



Designation: D6743 – 06

## Standard Test Method for Thermal Stability of Organic Heat Transfer Fluids<sup>1</sup>

This standard is issued under the fixed designation D6743; 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 determination of the thermal stability of unused organic heat transfer fluids. The procedure is applicable to fluids used for the transfer of heat at temperatures both above and below their boiling point (refers to normal boiling point throughout the text unless otherwise stated). It is applicable to fluids with maximum bulk operating temperature between 260°C (500°F) and 454°C (850°F). The procedure shall not be used to test a fluid above its critical temperature. In this test method, the volatile decomposition products are in continuous contact with the fluid during the test. This test method will not measure the thermal stability threshold (the temperature at which volatile oil fragments begin to form), but instead will indicate bulk fragmentation occurring for a specified temperature and testing period. Because potential decomposition and generation of high pressure gas may occur at temperatures above 260°C (500°F), do not use this test method for aqueous fluids or other fluids which generate high-pressure gas at these temperatures.

1.2 DIN Norm 51528 covers a test method that is similar to this test method.

1.3 The applicability of this test method to siloxane-based heat transfer fluids has not been determined.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see 7.2, 8.8, 8.9, and 8.10.

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.L0.06 on Nonlubricating Process Fluids.

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<sup>2</sup> 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.

D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography

D4175 Terminology Relating to Petroleum, Petroleum Products, and Lubricants

2.2 DIN Norms:

51528 Determination of the Thermal Stability of Unused Heat Transfer Fluids<sup>3</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *thermal stability, n*—the resistance to permanent changes in properties caused solely by heat. **D4175**

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *decomposition products that cannot be vaporized, n*—materials from the thermally stressed heat transfer fluid, from which those fractions that can be vaporized are removed by distillation procedures, that are quantitatively determined as residues in a bulb tube distillation apparatus.

3.2.2 *fluid within the unstressed fluid boiling range, n*—any fluid components with boiling point between the initial boiling point and final boiling point of the unstressed fluid.

3.2.3 *gaseous decomposition products, n*—materials with boiling points below room temperature, at normal pressure, such as hydrogen and methane, that escape upon opening the test cell and that can be determined by measuring the mass immediately thereafter.

3.2.4 *high boiling components, n*—materials from the thermally stressed heat transfer fluid, with boiling points above the final boiling point of the unstressed heat transfer fluid, but which can still be separated by distillation from the heat transfer fluid by means of classical separation procedures.

3.2.5 *low boiling components, n*—materials from the thermally stressed heat transfer fluid, with boiling points below the initial boiling point of the unstressed heat transfer fluid.

3.2.6 *mass percentage of high boiling components, n*—the percentage of thermally stressed heat transfer fluid with a boiling point above the final boiling point of the unstressed fluid.

3.2.7 *mass percentage of low boiling components, n*—the percentage of thermally stressed heat transfer fluid with a boiling point below the initial boiling point of the unstressed fluid.

<sup>3</sup> Available from Beuth Verlag GmbH, Burggrafen Strasse 6, 1000 Berlin 30 Germany.

\*A Summary of Changes section appears at the end of this standard.

3.2.8 *test cell, n*—an ampoule constructed from stainless steel tubing and sealed with compression fittings at each end.

3.2.9 *thermally stressed, adj*—subjected to heating, as described in this test method.

#### 4. Summary of Test Method

4.1 Charge the test fluid in a thermal stability test cell purged with nitrogen and tightly seal the test cell to remove and preclude introduction of oxygen and water from the atmosphere. Heat the fluid in an oven at a given temperature and for a given period of time. Determine the boiling range of the heated fluid by gas chromatography (GC) analysis and compare it to the boiling range of pure, unused fluid.

#### 5. Significance and Use

5.1 Heat transfer fluids degrade when exposed to sufficiently high temperatures. The amount of degradation increases as the temperature increases or the length of exposure increases, or both. Due to reactions and rearrangement, degradation products can be formed. Degradation products include high and low boiling components, gaseous decomposition products, and products that cannot be evaporated. The type and content of degradation products produced will change the performance characteristics of a heat transfer fluid. In order to evaluate thermal stability, it is necessary to quantitatively determine the mass percentages of high and low boiling components, as well as gaseous decomposition products and those that cannot be vaporized, in the thermally stressed heat transfer fluid.

5.2 This test method differentiates the relative stability of organic heat transfer fluids at elevated temperatures in the absence of oxygen and water under the conditions of the test.

5.3 The user shall determine to his own satisfaction whether the results of this test method correlate to field performance. Heat transfer fluids in industrial plants are exposed to a variety of additional influencing variables. Interaction with the plant's materials, impurities, heat build-up during impaired flow conditions, the temperature distribution in the heat transfer fluid circuit, and other factors can also lead to changes in the heat transfer fluid. The test method provides an indication of the relative thermal stability of a heat transfer fluid, and can be considered as one factor in the decision-making process for selection of a fluid.

5.4 The accuracy of the results depends very strongly on how closely the test conditions are followed.

5.5 This test method does not possess the capability to quantify or otherwise assess the formation and nature of thermal decomposition products within the unstressed fluid boiling range. Decomposition products within the unstressed fluid boiling range may represent a significant portion of the total thermal degradation.

#### 6. Apparatus

6.1 *Test Cell*—The test cell shall be a new, clean ampoule made from ASTM A-269 grade 316L stainless steel tubing, 25 mm (1 in.) outside diameter, 2 mm (0.083 in.) wall thickness. The test cell shall be  $0.152 \pm 0.003$  m ( $6 \pm 0.125$  in.) in length and sealed with compression fittings at each end.

NOTE 1—Where tubing with SI dimensions is not readily available, the use of tubing with inch-pound dimensions is acceptable.

6.2 *Heating Oven*—The oven shall be capable of being controlled within  $\pm 1^\circ\text{C}$  ( $\pm 1.8^\circ\text{F}$ ) at test temperature. The test temperature selected will typically be between  $260^\circ\text{C}$  ( $500^\circ\text{F}$ ) and  $427^\circ\text{C}$  ( $800^\circ\text{F}$ ), depending on the fluid being tested.

6.3 *Bulb Tube Distillation Apparatus*—This apparatus shall be capable of heating to at least  $250^\circ\text{C}$  ( $482^\circ\text{F}$ ) and pressure down to at least 0.1 mm Hg.

6.4 *Dewar Flask*—The flask is used to hold the test cells during cooling after removal from the heating oven.

6.5 *Balance*—The balance shall be capable of measuring mass to the nearest 0.01 g.

#### 7. Preparation of Apparatus

7.1 *Test Cell*—The test cell used shall always be a clean, new ampoule. Reuse of ampoules is not permitted.

7.2 *Cleaning of Test Cell*—A new test cell shall be cleaned by washing with a suitable volatile solvent such as acetone and dried. (**Warning**—Use adequate safety precautions with all solvents and cleaners.)

#### 8. Procedure

8.1 Determine the initial boiling point (IBP) and final boiling point (FBP) of the unstressed heat transfer fluid by GC, in accordance with Test Method **D2887** with the following requirements: the column shall be wall-coated open tubular type of 7.5 to 10 m length with a 100 % polydimethylsiloxane film thickness of 0.88  $\mu\text{m}$ , the detector shall be flame ionization type, the initial oven temperature shall be set to  $35^\circ\text{C}$  ( $95^\circ\text{F}$ ) eliminating cryogenic cooling, the calibration mixture shall cover the boiling range from *n*-C<sub>5</sub> to *n*-C<sub>60</sub>. The following GC parameters are recommended: oven temperature rate  $10^\circ\text{C}$  ( $18^\circ\text{F}$ ) per minute, oven final temperature  $375^\circ\text{C}$  ( $707^\circ\text{F}$ ), time at oven final temperature 3 min, injector initial temperature  $100^\circ\text{C}$  ( $212^\circ\text{F}$ ), injector temperature rate  $10^\circ\text{C}$  ( $18^\circ\text{F}$ ) per minute, injector final temperature  $375^\circ\text{C}$  ( $707^\circ\text{F}$ ), detector temperature  $375^\circ\text{C}$  ( $707^\circ\text{F}$ ).

8.2 Measure the mass of a clean, dry test cell including compression fittings to the nearest 0.01 g. Pour the unstressed heat transfer fluid into the clean, dry test cell in a vertical position. The quantity of heat transfer fluid transferred to the test cell shall be  $27 \text{ g} \pm 0.2 \text{ g}$ . Invert the test cell in a vertical position and allow it to drain until all free-flowing material has been removed. More viscous fluids may require as long as 15 min to drain completely. At the end of the draining period, tap the test cell to remove a drop clinging to the open end of the test cell – do not wipe away any fluid. Measure the mass of the test cell and its remaining contents including compression fittings to the nearest 0.01 g.

NOTE 2—The intent is to perform this step only once for each heat transfer fluid being tested at this time.

8.3 Measure the mass of a clean, dry test cell including compression fittings to the nearest 0.01 g. Introduce high purity nitrogen using tubing at the bottom of the clean, dry test cell for 2 min at 60 to 70 mL/min.

NOTE 3—To ensure accurate results, at least three test cells containing samples of the same heat transfer fluid should be heated simultaneously.