



Designation: E2046 – 19

Standard Test Method for Reaction Induction Time by Thermal Analysis¹

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1. Scope

1.1 This test method describes the measurement of reaction induction time (RIT) of chemical materials that undergo exothermic reactions with an induction period. The techniques and apparatus described may be used for solids, liquids, or slurries of chemical substances. The temperature range covered by this test method is typically from ambient to 400 °C. This range may be extended depending upon the apparatus used.

1.2 The RIT is a relative index value, not an absolute thermodynamic property. As an index value, the RIT value may change depending upon experimental conditions. A comparison of RIT values may be made only for materials tested under similar conditions of apparatus, specimen size, and so forth. Furthermore, the RIT value may not predict behavior of large quantities of material.

1.3 The RIT shall not be used by itself to establish a safe operating temperature. It may be used in conjunction with other test methods (for example, Test Methods E487 and E537, and Guide E1981) as part of a hazard analysis of a particular operation.

1.4 This test method may be used for RIT values greater than 15 min (as relative imprecision increases at shorter periods).

1.5 This test method is used to study catalytic, autocatalytic, and accelerating reactions. These reactions depend upon time as well as temperature. Such reactions are often studied by fixing one experimental parameter (that is, time or temperature) and then measuring the other parameter (that is, temperature or time). This test method measures time to reaction onset detection under isothermal conditions. It is related to Test Method E487 that measures detected reaction onset temperature under constant time conditions

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

¹ This test method is under the jurisdiction of ASTM Committee E27 on Hazard Potential of Chemicals and is the direct responsibility of Subcommittee E27.02 on Thermal Stability and Condensed Phases.

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1.7 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.

1.8 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

- D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
- D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
- D4565 Test Methods for Physical and Environmental Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable
- D5483 Test Method for Oxidation Induction Time of Lubricating Greases by Pressure Differential Scanning Calorimetry
- D6186 Test Method for Oxidation Induction Time of Lubricating Oils by Pressure Differential Scanning Calorimetry (PDSC)
- E473 Terminology Relating to Thermal Analysis and Rheology
- E487 Test Method for Constant-Temperature Stability of Chemical Materials
- E537 Test Method for The Thermal Stability of Chemicals by Differential Scanning Calorimetry
- E967 Test Method for Temperature Calibration of Differential Scanning Calorimeters and Differential Thermal Analyzers
- E968 Practice for Heat Flow Calibration of Differential Scanning Calorimeters
- E1445 Terminology Relating to Hazard Potential of Chemicals

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.

E1858 Test Methods for Determining Oxidation Induction Time of Hydrocarbons by Differential Scanning Calorimetry

E1860 Test Method for Elapsed Time Calibration of Thermal Analyzers

E1981 Guide for Assessing Thermal Stability of Materials by Methods of Accelerating Rate Calorimetry

E2070 Test Methods for Kinetic Parameters by Differential Scanning Calorimetry Using Isothermal Methods

3. Terminology

3.1 The specialized terms used in this test method are described in Terminologies **E473** and **E1445**, including *differential scanning calorimetry*, *differential thermal analysis*, *extrapolated onset value*, *first-deviation-from-baseline*, *onset value*, *isothermal*, and *reaction*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *constant temperature stability (CTS) value, n*—the maximum temperature at which a chemical compound or mixture may be held for a minimum of two hours without exhibiting a measurable exothermic reaction. (See Test Method **E487**.)

3.2.2 *reaction induction time (RIT) value, n*—the time a chemical compound or mixture may be held under isothermal conditions until it exhibits a specified exothermic reaction.

4. Summary of Test Method

4.1 A specimen of the chemical compound or mixture is placed in an inert container that is then heated to an operator-selected test temperature of interest. The specimen temperature and the difference in heat flow or temperature between the test specimen and an inert reference are monitored until an exothermic reaction is recorded. The time from the attainment of the isothermal test temperature until the extrapolated onset to the exothermic reaction is taken as the RIT.

4.2 Using fresh specimens measurements at more than one isothermal test temperature may be made.

4.3 The RIT is expressed as time at a specific test temperature. For example:

$$\text{RIT} = 120 \text{ min at } 100 \text{ }^\circ\text{C}$$

5. Significance and Use

5.1 This test method measures the time to extrapolated onset of an exothermic reaction under constant temperature (isothermal) conditions for reactions which have an induction period, for example, those which are catalytic, autocatalytic, or accelerating in nature or which contain reaction inhibitors.

5.2 The RIT determined by this test method is an index measurement that is useful for comparing one material to another at the test temperature of interest and in the same apparatus type only.

5.3 This test method is a useful adjunct to dynamic thermal tests, such as Test Method **E537**, which are performed under conditions in which the sample temperature is increased continuously at constant rate. Results obtained under dynamic test conditions may result in higher estimates of temperature at

which an exothermic reaction initiates because the detected onset temperature is dependent upon the heating rate and because dynamic methods allow insufficient time for autocatalytic reactions to measurably affect the onset temperature.

5.4 RIT values determined under a series of isothermal test conditions may be plotted as their logarithm versus the reciprocal of the absolute temperature to produce a plot, the slope of which is proportional to the activation energy of the reaction as described in Test Methods **E2070**.

5.5 This test method may be used in research and development, manufacturing, process and quality control, and regulatory compliance.

5.6 This test method is similar to that for oxidation induction time (OIT) (for example, Specification **D3350** and Test Methods **D3895**, **D4565**, **D5483**, **D6186**, and **E1858**) where the time to the oxidation reaction under isothermal test conditions is measured. The OIT test method measures the presence of antioxidant packages and is a relative measurement of a material's resistance to oxidation.

6. Apparatus

6.1 The design and complexity of the apparatus required for this test method depends upon the size of the specimen to be used. In general, observation of an exothermic reaction in small specimens (less than 50 mg) is performed using differential scanning calorimetry or differential thermal analysis equipment and techniques. Large samples (up to 2 g) may be tested using devices such as the Kuhner Micro CTS apparatus.

6.2 The following items are required to obtain the appropriate experimental data.

NOTE 1—Commercially available differential scanning calorimetry apparatus may be used. Alternatively, the apparatus may be assembled or fabricated from commercially available components.

6.2.1 *Test Chamber*, composed of the following:

6.2.1.1 *Furnace(s)*, to provide uniform controlled heating of a specimen and reference to a constant temperature.

6.2.1.2 *Temperature Sensor*, to provide an indication of specimen/furnace temperature readable to ± 0.1 K.

6.2.1.3 *Differential Sensor*, to detect a difference in heat flow (or temperature) between the specimen and the reference specimen equivalent to 10 μW or 0.01 mK.

NOTE 2—A reference material is used when differential heat flow or differential temperature measurements are made. The reference material should match the physical state and heat capacity of the specimen as closely as practical. Typical reference materials include calcined aluminum oxide, glass beads, silicone oil, or combinations thereof.

6.2.1.4 *Means of Sustaining a Test Chamber Environment*, through the use of an air purge gas at a rate of 10 mL/min to 100 ± 5 mL/min.

NOTE 3—Typically, air or inert 99.9+ % pure nitrogen, argon, or helium is employed (when oxidation in air is a concern). Unless effects of moisture are to be studied, use of dry purge gas is recommended.

NOTE 4—For the Kuhner Micro CTS apparatus, the purge gas is provided by operation in a laboratory hood with the door(s) approximately 50 % closed.

6.2.2 *Temperature Controller*, capable of heating from ambient to 400 $^\circ\text{C}$ at a rate of up to 20 $^\circ\text{C}/\text{min}$ and maintaining an