Determination of carbon-type composition of mineral oils	DIN 51378

Prüfung von Mineralölen; Bestimmung der Kohlenstoffverteilung

See Explanatory notes for connection with ASTM D 2140-91 published by the American Society for Testing and Materials (ASTM).

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

1 Field of application

This standard covers unused mineral oils with an average molecular mass of more than 200, which do not contain additives foreign to mineral oils and have a viscosity-gravity constant of less than 0,98.

The test method may also be applied to inhibited insulating oils.

2 Scope

The method described in this standard serves to determine the carbon-type composition of mineral oils, expressed in terms of fractions, X, of carbon atoms that are combined in aromatic rings (A), in naphthenic rings (N) and in paraffinic chains (P).

These fractions (X(A), X(N) and X(P)) characterize the statistical composition of the mineral oil, but do not provide any information on its chemical structure.

3 Concept

The fraction of a constituent X, X(X), is the ratio of the number of atoms of the constituent X, N(X), and the sum of the number of atoms of all such constituents, Σ N(X), of an unused mineral oil.

4 Principle

The kinematic viscosity, the density, the refractive index and the sulfur content of the sample are determined in order to calculate the viscosity-gravity constant and the refractivity intercept. The carbon-type composition, in terms of X(A), X(N) and X(P) percentage fractions, is then read from the nomogram or calculated by computer.

Subject to agreement, X(A), X(N) and X(P) are reported either with (calculation method K) or without (calculation method U) sulfur correction.

5 Sampling

Sampling shall be carried out as specified in DIN 51750 Parts 1 and 2.

6 Procedure

6.1 Determination of density, kinematic viscosity, refractive index and sulfur content

6.1.1 Density

Determine the density at 15 °C as described in DIN 51757.

6.1.2 Kinematic viscosity

Determine the kinematic viscosity, in mm²/s[1]), at 40 °C using the Ubbelohde viscometer as described in DIN 51562 Part 1.

6.1.3 Refractive index

Determine the refractive index at 20 °C as described in DIN 51423 Part 1 or 2.

> NOTE: In the case of oils having a colour index of more than 6, a reduction in the precision of the measurement is to be expected, its effect on the carbon-type composition being generally negligible.

6.1.4 Sulfur content

Determine the sulfur content, as a percentage by mass, as described in DIN 51400 Part 2, 3 or 6, or as described in DIN EN 41.

6.2 Calculation of viscosity-gravity constant and refractivity intercept

Calculate the viscosity-gravity constant, VGC, and the refractivity intercept, r_i, using equations (1) and (2).

$$VGC = \frac{\varrho - 0{,}0822 - 0{,}776 \, \lg\lg\left(10\,v - 4\right)}{1{,}0763 - 0{,}72 \, \lg\lg\left(10\,v - 4\right)} \tag{1}$$

$$r_i = n - \frac{\varrho - 0{,}0030}{2} \tag{2}$$

where

ϱ is the density at 15 °C, in kg/l;

v is the kinematic viscosity at 40 °C, in mm²/s;

n is the refractive index for the sodium D line at 20 °C.

---

[1]) 1 mm²/s = 1 cSt = 10^{-6} m²/s (m²/s is the SI unit of the kinematic viscosity).

Table 1: Example of calculations as described in subclauses 6.2 to 6.4

Epression of results	Oil No. 1	Oil No. 2
Measured values:		
density at 15°C, ϱ, in kg/l	0,8597	0,8990
kinematic viscosity at 40°C, v, in mm²/s	7,62	500,0
refractive index at 20°C, n	1,4738	1,4935
sulfur content, w (S), as a percentage by mass	0,01	0,90
Calculated values:		
VDC	0,831	0,810
r_i	1,0455	1,0455
Taken from nomogram:		
Calculation method U:		
X (A) %	7	4
X (N) %	34	29
X (P) %	59	67
Calculation method K:		
X_1 (A) %	7	4
X_1 (N) %	34	26
X_1 (P) %	59	71

6.3 Carbon-type composition

Use the viscosity-gravity constant, VGC, and the refractivity intercept, r_i, calculated from equations (1) and (2), respectively, to read from the nomogram (cf. figure 1) fractions $X(N)$ and $X(A)$ or to calculate the percentage fractions by computer[2] (calculation method U). This method is not suitable for mineral oils having VGC and r_i lines intersecting outside the nomogram.

Take the sulfur content of the sample analysed into account as described in subclause 6.4 and correct fractions $X(N)$ and $X(A)$ accordingly (calculation method K).

6.4 Sulfur correction of fractions read from the nomogram

Correct fractions $X(N)$ and $X(A)$ read from the nomogram for the sulfur content using equations (3) and (4).

$$X_1(A) = X(A) - 1,158 \cdot w(S) \tag{3}$$

$$X_1(N) = X(N) - 3,472 \cdot w(S) \tag{4}$$

Calculate fraction $X_1(P)$ from fractions $X_1(A)$ and $X_1(N)$, using equation (5).

$$X_1(P) = 100 - (X_1(A) + X_1(N)) \tag{5}$$

where

$X_1(A)$ is the fraction of the carbon atoms combined in aromatic rings, corrected for the sulfur content, as a percentage by mass;

$X_1(N)$ is the fraction of the carbon atoms combined in naphthenic rings, corrected for the sulfur content, as a percentage by mass;

$X_1(P)$ is the fraction of the carbon atoms bound in paraffinic chains, corrected for the sulfur content, as a percentage by mass;

$w(S)$ is the sulfur content, as a percentage by mass.

7 Expression of result

The test report shall refer to this standard and report the fractions $X(A)$, $X(N)$ and $X(P)$, as percentages, to the nearest 1 %, as specified in DIN 1333, as follows

a) values corrected for sulfur content (K):

Carbon-type composition as specified in DIN 51378 – K

and

b) values not corrected for sulfur content (U):

Carbon-type composition as specified in DIN 51378 – U

Example of a):

Carbon-type composition

$$\left. \begin{array}{l} X(A) = \ 9\,\% \\ X(N) = 29\,\% \\ X(P) = 62\,\% \end{array} \right\} \text{ as specified in DIN 51378 – K}$$

8 Precision

(Cf. DIN 51848 Part 1.)

The precision of the method depends on the methods used to determine the characteristics specified in subclause 6.1.

Repeatability limit
(same operator, same apparatus)

The repeatability limits of the individual methods specified in this standard determine the overall repeatability limit of the results.

Reproducibility limit
(different operators, different apparatus)

The reproducibility limits of the individual methods specified in this standard determine the overall reproducibility limit of the results. The limits given below were determined in interlaboratory tests.

If two separate laboratories each obtain a result for $X(A)$, $X(N)$ and $X(P)$ under reproducibility conditions, both results shall be considered acceptable and in conformity with this standard if the values for $X(A)$ differ by no more than 2 and if the values for $X(N)$ and $X(P)$ differ by no more than 3.

---

[2] Computer-aided calculation of the fractions $X(A)$, $X(N)$ and $X(P)$ is permitted if a check has ensured that the values agree with those taken from the nomogram.