A.3 RELATIVE DENSITY

1. METHOD

The methods described are based on the OECD Test Guideline (1). The fundamental principles are given in reference (2).

1.1. INTRODUCTION

The methods for determining relative density described are applicable to solid and to liquid substances, without any restriction in respect to their degree of purity. The various methods to be used are listed in table 1.

1.2. DEFINITIONS AND UNITS

The relative density D_4^{20} of solids or liquids is the ratio between the mass of a volume of substance to be examined, determined at 20 °C, and the mass of the same volume of water, determined at 4 °C. The relative density has no dimension.

The density, ρ, of a substance is the quotient of the mass, m, and its volume, v.

The density, ρ, is given, in SI units, in kg/m^3.

1.3. REFERENCE SUBSTANCES (1) (3)

Reference substances do not need to be employed in all cases when investigating a new substance. They should primarily serve to check the performance of the method from time to time and to allow comparison with results from other methods.

1.4. PRINCIPLE OF THE METHODS

Four classes of methods are used.

1.4.1. Buoyancy methods

1.4.1.1. Hydrometer (for liquid substances)

Sufficiently accurate and quick determinations of density may be obtained by the floating hydrometers, which allow the density of a liquid to be deduced from the depth of immersion by reading a graduated scale.

1.4.1.2. Hydrostatic balance (for liquid and solid substances)

The difference between the weight of a test sample measured in air and in a suitable liquid (e.g. water) can be employed to determine its density.

For solids, the measured density is only representative of the particular sample employed. For the determination of density of liquids, a body of known volume, v, is weighed first in air and then in the liquid.

1.4.1.3. Immersed body method (for liquid substances) (4)

In this method, the density of a liquid is determined from the difference between the results of weighing the liquid before and after immersing a body of known volume in the test liquid.

1.4.2. Pycnometer methods

For solids or liquids, pycnometers of various shapes and with known volumes may be employed. The density is calculated from the difference in weight between the full and empty pycnometer and its known volume.

1.4.3. Air comparison pycnometer (for solids)

The density of a solid in any form can be measured at room temperature with the gas comparison pycnometer. The volume of a substance is measured in air or in an inert gas in a cylinder of variable calibrated volume. For the calculation of density one mass measurement is taken after concluding the volume measurement.

1.4.4. Oscillating densitimeter (5) (6) (7)

The density of a liquid can be measured by an oscillating densitimeter. A mechanical oscillator constructed in the form of a U-tube is vibrated at the resonance frequency of the oscillator which depends on its mass. Introducing a sample changes the resonance frequency of the oscillator. The apparatus has to be calibrated by two liquid substances of known densities. These substances should preferably be chosen such that their densities span the range to be measured.

1.5. QUALITY CRITERIA

The applicability of the different methods used for the determination of the relative density is listed in the table.

1.6. DESCRIPTION OF THE METHODS

The standards given as examples, which are to be consulted for additional technical details, are attached in the Appendix.

The tests have to be run at 20 °C, and at least two measurements performed.

2. DATA

See standards.

3. REPORTING

The test report shall, if possible, include the following information:

-method used,

-precise specification of the substance (identity and impurities) and preliminary purification step, if any.

The relative density, D_4^{20}, shall be reported as defined in 1.2, along with the physical state of the measured substance.

All information and remarks relevant for the interpretation of results have to be reported, especially with regard to impurities and physical state of the substance.

TABLE: APPLICABILITY OF METHODS

Method of measurement	Density		Maximum possible dynamic viscosity	Existing Standards
	solid	liquid		
1.4.1.1. Hydrometer		yes	5 Pa s	ISO 387, ISO 649-2, NF T 20-050
1.4.1.2. Hydrostatic balance				
(a) solids	yes			ISO 1183 (A)
(b) liquids		yes	5 Pa s	ISO 901 and 758
1.4.1.3. Immersed body method		yes	20 Pa s	DIN 53217
1.4.2. Pycnometer				ISO 3507
(a) solids	yes			ISO 1183(B), NF T 20-053
(b) liquids		yes	500 Pa s	ISO 758
1.4.3. Air comparison pycnometer	yes			DIN 55990 Teil 3, DIN 53243
1.4.4. Oscillating densitimer		yes	5 Pa s	

4. **REFERENCES**

(1) OECD, Paris, 1981, Test Guideline 109, Decision of the Council C(81) 30 final.

(2) R. Weissberger ed., Technique of Organic Chemistry, Physical Methods of Organic Chemistry, 3rd ed., Chapter IV, Interscience Publ. , New York, 1959, vol. I, Part 1.

(3) IUPAC, Recommended reference materials for realization of physico-chemical properties, Pure and applied chemistry, 1976, vol. 48, 508.

(4) Wagenbreth, H., Die Tauchkugel zur Bestimmung der Dichte von Flüssigkeiten, Technisches Messen tm, 1979, vol.ll, 427-430.

(5) Leopold, H., Die digitale Messung von Flüssigkeiten, Elektronik, 1970, vol. 19,297-302.

(6) Baumgarten, D., Füllmengenkontrolle bei vorgepackten Erzeugnissen -Verfahren zur Dichtebestimmung bei flüssigen Produkten und ihre praktische Anwendung, Die Pharmazeutische Industrie, 1975, vol. 37,717 -726.

(6) Riemann, J., Der Einsatz der digital en Dichtemessung im Brauereilaboratorium, Brauwissenschaft, 1976, vol. 9,253-255.

Appendix

For additional technical details, the following standards may be consulted for example:

1. BUOYANCY METHODS

1.1. Hydrometer

DIN 12790, ISO 387	Hydrometer; general instructions
DIN 12791	Part I: Density hydrometers; construction, adjustment and use Part II: Density hydrometers; standardized sizes, designation Part III: Use and test
ISO 649-2	Laboratory glassware: Density hydrometers for general purpose

NF T 20-050	Chemical products for industrial use - Determination of density of liquids - Areometric method
DIN 12793	Laboratory glassware: range find hydrometers

1.2. Hydrostatic balance

For solid substances

ISO 1183	Method A: Methods for determining the density and relative density of plastics excluding cellular plastics
NF T 20-049	Chemical products for industrial use - Determination of the density of solids other than powders and cellular products - Hydrostatic balance method
ASTM-D-792	Specific gravity and density of plastics by displacement
DIN 53479	Testing of plastics and elastomers; determination of density

For liquid substances

ISO 901	ISO 758
DIN 51757	Testing of mineral oils and related materials; determination of density

ASTM D 941-55, ASTM D 1296-67 and ASTM D 1481-62

ASTM D 1298	Density, specific gravity or API gravity of crude petroleum and liquid petroleum products by hydrometer method
BS 4714	Density, specific gravity or API gravity of crude petroleum and liquid petroleum products by hydrometer method

1.3. Immersed body method

DIN 53217	Testing of paints, varnishes and similar coating materials; determination of density; immersed body method

2. PYCNOMETER METHODS

2.1. For liquid substances

ISO 3507	Pycnometers
ISO 758	Liquid chemical products; determination of density at 20 °C
DIN 12797	Gay-Lussac pycnometer (for non-volatile liquids which are not too viscous)
DIN 12798	Lipkin pycnometer (for liquids with a kinematic viscosity of less than l00 . 10^{-6} m^2 s^{-1} at 15 °C)
DIN 12800	Sprengel pycnometer (for liquids as DIN 12798)
DIN 12801	Reischauer pycnometer (for liquids with a kinematic viscosity of less than l00 . 10^{-6} m^2 s^{-1} at 20 °C, applicable in particular also to hydrocarbons and aqueous solutions as well as to liquids with higher vapour pressure, approximately 1 bar at 90 °C)
DIN 12806	Hubbard pycnometer (for viscous liquids of all types which do not have too high a vapour pressure, in particular also for paints, varnishes and bitumen)
DIN 12807	Bingham pycnometer (for liquids, as in DIN 12801)

DIN 12808	Jaulmes pycnometer (in particular for ethanol - water mixture)
DIN 12809	Pycnometer with ground-in thermometer and capillary side tube (for liquids which are not too viscous)
DIN 53217	Testing of paints, varnishes and similar products; determination of density by pycnometer
DIN 51757	Point 7: Testing of mineral oils and related materials; determination of density
ASTM D 297	Section 15: Rubber products - chemical analysis
ASTM D 2111	Method C: Halogenated organic compounds
BS 4699	Method for determination of specific gravity and density of petroleum products (graduated bicapillary pycnometer method)
BS 5903	Method for determination of relative density and density of petroleum products by the capillary- stoppered pycnometer method
NF T 20-053	Chemical products for industrial use - Determination of density of solids in powder and liquids - Pyknometric method

2.2. For solid substances

ISO 1183	Method B: Methods for determining the density and relative density of plastics excluding cellular plastics.
NF T 20-053	Chemical products for industrial use -Determination of density of solids in powder and liquids -Pyknometric method
DIN 19683	Determination of the density of soils

3. AIR COMPARISON PYCNOMETER

DIN 55990	Part 3: Prüfung von Anstrichstoffen und ähnlichen Beschichrungsstoffen; Pulverlack; Bestimmung der Dichte
DIN 53243	Anstrichstoffe; Chlorhaltige Polymere; Prüfung