



Designation: D8164 – 21

Standard Guide for Digital Contact Thermometers for Petroleum Products, Liquid Fuels, and Lubricant Testing¹

This standard is issued under the fixed designation D8164; 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 The intent of this guide is to suggest an initial configuration and provide guidance when establishing the appropriate criteria needed for a DCT to correctly measure the temperature in a laboratory test method for products within the scope of this committee. This guide includes examples of the approximate digital contact thermometer (DCT) criteria that was found suitable for measuring temperature in the test methods utilized by Committee D02.

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

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:²

- D97 Test Method for Pour Point of Petroleum Products
- D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
- D2162 Practice for Basic Calibration of Master Viscometers and Viscosity Oil Standards
- D2386 Test Method for Freezing Point of Aviation Fuels

¹ This guide is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.91 on Coordinating Subcommittee on Thermometry.

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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.

- D2500 Test Method for Cloud Point of Petroleum Products and Liquid Fuels
- D2532 Test Method for Viscosity and Viscosity Change After Standing at Low Temperature of Aircraft Turbine Lubricants
- D2983 Test Method for Low-Temperature Viscosity of Automatic Transmission Fluids, Hydraulic Fluids, and Lubricants using a Rotational Viscometer
- D3829 Test Method for Predicting the Borderline Pumping Temperature of Engine Oil
- D4539 Test Method for Filterability of Diesel Fuels by Low-Temperature Flow Test (LTFT)
- D4684 Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature
- D5481 Test Method for Measuring Apparent Viscosity at High-Temperature and High-Shear Rate by Multicell Capillary Viscometer
- D5853 Test Method for Pour Point of Crude Oils
- D6371 Test Method for Cold Filter Plugging Point of Diesel and Heating Fuels
- D6821 Test Method for Low Temperature Viscosity of Drive Line Lubricants in a Constant Shear Stress Viscometer
- D6896 Test Method for Determination of Yield Stress and Apparent Viscosity of Used Engine Oils at Low Temperature
- D7279 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids by Automated Houillon Viscometer
- D7962 Practice for Determination of Minimum Immersion Depth and Assessment of Temperature Sensor Measurement Drift
- D8210 Test Method for Automatic Determination of Low-Temperature Viscosity of Automatic Transmission Fluids, Hydraulic Fluids, and Lubricants Using a Rotational Viscometer
- D8278 Specification for Digital Contact Thermometers for Test Methods Measuring Flow Properties of Fuels and Lubricants
- E1 Specification for ASTM Liquid-in-Glass Thermometers
- E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
- E563 Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature

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

E644 Test Methods for Testing Industrial Resistance Thermometers

E1750 Guide for Use of Water Triple Point Cells

E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

E2877 Guide for Digital Contact Thermometers

2.2 *ISO Standard*.³

ISO 17025 General requirements for the competence of testing and calibration laboratories

3. Terminology

3.1 Definitions:

3.1.1 *accuracy, n*—the closeness of agreement between a test result and an accepted reference value. **E177**

3.1.2 *DCT immersion depth, n*—depth that a DCT probe should be immersed in a uniform temperature environment, such that further immersion does not produce a change in indicated temperature greater than the specified tolerance.

3.1.2.1 *Discussion*—This is a DCT probe characteristic and establishes a baseline immersion for the probe. This is separate and distinct from how the probe is located in a test method. The use and positioning of a DCT probe in a test method is to be described in the test method.

3.1.3 *digital contact thermometer (DCT), n*—an electronic device consisting of a digital display and associated temperature sensing probe.

3.1.3.1 *Discussion*—This device consists of a temperature sensor connected to a measuring instrument; this instrument measures the temperature-dependent quantity of the sensor, computes the temperature from the measured quantity, and provides a digital output. This digital output goes to a digital display and/or recording device that may be internal or external to the device.

3.1.3.2 *Discussion*—The devices are often referred to as a “digital thermometers,” however the term includes devices that sense temperature by means other than being in physical contact with the media.

3.1.3.3 *Discussion*—PET is an acronym for portable electronic thermometers, a subset of digital contact thermometers (DCT).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *range-of-use, n*—a subset of the nominal DCT temperature range.

3.2.1.1 *Discussion*—This is the temperature range over which a particular DCT is to be used and calibrated. For example, if a DCT is to be used for viscosity measurements as 40 °C and 100 °C, then its range-of-use is 60 °C.

3.3 Acronyms:

3.3.1 *PRT, n*—Platinum Resistance Thermometer

3.3.1.1 *Discussion*—The sensor used in a PRT is made from platinum, whose resistance varies with temperature.

3.3.2 *SPRT, n*—Standard Platinum Resistance Thermometer

3.3.2.1 *Discussion*—An SPRT is a high precision PRT with an accuracy on the order of a milliKelvin (0.0010 °C).

4. Summary of Guide

4.1 The purpose of this guide is to assist users in determining the criteria needed to define the performance of a digital contact thermometer (DCT) that is suitable for use in test methods within the scope of Committee D02. This guide includes examples of criteria that are approximately those used successfully to measure the temperature in different measurement test configurations. The parameters in these examples are based on the design and sensing characteristics of the liquid-in-glass thermometers. These examples should be considered as a starting point for establishing the DCT criteria for other applications. Other temperature measurement configurations may require additional criteria in order to appropriately assess the temperature in a test method. *It is the responsibility of the standard developer and user to ensure that the chosen DCT criteria will adequately indicate the test temperature especially when replacing a cited liquid-in-glass thermometer.*

4.2 The DCT temperature sensing elements used in this guide are platinum resistance temperature (PRT) detector, thermistor or thermocouple which are in contact with the substance thus referred to as a digital contact thermometer. Both PRTs and thermistors are members of a group referred to as resistance temperature detectors (RTD) as their resistance is a function of temperature. Thermocouples are created by linking two dissimilar metals which results in a temperature dependent potential.

5. Significance and Use

5.1 The information in the examples of this guide are intended to be a starting point for determining the appropriate DCT criteria for a test method that measures a temperature-dependent property of a product within the scope of Committee D02. The criteria examples noted in this guide are based on the liquid-in-glass (LiG) thermometer design components, which are the bulb length, immersion depth, precision of measurement, thermometer position, and so forth. The parameters such as sensor length, immersion depth, and sheath diameter are especially critical when measuring the temperature of small static samples. This is due in part to the difference in thermal conductivity of a LiG vs. a DCT, however other aspects of the devices can contribute to unequal results. For example a DCT that is suitable for use in a stirred constant temperature bath will likely result in measurement errors when used to measure the temperature of a small static sample. This difference can be a degree or more when the sample temperature differs from room temperature by 40 °C or more using a 7 mm probe. This error is due to the difference in thermal conductivity and specific heat value of a DCT and LiG thermometer, however other aspects of the two different devices can contribute unequal results. One way to counter this is by reducing DCT sheath diameter, insulating the sheath above the immersion level, and using a probe that has a small immersion depth as determined by Practice **D7962**. For more guidance on selecting an appropriate DCT, see Guide **E2877**.

5.2 When replacing a LiG thermometer with a DCT noted in this guide and the test method does not list any DCT criteria, *it is incumbent on the user to verify the suitability of the DCT*

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.