GB

NATIONAL STANDARD

OF THE PEOPLE'S REPUBLIC OF CHINA

ICS 71.040.50
G 04

GB/T 4472-2011

Replacing GB/T 4472-1984

Determination of density and relative density for chemical products

化工产品密度、相对密度的测定

Issued on: December 30, 2011 Implemented on: October 01, 2012

Issued by: General Administration of Quality Supervision, Inspection and Quarantine;

Standardization Administration of PRC.

Table of contents

Foreword

This standard was drafted in accordance with the rules given in GB/T 1.1-2009.

This standard replaces GB/T 4472-1984 “General provisions on the determination of density and relative density for chemical products”. As compared with GB/T 4472-1984, the main technical changes except for editorial modification are as follows:

- MODIFY the name of the standard, from the “General provisions on the determination of density and relative density for chemical products” to the “Determination of density and relative density for chemical products”;
- ADD foreword;
- MODIFY the definitions, units and symbols of the density (mass density) and relative density in terms and definitions (SEE Chapter 3; Chapter 2 of 1984 version);
- MODIFY the name of the “balance method” to “hydrostatic weighing method” in the determination of the solid density (SEE 4.2.3; 3.2.3 of 1984 version);
- MODIFY part of the metering units in the standard so that it is consistent with the legal metering units of China;
- MODIFY part of the test report to make it in line with the international practice (SEE Chapter 5; Chapter 4 of 1984 version);
- DELETE the Appendix A, Appendix B, Appendix C, and Appendix D of the original standard; and CHANGE the original Appendix E into Appendix A.

This standard was proposed by the China Petroleum and Chemical Industry Association.

This standard shall be under the jurisdiction of the National Chemical Standardization Technical Committee (SAC/TC 63).

The drafting organizations of this standard: China Chemical Industry Economic and Technological Development Center, Zhejiang Chemical Industry Research Institute, Sinochem Chemical Standardization Institute.

The main drafters of this standard: Wei Jing, Fang Lu, Wei Naixin, Zhong Zhiwan.

Determination of density and relative density for chemical products

1 Scope

This standard specifies terms and definitions for the determination of density and relative density for chemical products, as well as the methods for the determination of density and relative density of solid, liquid and gaseous chemical products.

This standard is applicable to the determination of density and relative density of general chemical products.

This standard does not apply to the determination of density and relative density of the chemical products of special status such as carbon black and open-cell foam rubber or plastic, etc.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this Standard.

GB/T 6682 Water for analytical laboratory use - Specification and test methods

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

Density

ρ

It refers to the result of mass divided by volume. $\rho = m/V$. It is expressed in kilograms per cubic meter (kg/m^3) or in multiples thereof: mega-gram per cubic meters (Mg/m^3), kilograms per cubic decimeters (kg/dm^3), or gram per cubic centimeters (g/cm^3). It may also expressed in ton per cubic meters

4.1.3 The reagents and water used in this test refer to, unless otherwise specified, the analytical grade reagents and Class III water as specified in GB/T 6682.

4.2 Determination of solid density

4.2.1 Requirements for test specimens

4.2.1.1 As for powder or granular samples, TAKE 2 g ~ 5 g; as for slice, bar or tubular samples, TAKE 1 g ~ 30 g.

4.2.1.2 The formed test specimens shall be clean AND free from defects such as cracks and air bubbles.

4.2.1.3 When the sample needs to be dried, it shall follow the provisions of the product standard.

4.2.1.4 Before the test, the sample shall be placed at room temperature for more than 2 hours, during which it shall avoid direct sunlight AND be away from heat source. When the difference between the test temperature and the room temperature is large, it shall extend the placing duration in order to make it achieve temperature balance.

4.2.2 Method 1: density bottle method

4.2.2.1 Method summary

PLACE the sample into the density bottle of known volume; ADD the determination medium; AND the sample volume can be calculated by subtracting the volume of the medium under determination from the volume of the density bottle. Then the sample density is the ratio of the mass of the sample to its volume.

4.2.2.2 Instruments

4.2.2.2.1 Analytical balance: division value of not less than 0.0001 g.

4.2.2.2.2 Density bottle: 25 cm^3 (SEE Figure 1 and 2). When the determination temperature is higher than the balance room temperature, USE the density bottle as shown in Figure 1.

4.2.2.2.3 Constant temperature water bath: temperature is controlled at (23 ± 0.5) °C.

4.2.2.2.4 Thermometer: the division value is 0.5 °C.

4.2.2.3 Test conditions

$$\rho = \frac{m_3 - m}{V - V_1} \quad \cdots\cdots (3)$$

Where:

m3 - The mass of the density bottle which is added with appropriate amount of test specimen, in grams (g);

m - The mass of the empty density bottle, in grams (g);

V - The volume of the density bottle, in cubic centimeter (cm^3);

V_1 - The volume of the determination medium in the density bottle, in cubic centimeters (cm^3).

4.2.3 Method 2: Hydrostatic weighing method

4.2.3.1 Principles

In accordance with the Archimedes principle, USE balance to respectively determine the mass of the solid test specimen in air and in the determination medium; when the test specimen is totally immersed in the determination medium, its mass is less than that in air, AND the reduced mass is the mass of the determination medium of the same volume as replaced by the test specimen, AND the test specimen volume equals to the volume of the replaced determination medium.

4.2.3.2 Instruments

4.2.3.2.1 Analytical balance: the division value is 0.0001 g.

4.2.3.2.2 Balance pan cross frame: the dimensions shall be suitable for placing in the between the pan and basket (SEE Figure 3).

4.2.3.3.5 USE the determination medium to fully wet the surface of the test specimen of known mass; USE the hair to cover the test specimen; PLACE it into the (23 ± 0.5) °C determination medium; it shall not have air bubbles. No part of the test specimen is allowed to contact the beaker; when the temperature of the test specimen is same as that of the determination medium, WEIGH its mass in the determination medium.

4.2.3.3.6 When the density of the solid is less than 1 g/cm^3, HANG another pendant onto the hair; LOWER the test specimen down into the determination medium for weighing; however, it shall determine the mass the pendant and the hair in the determination medium.

4.2.3.4 Result calculation

4.2.3.4.1 The density ρ of the test specimen at the test temperature, expressed in grams per cubic centimeter (g/cm^3), is calculated in accordance with the equation (4):

$$\rho = \frac{m_1 \times \rho_0}{m_1 - m_2} \quad \cdots\cdots (4)$$

Where:

m_1 - The mass of the test specimen in the air, in grams (g);

m_2 - The mass of the test specimen in the determination medium, in grams (g);

ρ_0 - The density of the determination medium at test temperature, in grams per cubic centimeter (g/cm^3).

4.2.3.4.2 When using the pendant, it is calculated in accordance with the equation (5):

$$\rho = \frac{m_1 \times \rho_0}{m_1 + m_3 - m_4} \quad \cdots\cdots (5)$$

Where:

m_1 - The mass of the test specimen in the air, in grams (g);

m_3 - The mass of the pendant in the determination medium, in grams (g);

m_4 - The mass of the test specimen and the pendant in the determination medium, in grams (g);

5 - Thermometer.

Figure 4 Density bottle

4.3.1.3 Operating procedure

4.3.1.3.1 WASH and DRY the density bottle; WEIGH it with plug.

4.3.1.3.2 USE the freshly boiled water cooled to 20 °C to full fill the density bottle; it is not allowed to lead in bubbles; immediately IMMERSE it into the constant temperature water bath of 20 °C ± 0.1 °C for more than 20 min; TAKE it out; USE filter paper to remove water overflow from the capillary; WIPE it dry; immediately WEIGH it.

4.3.1.3.3 POUR out the water from the density bottle; WASH it clean; DRY it; and WEIGH it. USE the test specimen to substitute water to repeat the operation aforementioned, in order to determine the mass of the test specimen.

4.3.1.4 Result calculation

The density ρ of the determination liquid sample is expressed in grams per cubic centimeter (g/cm^3) AND calculated in accordance with the equation (6):

$$\rho = \frac{m_1 + A}{m_2 + A} \times \rho_0 \quad \cdots\cdots (6)$$

Where:

m_1 - The mass of the test specimen required to full fill the density bottle, in grams (g);

m_2 - The mass of the water required to full fill the density bottle, in grams (g);

ρ_0 - The density of water at 20 °C, in grams per cubic centimeter (g/cm^3);

A - Buoyancy correction is $\rho_1 \times V$, where ρ_1 is the density of the dry air at 20 °C and 101.325 kPa; V is the volume of the test specimen taken (cm^3); but in general, the effect of A is small and negligible.

4.3.2 Method 2: Wechsler balance method

4.3.2.1 Principles

In the water and the determination test specimen, respectively MEASURE the buoyancy of the "floating hammer"; through the reading of the rider, CALCULATE the density of the test specimen.

4.3.2.3.1 INSTALL the Wechsler balance; HANG the floating hammer onto the small hook through the fine platinum wire; ROTATE the regulation screw to make the two pointers align with each other.

4.3.2.3.2 Slowly INJECT the water pre-boiled and cooled to about 20 °C into the glass tube; MAKE the floating hammer totally immerse into water; it is not allowed to lead in air bubble; PLACE the glass tube in the (20 ± 0.1) °C constant temperature water bath for constant temperature over 20 min; when the temperature is same, REGULATE the rider of balance to make the balance equilibrium; RECORD the readings.

4.3.2.3.3 TAKE out the floating hammer and, after drying, ADD the test specimen at the same temperature; and REPEAT the operation aforementioned.

4.3.2.4 Result calculation

The density ρ of the determination test specimen is in grams per cubic centimeter (g/cm^3) AND calculated in accordance with the equation (7):

$$\rho = \frac{\rho_2}{\rho_1} \times \rho_0 \qquad \cdots\cdots (7)$$

Where:

ρ_1 - The reading of the rider in the water, in grams per cubic centimeter (g/cm^3);

ρ_2 - The reading of the rider in the test specimen, in grams per cubic centimeter (g/cm^3);

ρ_0 - The density of water at 20 °C, in grams per cubic centimeter (g/cm^3).

4.3.3 Method 3: Density meter method

4.3.3.1 Method summary

From the depth of the density meter as immersed in the determination liquid when it reaches to the equilibrium state, READ out the density of this liquid.

4.3.3.2 Instruments

4.3.3.2.1 Density meter: the division value is 0.001 g/cm^3 (SEE Figure 6).

the liquid level shall not exceed (2 ~ 3) division; after the density meter is stable in the liquid, READ out the lower scale the meniscus of the density meter (except for the density meter marked with the upper scale of the meniscus), which is the density of the test specimen at 20 °C.

4.3.3.3.2 Determination at room temperature: when the temperature of the test specimen is in agreement with the room temperature, PROCEED the aforementioned operations at room temperature.

4.3.3.4 Test results

4.3.3.4.1 The density ρ_t as determined at room temperature t °C is expressed in gram per cubic centimeter (g/cm^3) AND calculated in accordance with the equation (8):

$$\rho_t = \rho_t + \rho_t \times \alpha(20 - t) \qquad \cdots\cdots (8)$$

Where:

ρ_t - The reading of the density meter at t °C, in grams per cubic centimeter (g/cm^3);

α - The glass expansion coefficient of the density meter, generally 0.000025;

20 - The standard temperature of the density meter, in degrees Celsius (°C);

t - The temperature at the time of determination, in degrees Celsius (°C).

4.3.3.4.2 The density ρ_t of the test specimen at room temperature t °C converted into the density ρ_{20} at 20 °C is expressed in gram per cubic centimeter (g/cm^3) AND calculated in accordance with the equation (9):

$$\rho_{20} = \rho_t + k \times (t - 20) \qquad \cdots\cdots (9)$$

Where:

k - The temperature coefficient of the density of the test specimen (it can be found from table OR calculated through measurement against different liquid chemical products).

4.4 Determination of gas density

4.4.1 Method 1: Density bottle method

4.4.1.1 Principles

$$\rho = \frac{m_3 - (m_4 - A)}{V \times k} = \frac{m_3 - m_4}{V \times k} + 1.2928 \quad \cdots\cdots (10)$$

$$A = V \times k \times 1.2928 \quad \cdots\cdots (11)$$

Where:

m_3 - The mass of the density bottle full of test specimen at room temperature t_2 °C and the atmospheric pressure P_2 (Pa), in grams (g);

m_4 - The mass of the density bottle full of air at room temperature t_2 °C and the atmospheric pressure P_2 (Pa), in grams (g);

A - The mass of the air in the density bottle at room temperature t_2 °C and the atmospheric pressure P_2 (Pa), in grams (g);

V - The volume of the density bottle, in cubic centimeter (cm^3);

k - The coefficient to convert the gas volume to the standard state;

1.2928 - The density of dry air in the standard state, in grams per cubic centimeter (g/cm^3).

4.4.2 Method 2: Gas effluent method (diffusion method)

WARNING: Inflammable, explosive, and toxic gases shall be determined in a fume hood.

4.4.2.1 Principles

At the same temperature and pressure, the time required by an equal volume of gas to flow through the orifice is proportional to the square root of the gas density. If requiring more accurate results, it shall use the density bottle method.

4.4.2.2 Instruments

4.4.2.2.1 Gas diffusers (SEE Figure 10).

4.4.2.2.2 Thermometer: (0 ~ 50) °C, AND the division value is 0.1 °C.

4.4.2.2.3 Stopwatch: the division value is 0.1 s.

4.4.2.3 Operating procedures

4.4.2.3.1 FILL water into the outer cylinder 3; OPEN the valve 9 to let the water flow into the glass inner tube 4; after the water temperature stabilizes, from the valve 9, CHARGE air to the lower mark 1; MAINTAIN for several minutes;

4.4.3 Result calculation

4.4.3.1 Under normal conditions, the relative density d of gas is calculated in accordance with the equation (12):

$$d = \frac{\tau^2}{\tau_1{}^2} \qquad \cdots\cdots (12)$$

Where:

τ - The average outflow time of the test specimen, in seconds (s);

τ_1 - The average outflow time of the air, in seconds (s).

4.4.3.2 If the air and the test specimen are saturated with water vapor, the relative density d of the dry gas is calculated in accordance with the equation (13):

$$d = \frac{\tau^2}{\tau_1{}^2} + \frac{0.627 \times P}{P + P_2 - P_1} \times \left(\frac{\tau^2}{\tau_1{}^2} - 1\right) \qquad \cdots\cdots (13)$$

$$P = \frac{h}{2 \times 13.546} \qquad \cdots\cdots (14)$$

Where:

P - The value of the external atmospheric pressure during determination, in kilopascals (kPa);

P_1 - The saturated water vapor pressure at the determination temperature, in kilopascals (kPa);

P_2 - The average pressure resulting from the difference of water level between two marks (1, 6), in kilopascals (kPa);

h - The height of the water level difference, in millimeters (mm);

13.546 - The relative density of mercury.

4.4.3.3 The density ρ of the determination gas is expressed in grams per cubic decimeter (g/dm^3) AND calculated in accordance with the equation (15):

$$\rho = d \times 1.2928 \qquad \cdots\cdots (15)$$

Where:

APPENDIX A

(Normative)

Calibration of the volume of the gas density bottle

The volume of the density bottle shall be calibrated at least once a year. During calibration, CHARGE the clean air which slowly passes through the drying tube into the density bottle; DETERMINE its mass m_1 at room temperature and atmospheric pressure. Full FILL it with water which is freshly boiled and cooled to room temperature; WIPE it dry and USE filter paper to remove the water from the ports of piston 1 and piston 2 (SEE Figure 7); MEASURE its mass m_2. RECORD the atmospheric pressure P_a and the room temperature t_0; the atmospheric pressure shall be accurate to 50 Pa, AND the room temperature shall be accurate to 0.1 °C.

Density bottle volume V is expressed in cubic decimetre (dm^3) And calculated in accordance with the equation (A.1):

$$V = \frac{m_2 - m_1}{(\rho_0 - \rho_a) \times 1\ 000} \qquad \text{(A.1)}$$

Where:

m_1 - The mass of the density bottle full of air at room temperature t_0 °C and atmospheric pressure P_1 (kPa), in grams (g);

m_2 - The mass of the density bottle full of water at room temperature t_0 °C, in grams (g);

ρ_0 - The density of water at room temperature t_0 °C, in grams per cubic decimeter (g/dm^3);

ρ_a - The density of air at room temperature t_0 °C and atmospheric pressure P_1 (kPa), in grams per cubic decimetre (g/dm^3).

END

------ The End ------