Designation: D5931 – 13

Standard Test Method for Density and Relative Density of Engine Coolant Concentrates and Aqueous Engine Coolants by Digital Density Meter[1]

This standard is issued under the fixed designation D5931; 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 covers the determination of the density or relative density of engine coolant concentrates and aqueous engine coolants.

1.2 This test method should not be applied to samples so dark in color that the absence of air bubbles in the sample cell cannot be established with certainty.

1.3 The accepted units of measure for density are grams per milliliter or kilograms per cubic meter.

1.4 *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 hazard statements, see Note 1.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1193 Specification for Reagent Water

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

E230 Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples

3. Terminology

3.1 *Definitions:*

3.1.1 *relative density, n*—the ratio of the density of a material at a stated temperature to the density of water at the same stated temperature.

4. Summary of Test Method

4.1 A small volume of liquid sample is introduced into an oscillating sample tube, and the change in oscillating frequency caused by the change in the mass of the tube is used in conjunction with calibration data to determine the density of the sample.

5. Significance and Use

5.1 Density is a fundamental physical property that can be used in conjunction with other properties to characterize engine coolant concentrates and aqueous engine coolants.

5.2 Determination of the density or relative density of these products is necessary for the conversion of measured volumes to volumes at the standard temperature of 20°C (68°F).

6. Apparatus

6.1 *Digital Density Analyzer,* consisting of a U-shaped, oscillating sample tube and a system for electronic excitation, frequency counting, and display. The analyzer must accommodate the accurate measurement of the sample temperature during measurement or must control the sample temperature as described in 6.2. The instrument must meet the precision requirements described in this test method.

6.2 *Circulating Constant—Temperature Bath,* (optional) capable of maintaining the temperature of the circulating liquid constant to ±0.05°C in the desired range. Temperature control can be maintained as part of the density analyzer instrument package.

6.3 *Syringes,* at least 2 mL in volume with a tip or an adapter tip that will fit the opening of the oscillating tube.

6.4 *Flow-Through or Pressure Adapter,* for use as an alternative means of introducing the sample into the density analyzer either by a pump or by vacuum.

6.5 *Temperature Measuring Instrument,* (Environmentally safe thermometer or thermocouple). An ASTM Partial Immersion Thermometer, having a range from -5 to 300°C (20 to 580°F) and conforming to the requirements for thermometer 2C or 2F, as prescribed in Specification D1193, or some suitable non-mercury containing temperature measuring

[1] This test method is under the jurisdiction of ASTM Committee D15 on Engine Coolants and Related Fluids and is the direct responsibility of Subcommittee D15.03 on Physical Properties.

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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.

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

device, such as a thermocouple, capable of operating in the same temperature range and having equal or better accuracy as summarized in Specification E230. See section 13, Precision and Bias. The data presented in this paragraph is derived using mercury-in-glass thermometers only.

7. Reagents and Materials

7.1 *Purity of Reagents*—Use reagent grade chemicals in all tests. Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water*—Unless otherwise indicated, references to water mean reagent water as defined by Type II of Specification D1193.

7.3 *Water,* redistilled, freshly boiled and cooled reagent water for use as a primary calibration standard.

7.4 *Acetone,* for flushing and drying the sample tube.

NOTE 1—**Warning:** Acetone is extremely flammable.

7.5 *Dry Air,* for drying the oscillator tube.

8. Preparation of Apparatus

8.1 Set up the density analyzer and constant temperature bath following the manufacturer's instructions. Adjust the bath or internal temperature control so that the desired test temperature is established and maintained in the sample compartment of the analyzer. Calibrate the instrument at the same temperature at which the density of the sample is to be measured.

NOTE 2—Precise setting and control of the test temperature in the sample tube is extremely important. An error of 1.0°C can result in a change in density of one in the third decimal place.

9. Calibration of Apparatus

9.1 Calibrate the instrument when first set up and whenever the test temperature is changed. Thereafter, conduct calibration checks at weekly intervals during routine operation.

9.2 Initial calibration, or calibration after a change in test temperature, necessitates calculation of the values of the constants *A* and *B* from the periods of oscillation (*T*) observed when the sample cell contains air and redistilled, freshly boiled and cooled reagent water.

9.2.1 While monitoring the oscillator period, (*T*), flush the sample tube with distilled water followed by an acetone flush and drying with dry air. Contaminated or humid air can affect the calibration. When these conditions exist in the laboratory, pass the air used for calibration through a suitable purification and drying train. In addition, the inlet and outlet ports for the U-tube must be plugged during measurement of the calibration air to prevent ingress of moist air.

9.2.2 Allow the dry air in the U-tube to come to thermal equilibrium with the test temperature and record the *T*-value for air.

9.2.3 Introduce a small volume of redistilled, freshly boiled and cooled reagent water into the sample tube opening using a suitable syringe. The test portion must be homogeneous and free of even the smallest air or gas bubbles. The sample tube does not have to be completely full as long as the liquid meniscus is beyond the suspension point. Allow the display to reach a steady reading and record the *T*-value for water.

9.2.4 Record the density of air at the temperature and atmospheric pressure of the test. Calculate the density of air at the temperature of test using the following equation:

$$d_a,\ \text{g/m}L = 0.001293[273.15/T][P/760] \quad (1)$$

where:

T = temperature, degrees Kelvin, K, and
P = barometric pressure, torr.

9.2.5 Determine the density of water at the temperature of test by reference to Table 1.

9.2.6 Using the observed *T*-values and the reference values for water and air, calculate the values of the constants *A* and *B* using the following equations:

$$A = [T_w^2 - T_a^2]/[d_w - d_a] \quad (2)$$

$$B = T_a^2 - (A \times d_a) \quad (3)$$

where:

T_w = observed period of oscillation for cell containing water,
T_a = observed period of oscillation for cell containing air,
d_w = density of water at test temperature, °C, and
d_a = density of air at test temperature,° C.

Alternatively, use the *T* and *d* values for the other reference liquid if one is used.

9.2.7 If the instrument is equipped to calculate density from the constants *A* and *B* and the observed *T*-value from the sample, enter the constants in the instrument memory in accordance with the manufacturer's instructions.

9.2.8 Check the calibration and adjust if needed by performing the routine calibration check described in 9.3.

TABLE 1 Density of Water[A]

Temperature, ° C	Density, g/mL	Temperature, °C	Density, g/mL	Temperature, °C	Density, g/mL
0	0.99987	21	0.99802	40	0.99224
3	0.99999	22	0.99780	45	0.99025
4	1.00000	23	0.99756	50	0.98807
5	0.99999	24	0.99732	55	0.98573
10	0.99973	25	0.99707	60	0.98324
15	0.99913	26	0.99681	65	0.98059
15.56	0.99904	27	0.99654	70	0.97781
16	0.99897	28	0.99626	75	0.97489
17	0.99880	29	0.99597	80	0.97183
18	0.99862	30	0.99567	85	0.96865
19	0.99843	35	0.99406	90	0.96534
20	0.99823	37.78	0.99307	100	0.95838

[A] From Test Method D4052.

[3] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.