Designation: D 2140 – 03

Standard Test Method for Carbon-Type Composition of Insulating Oils of Petroleum Origin [1]

This standard is issued under the fixed designation D 2140; 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 may be used to determine the carbon-type composition of mineral insulating oils by correlation with basic physical properties. For routine analytical purposes it eliminates the necessity for complex fractional separation and purification procedures. The test method is applicable to oils having average molecular weights from 200 to above 600, and 0 to 50 aromatic carbon atoms.

1.2 Carbon-type composition is expressed as percentage of aromatic carbons, percentage of naphthenic carbons, and percentage of paraffinic carbons. These values can be obtained from the correlation chart, Fig. 1, if both the viscosity-gravity constant (VGC) and refractivity intercept (r_i) of the oil are known. Viscosity, density and relative density (specific gravity), and refractive index are the only experimental data required for use of this test method.

1.3 This test method is useful for determining the carbon-type composition of electrical insulating oils of the types commonly used in electric power transformers and transmission cables. It is primarily intended for use with new oils, either inhibited or uninhibited.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)[2]

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)[2]

D 923 Practices for Sampling Electrical Insulating Liquids[3]

D 1218 Test Method for Refractive Index and Refractive Dispersion of Hydrocarbon Liquids[2]

D 1481 Test Method for Density and Relative Density (Specific Gravity) of Viscous Materials by Lipkin Bicapillary Pycnometer[2]

D 2007 Test Method for Characteristic Groups in Rubber Extender and Processing Oils and Other Petroleum Derived Oils by the Clay Gel Absorption Chromatographic Method[2]

D 2501 Test Method for Calculation of Viscosity-Gravity Constant (VGC) of Petroleum Oils[2]

D 3238 Test Method for Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the n-d-M Method[4]

D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *percent of aromatic carbons (% C_A)*—the weight percent of the total carbon atoms present in an oil that are combined in aromatic ring-type structures.

3.1.2 *percent of naphthenic carbons (% C_N)*—the weight percent of the total carbon atoms present in an oil that are combined in naphthenic ring-type structures.

3.1.3 *percent of paraffinic carbons (% C_P)*—the weight percent of the total carbon atoms present in an oil that are combined in paraffinic chain-type structures.

NOTE 1—The resolution of carbon atoms into structural classifications is independent of whether the structures exist as separate molecules or are combined with other structural forms in a molecule. For example, a paraffinic chain may be either an aliphatic hydrocarbon molecule, or may be an alkyl group attached to an aromatic or naphthenic ring.

4. Summary of Test Method

4.1 A sample of the oil to be analyzed by this method is first tested to determine its viscosity, density and relative density (specific gravity), and refractive index. From these measured properties the viscosity-gravity constant (VGC) and refractivity intercept (r_i) are obtained by calculation, using the equations given. The calculated values of VGC and r_i are used with

[1] This test method is under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.07 on Physical Tests.

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 10.03.

[4] *Annual Book of ASTM Standards*, Vol 05.02.

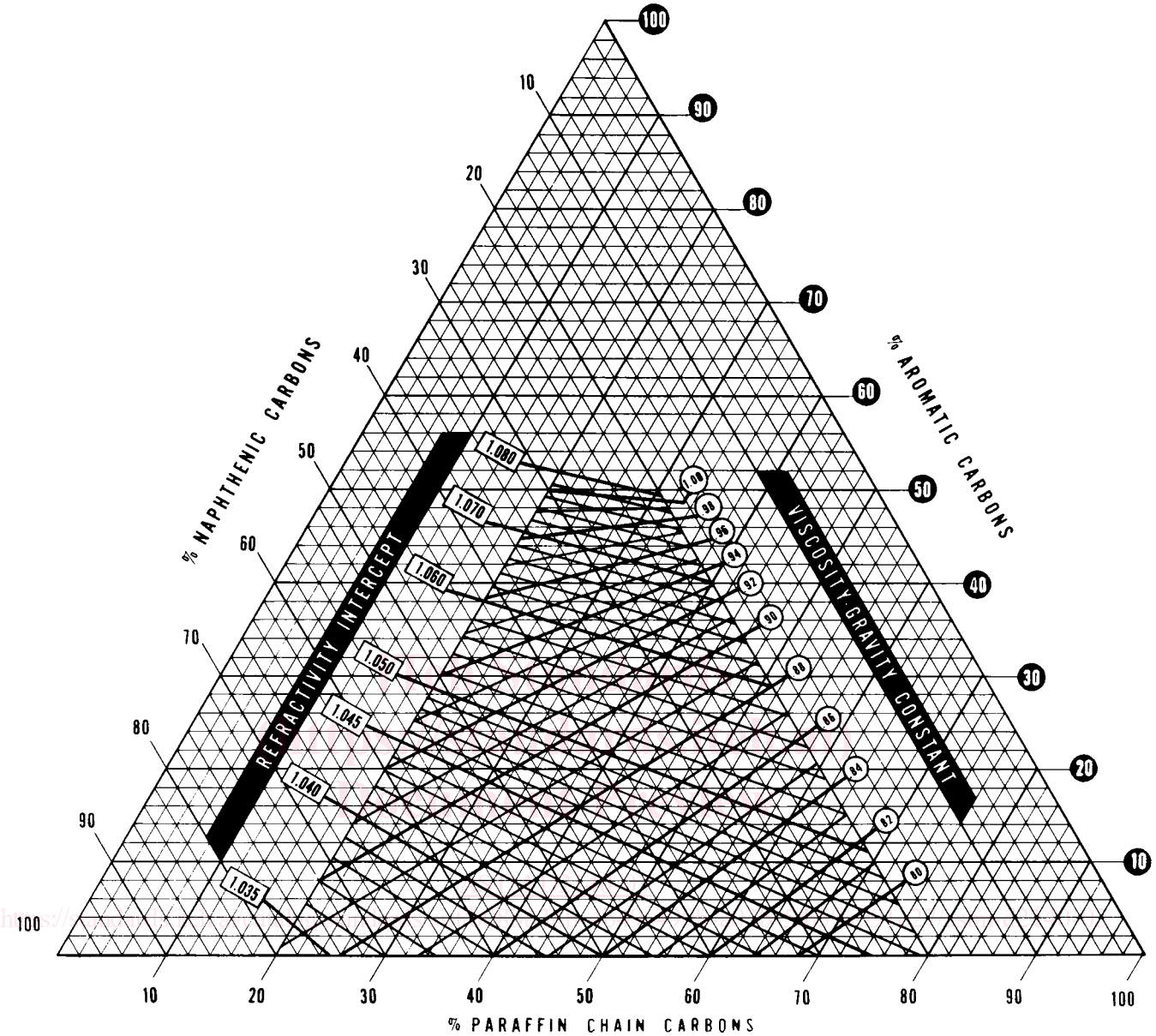

FIG. 1 Correlation Chart for Determining % C_A, % C_N, and % C_P

Fig. 1, to correlate those parameters with carbon-type composition. The composition in terms of % C_A, % C_N, and % C_P may be read directly from Fig. 1.

NOTE 2—Fig. 1 is a form of correlation chart that has been found satisfactory for use with this method. Other chart forms may be devised and used in preference to Fig. 1 if it is determined that the data obtained are consistent with similar data from Fig. 1. In addition, some users will find it convenient to develop a computer program or spreadsheet which will provide a consistent evaluation of the data.

5. Significance and Use

5.1 The primary purpose of this test method is to characterize the carbon-type composition of an oil. It is also applicable in observing the effect on oil constitution, of various refining processes such as hydrotreating, solvent extraction, and so forth. It has secondary application in relating the chemical nature of an oil to other phenomena that have been demonstrated to be related to oil composition.

5.2 Results obtained by this method are similar to, but not identical with, results obtained from Test Method D 3238. The relationship between the two methods and the equations used in deriving Fig. 1 are discussed in the literature.[5]

5.3 Although this test method tends to give consistent results, it may not compare with direct measurement test methods such as Test Method D 2007.

6. Apparatus

6.1 No specific apparatus is required for use by this test method. However, to obtain the VGC and r_i parameters of Fig. 1, certain measurements of basic physical properties of the test

[5] Kurtz, S. S., King, R. W., Stout, W. J., Partikian, D. G., and Skrabek, E. A., "Relationship Between Carbon-Type Composition, Viscosity-Gravity Constant, and Refractivity Intercept of Viscous Fractions of Petroleum," *Analytical Chemistry*, Vol 28, pp 1928–1936 (1956).