OECD GUIDELINE FOR THE TESTING OF CHEMICALS

Adopted by the Council on 27th July 1995

Density of Liquids and Solids

INTRODUCTION

1. This guideline is a revised version of the original Guideline 109 which was adopted in 1981. There are no differences of substance between this and the 1981 version. Mainly the format has been changed. The revision was based on the EC method "Relative Density" (1) published in 1992.

INITIAL CONSIDERATIONS

2. Most methods for determining the density of liquids and solids are the object of international and national standards. This guideline lists these methods, giving only a very succinct description of them, and the reader is referred to the standards which are listed in the appendix. Some other methods mentioned in the guideline are taken from the scientific literature, and again only succinct information is given on those methods. The fundamental principles can be found in reference 2.

DEFINITIONS AND UNITS

3. The density, ρ, of a substance is the quotient of its mass and its volume and is expressed in SI units of kg/m^3.

REFERENCE SUBSTANCES

4. Reference substances do not need to be employed when investigating a substance. They serve primarily to check the performance of a method from time to time as well as to allow comparison between results of different methods.

PRINCIPLE OF THE METHODS

Hydrometer (*a buoyancy method for liquids*)

5. Hydrometers are weighted glass floats which sink into the liquid to a depth dependent on the density. The density is read at the level of the liquid on a calibrated stem extending above the liquid. The dynamic viscosity of the liquid to be investigated should not exceed 5 Pa s.

Hydrostatic balance (*a buoyancy method for liquids and solids*)

6. The density of a solid is derived from the difference in weight between a sample in air and in a liquid of known density (e.g. water). The density thus measured is only representative of the particular sample employed (bulk density).

7. For the determination of density of liquids, a solid body of known volume is weighed first in air and then when immersed in the liquid. The dynamic viscosity of liquids to be investigated, should not exceed 5 Pa s.

Immersed body method (*a buoyancy method for liquids*)

8. A vessel containing a sample of the liquid test substance is placed on a balance and weighed. Then, a body of known volume (generally a sphere of approximately 10 cm^3 made of metal), which is clamped to a stand independent from the balance, is immersed in the liquid. The action exerted by the immersed body on the balance cannot be distinguished from that of a freely floating body with a volume identical with that of the immersed body and having the density of the surrounding liquid. The density of the liquid is obtained by dividing the gain in weight due to the immersion of the body by the known volume of the body. The method is applicable to liquids with a dynamic viscosity below 20 Pa s (3).

Pycnometer (*liquids and solids*)

9. The density is calculated from the difference in weight between the full and empty pycnometer and its volume. In the case of liquids, the dynamic viscosity should not be above 500 Pa s.

Air comparison pycnometer (*solids*)

10. The volume of a sample of the solid is measured in air or in an inert gas in a calibrated cylinder of variable volume. After concluding the volume measurement, the sample is weighed.

Oscillating densitimeter (*liquids*)

11. A mechanical oscillator, constructed in the form of a U-tube, is vibrated at its resonance frequency which depends on its mass. Introducing a sample changes the resonance frequency. The apparatus has to be calibrated with two liquids of known density. The liquids should preferably be chosen such that their densities span the range into which the liquid under investigation falls. The method is applicable to liquids with a dynamic viscosity below 5 Pa s (4)(5)(6).

TEST CONDITIONS

12. The test is done at constant temperature, preferably at 20°C. Duplicate measurements are required.

DESCRIPTION OF THE METHODS

13. For the technical details of apparatus and procedures the standards listed in the appendix should be consulted.

TEST REPORT

14. The test report must include the following information;

- method used;
- chemical identity and impurities (preliminary purification step, if any);
- estimated accuracy;
- density (the mean of at least two measurements which are in the range of the estimated accuracy);
- all information and remarks relevant for the interpretation of the results, especially with regards to impurities and physical state of the substance).

LITERATURE

(1) Official Journal of the European Communities L 383 A, 21-25 (1992)

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

(3) Wagenbreth, H. (1979). Die Tauchkugel zur Bestimmung der Dichte von Flüssigkeiten, Technisches Messen, 11, 427-430.

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

(5) Baumgarten, D. (1975). Die Pharmazeutische Industrie, 37, 717-726.

(6) Riemann, J. (1976). Brauwirtschaft, 9, 253-255.

APPENDIX

LIST OF STANDARDS

Hydrometer

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
DIN 12790	Laborgeräte aus Glas; Aräometer. Grundlagen für Bau und Justierung
DIN 12791	Laborgeräte aus Glas; Dichte-Aräometer. Allgemeine Anforderungen
DIN 12793	Laborgeräte aus Glas. Sucharäometer für Vormessung und rohe Betriebs-messung
ISO 387	Hydrometers - Principles of construction and adjustment
ISO 649-1	Density hydrometers for general purposes - Specification
ISO 649-2	Density hydrometers for general purposes - Test methods and use

Hydrostatic balance

for solid substances

NF T 20-049	Chemical products for industrial use - Determination of the density of solids other than powders and cellular products

for liquid substances

ASTM D 941-55	
ASTM D 1296-67	
ASTM D 1481-62	
DIN 51757	Prüfung von Mineralölen und verwandten Stoffen. Bestimmung der Dichte
ISO 758	Liquid chemical products, determination of density at 20°C

Immersed body method

DIN 53217	Teil 3: Lacke, Austrichstoffe und ähnliche Beschichtungsstoffe, Bestimmung der Dichte. Tauchkörper-Verfahren

Pycnometer

ISO 3507	Pyknometers
NF T 20-053	Chemical products for industrial use - Determination of density of solids in powder and liquids
for liquid substances	
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
DIN 12797	Laborgeräte aus Glas. Pyknometer nach Gay-Lussac (for non-volatile liquids which are not too viscous)
DIN 12798	Laborgeräte aus Glas. Pyknometer nach Lipkin (for liquids with a kinematic viscosity of less than 10^{-4} m^2 s^{-1} at 15°C)
DIN 12806	Laborgeräte aus Glas. Pyknometer nach Hubbard (for viscous liquids of all types which do not have too high a vapour pressure, in particular also for paints, varnishes and bitumen)
DIN 12809	Laborgeräte aus Glas. Pyknometer mit eingeschliffenem thermometer und Seiten Kapillare (for liquids which are not too viscous)
DIN 53217	Teil 2: Lacke, Austrichstoffe und ähnliche Beschichtungsstoffe Bestimmung der Dichte. Pyknometer-Verfahren
ISO 758	Liquid chemical products for industrial use - Determination of density at 20°C
for solid substances	
ISO 901	Aluminum oxide primarily used for the production aluminum -Determination of absolute density