, using a 2500 J Ignitor

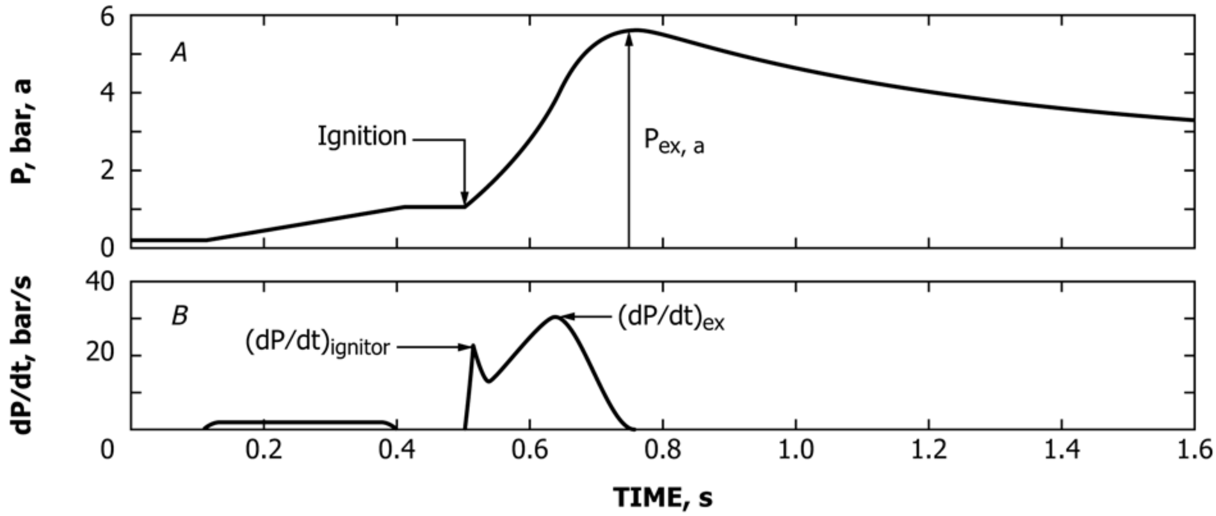

FIG. 2 Typical Recorder Tracings for a Moderate Dust Deflagration in a 20-L Chamber, using a 2500 J Ignitor

6. Interferences

6.1 Unburned dust or combustion products remaining in the chamber or disperser from a previous test may affect results. The chamber and disperser should both be cleaned thoroughly before each test is made.

7. Apparatus

7.1 The equipment consists of a closed steel combustion chamber with an internal volume of at least 20 L, spherical or cylindrical (with a length to diameter ratio between 1.3:1 and 0.7:1) in shape.

7.2 The vessel should be designed and fabricated in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII.[6] A maximum allowable working pressure (MAWP) of at least 15 bar is recommended.

7.3 The apparatus must be capable of dispersing a fairly uniform dust cloud of the material.

7.4 Optical dust probes, such as those described in Footnotes[7,8] may be used to monitor the uniformity of the dust dispersion.

7.5 The pressure transducer and recording equipment must have a combined response rate that is greater than the maximum measured rate of pressure rise.

7.6 An example of a chamber and specific procedures that have been found suitable are shown in Appendix X1.

NOTE 2—Another 20 L chamber design is described in Appendix X1 of Test Method E1226.

8. Safety Precautions

8.1 Prior to handling a dust, the toxicity of the sample and its combustion products must be considered. This information is generally obtained from the manufacturer or supplier. Appropriate safety precautions must be taken if the material has toxic or irritating characteristics. Tests using this apparatus should be conducted in a ventilated hood or other area having adequate ventilation.

8.2 Before initiating a test, a physical check of all gaskets and fittings should be made to prevent leakage.

8.3 If chemical ignitors are used as an ignitor source, safety in handling and use is a primary consideration. Premature ignition by electrostatic discharge must be considered a possibility. When handling these ignitors, eye protection must be worn at all times. A grounded, conductive tabletop is recommended for preparation. Federal, state, and local regulations for the procurement, use, and storage of chemical ignitors must be followed.

8.4 All testing should initially be conducted with small quantities of sample to prevent overpressurization due to high energy material.

8.5 Explosive, highly reactive, or easily decomposed materials should not be tested unless they have been characterized by prior testing. Procedures such as the use of barricades, hoods, and personal protective equipment should be used as judgment indicates.

9. Sampling, Test Specimens, and Test Units

9.1 It is not practical to specify a single method of sampling dust for test purposes because the character of the material and its available form affect selection of the sampling procedure. Generally accepted sampling procedures should be used as described in MNL 32.[9]

[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[7] Cashdollar, K. L., Liebman, I., and Conti, R. S., "Three Bureau of Mines Dust Probes," RI 8542, U.S. Bureau of Mines, 1981.

[8] Conti, R. S., Cashdollar, K. L., and Liebman, I., "Improved Optical Dust Probe for Monitoring Dust Explosions," *Review of Scientific Instruments*, Vol 53, 1982, pp. 311–313.

[9] MNL 32, Manual on testing Sieving Methods, is available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428.