INTERNATIONAL STANDARD ISO 3675

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Crude petroleum and liquid petroleum products — Laboratory determination of density or relative density — Hydrometer method

Pétroles bruts et produits pétroliers liquides — Détermination en laboratoire de la masse volumique ou de la densité relative — Méthode à l'aréomètre

First edition — 1976-12-15

UDC 665.6/.7 : 531.756

Ref. No. ISO 3675-1976 (E)

Descriptors : petroleum products, crude oil, liquid fuels, physical tests, laboratory tests, density measurement, density (mass/volume), test equipment, hydrometers.

Price based on 6 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3675 was drawn up by Technical Committee ISO/TC 28, *Petroleum products*, and was circulated to the Member Bodies in November 1974.

It has been approved by the Member Bodies of the following countries :

Austria	Iran	South Africa, Rep. of
Belgium	Israel	Spain
Brazil	Japan	Sweden
Bulgaria	Mexico	Turkey
Czechoslovakia	Netherlands	United Kingdom
France	Pakistan	U.S.A.
Germany	Poland	U.S.S.R.
Hungary	Portugal	Yugoslavia
India	Romania	

No Member Body expressed disapproval of the document.

Printed in Switzerland

Crude petroleum and liquid petroleum products — Laboratory determination of density or relative density — Hydrometer method

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard specifies a method for the laboratory determination, using a glass hydrometer, of the density or relative density of crude petroleum, petroleum products of mixtures of petroleum and non-petroleum products normally handled as liquids, and having a Reid vapour pressure of 1,8 bar (180 kPa) or less, determined according to ISO 3007.

Hydrometer readings are obtained at convenient temperatures, readings of density being reduced to 15 °C or 20 °C, and readings or relative density to 60 °F, by means of international standard measurement tables. By means of these same tables, values determined in each of the two systems of measurement are convertible to equivalent values in the other, so that measurements may be made in the units of local convenience.

1.2 Accurate determination of the density or relative density of petroleum and its products is necessary for the conversion of measured volumes to volumes at the standard temperatures of 15 °C, 20 °C or 60 °F and also volume to mass and vice versa.

1.3 The hydrometer method is most suitable for determining the density or relative density of mobile transparent liquids. It can also be used for viscous oils by allowing sufficient time for the hydrometer to reach equilibrium, or for opaque oils by employing a suitable meniscus correction.

NOTE — In view of the widespread international use of the arbitrary scale of API gravity, information relating to this system is given in annex A, but it is expected that the use of API gravity will be phased out in the future.

2 REFERENCES

ISO/R 91, *Petroleum measurement tables.*

ISO/R 91 Addendum 1, *Petroleum measurement tables based on a reference temperature of 20 °C.*

ISO/R 649, *Density hydrometers for general purposes.*

ISO/R 650, *Relative density 60/60 °F hydrometers for general purposes.*

ISO 3007, *Petroleum products — Determination of vapour pressure — Reid method.*

3 DEFINITIONS

For the purposes of this International Standard, the following definitions apply.

3.1 density : The mass of the liquid divided by its volume at 15 °C or 20 °C.

When reporting results, state the density in units of mass and volume, together with the standard reference temperature; for example, grams per millilitre at 15 °C. (See note in 3.2.)

For practical purposes, the weight *in vacuo* may be taken to represent the mass.

3.2 relative density : The ratio of the mass of a volume of a liquid at 60 °F to the mass of an equal volume of pure water at the same temperature, i.e. the ratio of the density of the liquid at 60 °F to the density of water at 60 °F.

When reporting results, state the standard reference temperatures, i.e. relative density 60/60 °F.

NOTE — **Observed values.** Since all hydrometers are calibrated to read correctly at a specified reference temperature, scale readings made at another temperature are only hydrometer readings and not values of density or relative density at that other temperature.

4 PRINCIPLE

The sample and a hydrometer cylinder are brought within a prescribed temperature range and a test portion is transferred to the cylinder at approximately the same temperature. The appropriate hydrometer is lowered into the test portion and allowed to settle. After temperature equilibrium has been reached, the hydrometer scale is read, and the temperature of the test portion is noted. If necessary, the cylinder and its contents are placed in a constant-temperature bath to avoid excessive temperature variation during the test.

5 APPARATUS

5.1 Hydrometers, of glass and of the general form and dimensions specified in ISO/R 649 or ISO/R 650, indicating density or relative density at the appropriate reference temperature as required, conforming to the requirements listed in table 1.

NOTE — Smaller hydrometers are widely used for product quality control; their essential requirements are given in annex B. (See also note in 5.2.)

TABLE 1 — **Essential requirements for hydrometers** (*see* 5.1)

Basis of scale	Range		Scale		Meniscus corrections
	Set of hydrometers	Each hydrometer in set	Interval	Maximum uncertainty	
Density at 15 °C or 20 °C, g/ml	0,600 to 1,100 0,600 to 1,100	0,050 0,050	0,000 5 0,001	± 0,000 3 ± 0,000 6	+ 0,000 7 + 0,001 4
Relative density 60/60 °F	0,600 to 1,100 0,600 to 1,100	0,050 0,050	0,000 5 0,001	± 0,000 3 ± 0,000 6	+ 0,000 7 + 0,001 4
Relative density 60/60 °F	0,650 to 1,100	0,050	0,000 5	± 0,000 5	+ 0,000 7

TABLE 2 — **Requirements for thermometers**

Range	Graduation interval	Maximum scale uncertainty
− 20 to + 102 °C	0,2	± 0,1
− 5 to + 215 °F	0,5	± 0,25

5.2 Thermometers, having ranges, graduation intervals and maximum uncertainties as shown in table 2.

Thermometers ASTM 12C, ASTM 12F, IP 64C, IP 64F are suitable, but any thermometer conforming to the requirements of table 2 may be used.

NOTE — A hydrometer or a thermometer that is provided with a calibration certificate issued by a recognized standardizing body is classed as "certified" and the appropriate corrections listed in the certificate shall be applied to the observed readings. Instruments that satisfy the requirements of this test method, but are not provided with a recognized calibration certificate, are classed as "uncertified".

5.3 Hydrometer cylinder, of clear glass, plastics material, or of metal for testing opaque samples (see note 1 following 7.2). Plastics materials used for the construction of hydrometer cylinders shall be resistant to discoloration or attack by oil samples, shall not become opaque under prolonged exposure to sunlight and oil samples and shall not affect the properties of the sample. For convenience in pouring, the cylinder may have a lip on the rim. The inside diameter of the cylinder shall be at least 25 mm greater than the outside diameter of the hydrometer used in it. The height of the cylinder shall be such that the hydrometer floats in the sample with at least 25 mm clearance between the bottom of the hydrometer and the bottom of the cylinder.

5.4 Constant-temperature bath, for use when the nature of the sample requires a test temperature much above or below room temperature or when the requirements of 7.8 cannot otherwise be met.

6 TEMPERATURE OF TEST

6.1 The determination of density or relative density by the hydrometer method is most accurate at or near the standard temperatures. These or any other temperatures between − 18 and + 90 °C (0 and 195 °F), shall be used, in so far as they are consistent with the type of sample and necessary limiting conditions shown in table 3.

6.2 When the hydrometer value is to be used to select multipliers for correcting volumes to standard temperatures, i.e. for entering tables 6, 24 or 54 referred to in ISO/R 91, the hydrometer reading should be made preferably at a temperature within ± 3 °C (± 5 °F) of the temperature at which the bulk volume of the oil was measured (see note). However, in cases when appreciable amounts of light fractions may be lost during determination at the bulk oil temperature, the limits given in table 3 shall be applied.

NOTE — The tables for correcting volume (i.e. tables 6, 24 and 54 referred to in ISO/R 91) or density and relative density (i.e. tables 5, 23 and 53 referred to in ISO/R 91) to standard temperatures are based on an average expansion for a number of typical materials. Since the same coefficients are used in computing both sets of tables, corrections made over the same temperature interval minimize errors arising from possible differences between the coefficients of the material under test and the standard coefficients. This effect becomes more important as temperatures diverge significantly from the selected reference temperature.

TABLE 3 — **Limiting conditions and test temperatures**

Sample type	Initial boiling point	Other limits	Test temperature
Highly volatile	—	Reid vapour pressure below 1,8 bar (180 kPa)	Cool in original closed container to 2 °C (35 °F) or lower.
Moderately volatile	120 °C (250 °F) and below	—	Cool in original closed container to 20 °C (68 °F) or lower.
Moderately volatile and viscous	120 °C (250 °F) and below	Viscosity too high at 18 °C (65 °F)	Heat to minimum temperature to obtain sufficient fluidity.
Non-volatile	Above 120 °C (250 °F)	—	Use any temperature between − 18 °C and + 90 °C (0 and 195 °F) as convenient.
Mixtures with non-petroleum products	—	—	Test at 15 ± 0,2 °C, 20 ± 0,2 °C (60 ± 0.5 °F).

7 PROCEDURE

7.1 Adjust the temperature of the sample according to the indications given in clause 6. Bring the clean hydrometer cylinder (5.3) and the appropriate thermometer (5.2) and hydrometer (5.1) (see note following 7.8) to approximately the same temperature as the sample to be tested.

7.2 Transfer a test portion (see note 1) to the temperature-stabilized hydrometer cylinder without splashing, to avoid the formation of air bubbles and to reduce to a minimum the evaporation of the lower boiling constituents of the more volatile samples. Transfer highly volatile samples to the cylinder by water displacement or by siphoning (see note 2). Remove any air bubbles formed, after they have collected on the surface of the test portion, by touching them with a piece of clean filter paper before inserting the hydrometer.

NOTES

1 When metal cylinders are used, accurate reading of the hydrometer can only be ensured if the level of the sample is within 5 mm of the top of the cylinder.

2 Highly volatile samples containing alcohols or other water-soluble material should always be transferred by siphoning.

7.3 Place the cylinder containing the test portion in a vertical position in a location free from air currents. Ensure that the temperature of the test portion does not change appreciably during the time necessary to complete the test; during this period, the temperature of the surrounding medium should not change by more than 2 °C (5 °F). When testing at temperatures much above or below room temperature, the constant-temperature bath (5.4) may be necessary to avoid excessive temperature changes.

7.4 Lower the hydrometer gently into the test portion. Take care to avoid wetting the stem above the level to which it will be immersed in the liquid. Continuously stir the test portion with the thermometer, taking care that the mercury thread is kept fully immersed and that the stem of the hydrometer is not wetted above the immersion level. As soon as steady reading is obtained, record the temperature of the test portion to the nearest 0,2 °C (0.5 °F) and then remove the thermometer.

7.5 Depress the hydrometer about two scale divisions into the liquid, and then release it. The remainder of the stem of the hydrometer, which is above the level of the liquid, must be kept dry since unnecessary liquid on the stem affects the reading obtained. With samples of low viscosity, impart a slight spin to the hydrometer on releasing to assist in bringing it to rest floating freely away from the walls of the cylinder. Allow sufficient time for the hydrometer to come to rest, and for all air bubbles to come to the surface. This waiting period is particularly necessary in the case of more viscous samples.

7.6 When the hydrometer has come to rest, floating freely away from the walls of the cylinder (see note), estimate the hydrometer scale reading to the nearest 0,000 1 interval of density or relative density. The correct hydrometer reading is that point on the hydrometer scale at which the principal surface of the liquid cuts the scale. Determine this point by placing the eye slightly below the level of the liquid and slowly raising it until the surface, first seen as a distorted ellipse, appears to become a straight line cutting the hydrometer scale.

NOTE — When using a cylinder of plastics material, dissipate any static charge by wiping the cylinder with a moist cloth before taking the reading. Static charges often build up when using such cylinders and may prevent the hydrometer from floating freely.

7.7 With an opaque liquid, take a reading by observing, with the eye slightly above the plane of the surface of the liquid, the point of the hydrometer scale to which the sample rises. This reading, at the top of the meniscus, requires correction since hydrometers, unless otherwise stated, are calibrated to be read at the principal surface of the liquid. The correction for the particular hydrometer in use may be determined by observing the maximum height above the principal surface of the liquid to which oil rises on the hydrometer scale when the hydrometer in question is immersed in a transparent oil having a surface tension similar to that of the sample under test.

NOTE — Alternatively, corrections as given in table 1 may be applied.

7.8 Immediately after observing the hydrometer scale value, again cautiously stir the liquid with the thermometer, keeping the mercury thread fully immersed. Record the temperature of the liquid to the nearest 0,2 °C (0.5 °F) (see note). Should this temperature differ from the previous reading by more than 0,5 °C (1 °F), repeat the hydrometer and the thermometer readings until the temperature becomes stable within 0,5 °C (1 °F).

NOTE – After use at a temperature higher than 38 °C (100 °F), allow hydrometers of the lead-shot-in-wax type to drain and cool in a vertical position. If it is necessary to warm the hydrometer (see 7.1), it should be warmed and handled in a vertical position.

8 CALCULATIONS

8.1 Apply any relevant calibration corrections to the thermometer reading and to the hydrometer reading. For opaque samples, make the appropriate meniscus correction to the observed hydrometer reading as given in 7.7. Record to the nearest 0,000 1 the final corrected hydrometer scale reading (see note).

After application of any relevant corrections, record to the nearest 0,5 °C (1 °F) the mean of the temperature values observed immediately before and after the final hydrometer reading.

NOTE – Hydrometer scale readings at temperatures other than the calibration temperature should not be considered as more than scale readings since the hydrometer dimensions change with temperature. (See 3.2.)

8.2 To convert the corrected hydrometer reading (see 8.1) to density or relative density at the temperature at which the hydrometer was calibrated, use the following petroleum measurement tables referred to in ISO/R 91 or its addendum 1 :

a) When a hydrometer calibrated in density at 15 °C has been employed, use table 53 to obtain density at 15 °C.

b) When a hydrometer calibrated in density at 20 °C has been employed, use table A referred to in addendum 1 to ISO/R 91 to obtain density at 20 °C.

c) When a hydrometer calibrated in relative density 60/60 °F has been employed, use table 23 to obtain relative density 60/60 °F.

NOTE – The tables in ISO/R 91 apply only to hydrometers constructed of soda lime glass having a volumetric coefficient of expansion of $25 \times 10^{-6}\ °C^{-1}$.

8.3 When a value is obtained with a hydrometer calibrated in one of the units described herein and a result is required in one of the other units, make the conversion using one of the appropriate tables referred to in ISO/R 91 or its addendum 1 :

a) For conversion from density at 15 °C, use table 5.

b) For conversion from density at 20 °C, use table E (addendum 1).

c) For conversion from relative density 60/60 °F, use table 21 and table E (addendum 1).

8.4 Carry out all calculations using the full number of decimal places given in the appropriate table.

9 PRECISION

The precision of the method, as obtained by statistical examination of inter-laboratory test results, is as follows :

9.1 Repeatability

The difference between successive test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the values shown in table 4 only in one case in twenty.

TABLE 4 – **Repeatability**

Product	Temperature range	Basis of scale	Repeatability
Transparent low viscosity	– 2 to + 24,5 °C 29 to 76 °F	Density Relative density	0,000 5 g/ml 0,000 5
Opaque	– 2 to + 24,5 °C 29 to 76 °F	Density Relative density	0,000 6 g/ml 0,000 6

9.2 Reproducibility

The difference between two single and independent results, obtained by different operators working in different laboratories on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the values shown in table 5 only in one case in twenty.

TABLE 5 – **Reproducibility**

Product	Temperature range	Basis of scale	Reproducibility
Transparent low viscosity	– 2 to + 24,5 °C 29 to 76 °F	Density Relative density	0,001 2 g/ml 0,001 2
Opaque	– 2 to + 24,5 °C 29 to 76 °F	Density Relative density	0,001 5 g/ml 0,001 5

NOTE – The precision data in tables 4 and 5 were obtained using specified hydrometers with a maximum permissible scale uncertainty of 0,000 6 g/ml or 0,000 6 relative density. No data are available derived from the use of specified hydrometers with a maximum permissible scale uncertainty of 0,000 3 g/ml or 0,000 3 relative density, but an equal or better precision would be expected.

9.3 For very viscous products, or when the temperature of test lies outside the limits given in 9.1 and 9.2, no precision data can be given.

10 TEST REPORT

Report the final result to the nearest 0,000 1 as density in grams per millilitre at 15 °C or 20 °C or relative density 60/60 °F, and make reference to this International Standard.