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 $D_{20}^{4}$ 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, $\rho$, of a substance is the quotient of the mass, $m$, and its volume, $v$.

The density, $\rho$, 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, \( D_{20}^{20} \), 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.
4. REFERENCES


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


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 \(100 \times 10^{-6} \text{ m}^2 \text{s}^{-1}\) 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 \(100 \times 10^{-6} \text{ m}^2 \text{s}^{-1}\) 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)
Please note that only European Community's legislation published in the paper editions of the Official Journal of the European Communities is deemed authentic.

When preparing this document, care has been taken to ensure correctness of the text; nevertheless possibility of errors cannot be completely excluded, so differences may exist between this version and the one agreed and published in the paper edition of the Official Journal. In case of doubt the reader is advised to consult the Official Journal.

This method can be found in Dir 92/69/EEC (O.J. L383 A).

A complete list of Annex V Testing Methods and the corresponding OJ can be downloaded from a previous page in this site.

- **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
- **NFT 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.
- **NFT 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 Beschichtungsstoffen; Pulverlack; Bestimmung der Dichte
- **DIN 53243**: Anstrichstoffe; Chlorhaltige Polymere; Prüfung