# OIV-MA-AS2-01 Density and specific gravity at 20°C

**Type I and IV methods**

## 1. Scope of application

This resolution is applicable for determining the density and specific gravity at 20 °C of wines and musts, using any of the following:

- Pycnometry: Type I Method,
- Electronic densimetry using a frequency oscillator: Type I Method,
- Densimetry using a hydrostatic balance: Type I Method,
- Hydrometry: Type IV Method.

## 2. Definition

Density is the quotient of the mass of a certain volume of wine or must at 20 °C by this volume. It is expressed in g/cm$^3$ and its symbol is $\rho_{20°C}$.

The specific gravity is the ratio of the density of a substance to the density of a reference material. For the analysis of wine or must, it is typically expressed as the ratio of the density of the wine or must at 20 °C to the density of water at 20 °C. Its symbol is: $d_{20°C}^{20°C}$ $d_{20°C}^{20°C}$

*Note*: It is possible to obtain the specific gravity from the density $\rho_{20}$ at 20 °C:

$\rho_{20}$ = 0.998203 x $d_{20°C}^{20°C}$ or $d_{20°C}^{20°C}$ = $\rho_{20}$ /0.998203 (where 0.998203 is the density of water at 20 °C in g/ cm$^3$)

## 3. Principle of the methods

The principle of each method is detailed in the following parts:

Method A: Pycnometry

Method B: Electronic densimetry using a frequency oscillator

Method C: Densimetry using a hydrostatic balance

Method D: Hydrometry

*Note:* For very precise determinations, the density should be corrected to account for sulphur-dioxide action.

$\rho_{20}$ (g/cm3)= $\rho'_{20}$ - 0.0006 × S

$\rho_{20}$ (g/cm3) = corrected density

$\rho'_{20}$ (g/cm3) = observed density

S (g/L) = total sulphur dioxide

## 4. Preliminary sample preparation

If the wine or must contains notable quantities of carbon dioxide, remove the grand majority by, for example, mixing 250 mL of sample in a 1000-mL vial, or by filtering under reduced pressure on 2 g of cotton placed in an extension tube, or by any other suitable method.

**Method A: Density at 20 °C and specific gravity at 20 °C measured by pycnometry (Type method)**

### A.1. Principle

The density of the wine or must is measured for a specific temperature using a glass pycnometer. This comprises a flask of known capacity, onto which a hollow ground-glass stopper is fitted equipped with a capillary tube. When the flask is closed, the overflow rises in the capillary. The volumes of the flask and the capillary being known, the density is determined by weighing using precision balances before and after filling of the pycnometer.

### A.2. Reagents and products

A.2.1. Type II water for analytical use (ISO 3696 standard), or of equivalent purity

A.2.2. Sodium chloride solution (2% m/v)

To prepare 1 litre, weigh out 20 g of sodium chloride and dissolve to volume in water.

### A.3. Apparatus and materials

Current laboratory apparatus, including the following:

A.3.1. Pyrex-glass pycnometer of around 100 mL capacity with a removable thermometer, with ground-glass joint and $10^{th}$-of-a-degree graduations, from 10 °C to 30 °C. This thermometer should be calibrated (Fig. 1).

Any pycnometer of equivalent characteristics may be used.

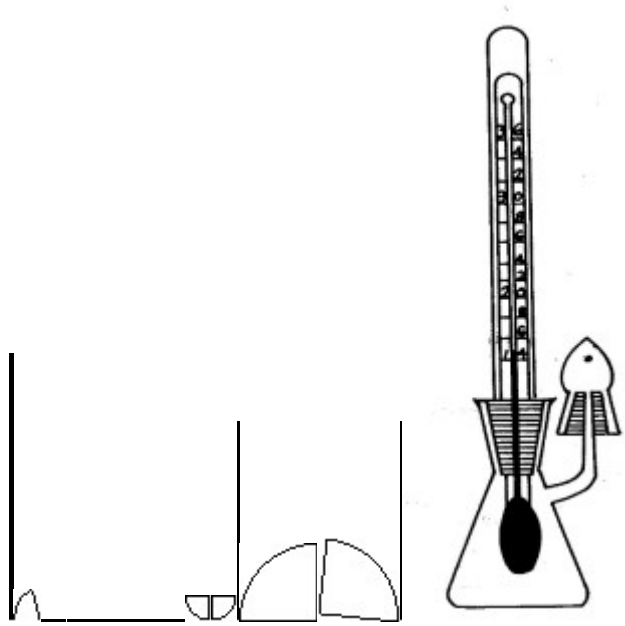


FIGURE 1: Pycnometer and its tare bottle

This pycnometer includes a side tube of 25 mm in length and an inside diameter of at most 1 mm, terminated by a ground-glass conical joint. This side tube may be capped by a 'reservoir stopper' composed of a ground-glass conical tube, terminated by a tapered joint. This stopper serves as an expansion chamber.

The two joints of the apparatus should be prepared with great care.

A.3.2. Tare bottle of the same external volume (to within 1 mL) as the pycnometer and with a mass equal to the mass of the pycnometer filled with a liquid of a density of 1.01 g/mL (sodium chloride solution at 2% m/v)

A.3.3. Thermally insulated jacket that fits the body of the pycnometer exactly.

A.3.4. Twin-pan balance accurate to the nearest 0.1 mg

or

single-plate balance accurate to the nearest 0.1 mg.

A.3.5. Masses calibrated by an accredited body

**A.4. Procedure**

A.4.1. Pycnometer calibration

The calibration of the pycnometer comprises the determination of the following characteristics:

- tare weight,

- volume at 20 °C,
- water mass at 20 °C.

1. *Using a twin-pan balance*

Place the tare bottle on the left-hand pan and the clean, dry pycnometer with its 'reservoir stopper' on the right-hand pan. Balance them by placing weights of known mass on the pycnometer side: *p* grams.

Fill the pycnometer carefully with water (A.2.1) at room temperature and fit the thermometer.

Carefully wipe the pycnometer dry and place it in the thermally insulated jacket.

Shake by inverting the container until the thermometer's temperature reading is constant, accurately adjust the level to the upper rim of the side tube, wipe the side tube clean and fit the reservoir stopper.

Read the temperature, *t* °C, carefully and if necessary correct for any inaccuracies in the temperature scale.

Weigh the water-filled pycnometer, with the weight in grams, *p'*, making up the equilibrium.

Calculations:

Tare of the empty pycnometer:

Tare weight = *p* + *m* where *m* (g) = mass of the air contained in the pycnometer

- *m* (g) = 0.0012 (*p* - *p'*)

Volume at 20 °C in mL:

- $V_{20°C}$ (mL) = (*p* + *m* - *p*') x $F_t$

$F_t$ = factor for temperature, *t*°C, taken from Table I

$V_{20°C}$ should be known to ± 0.001 mL

Water mass at 20 °C:

- $M_{20°C}$ (g) = $V_{20°C}$ x 0.998203
- 0.998203 (g/cm$^3$) = water density at 20 °C

*2. Using a single-pan balance*

Determine:

- the mass of the clean, dry pycnometer: P,

- the mass of the water-filled pycnometer at *t* °C: $P_1$ following the instructions outlined in A.4.1.1,
- the mass of the tare bottle, $T_0$.

Calculations:
Tare of the empty pycnometer:
Tare weight: P – m where m (g) = mass of the air contained in the pycnometer

- *m* (g) = 0.0012 ($P_1$ - P)

Volume at 20 °C in mL:

- $V_{20°C}$ (mL) = [P1 - (P - *m*)] x $F_t$

$F_t$ = factor for temperature, *t*°C, taken from Table I
$V_{20°C}$ should be known to $\pm$ 0.001 mL
Water mass at 20°C:

- $M_{20°C}$(g) = $V_{20°C}$ x 0.998203
- 0.998203 = water density at 20 °C ( g/cm$^3$)

A.4.2. Determination of the density:

A.4.2.1. *Using a twin-pan balance*

Weigh the pycnometer filled with the test sample following the instructions outlined in A.4.1.1.
Where *p*" represents the mass in grams that makes up the equilibrium at *t*°C,
taking into account that the liquid mass contained in the pycnometer = *p* + *m* - *p*", the apparent density at *t*°C, in g/cm$^3$, is given by the following equation:

$$\rho_{t°C} = \frac{p + m - p''}{V_{20°C}}$$

Calculate the density at 20 °C using one of the following correction tables in Annex I, according to the nature of the liquid to be analysed and the type ofpycnometer to be used: dry wine and dealcoholized wine (Table II or V), natural or concentrated must (Table III or VI), or liqueur wine (Table IV or VII).

A.4.2.2. *Using a single-pan balance*

Weigh the tare bottle, where $T_1$ is its mass in g.

Calculate $d$T = $T_1 - T_0$

Mass of the empty pycnometer at the time of measurement = P - $m$ + $d$T in g

Weigh the pycnometer filled with the test sample following the instructions outlined in A.4.1.1.

Where $P_2$ represents its mass at $t$°C,

the liquid mass contained in the pycnometer at $t$°C = $P_2$ (P - $m$ + $d$T) in g

and the apparent density at °C, in g/cm$^3$, is as follows

$$\rho_{t°C} = \frac{P_2 - (P - m + dT)}{V_{20°C}}$$

Calculate the density at 20°C of the liquid to be analysed: dry wine, natural or concentrated must, or liqueur wine, as indicated in A.4.2.1.

**A.5. Expression of results**

The density is expressed in g/cm$^3$ to 5 decimal places.

**A.6. Precision**

A.6.1. Repeatability in terms of density:

- for dry and sweet wines, except liqueur wines: $r$ = 0.00010 g/cm$^3$,
- for liqueur wines: $r$ = 0.00018 g/ cm$^3$.

2. Reproducibility in terms of density:

- for dry and sweet wines, except liqueur wines: R = 0.00037 g/cm$^3$,
- for liqueur wines: R = 0.00045 g/cm$^3$.

**A.7. Numerical example**

A.7.1. Measurement by pycnometer on a twin-pan balance

A/Calibration of the pycnometer

1. Weighing of the clean, dry pycnometer:

- Tare = pycnometer + $p$
- ρ = 104.9454 g

2. Weighing of the water-filled pycnometer at the temperature $t$°C:

- Tare = pycnometer + water + $p$'

- $p'$ = 1.2396 g for $t$ = 20.5 °C

3. Calculation of the mass of the air contained in the pycnometer:

- $m = 0.0012 (p - p')$
- $m = 0.0012 (104.9454 - 1.2396)$
- $m = 0.1244$

4.Parameters to be kept:

- Tare of the empty pycnometer: $p + m$
- $p + m = 104.9454 + 0.1244$
- $p + m = 105.0698$ g
- Volume at 20 °C = $(p + m - p') \times F_{t°C}$
- $F_{20.50°C} = 1.001900$
- $V_{20°C} = (105.0698 - 1.2396) \times 1.001900$
- $V_{20°c} = 104.0275$ mL
- Water mass at 20°C = $V_{20°} \times 0.998203$
- $M_{20°c} = 103.8405$ g

B/ Determination of the density at 20°C and the 20°C/20°C specific gravity of a dry wine:

$p'$ = 1.2622 g at 17.80 °C

$$\rho^{17.80\,°C} = \frac{105.0698 - 1.2622}{104.0275}$$

- $\rho_{17.80\,°C} = 0.99788$ g/cm$^3$

Table II makes it possible to calculate $\rho_{20\,°C}$ from $\rho_{t\,°C}$ using the following formula:

$$\rho_{20°C} = \rho_{t°c} \pm \frac{c}{1000}$$

For $t$ = 17.80 °C and for an alcoholic strength of 11% vol., $c$ = 0.54:

$$\rho^{20\,°C} = 0.99788 - \frac{0.54}{1000}$$

$\rho_{20°c} = 0.99734\ g/cm^3$

$d_{20°c}^{20°c} = \frac{0.99734}{0.998203} = 0.99913$

A.7.1.2. Measurement by pycnometer on a single-pan balance

A/ Establishment of the pycnometer constants

1.Weighing of the clean, dry pycnometer:

- P = 67.7913 g

2. Weighing of the water-filled pycnometer at t°C:

- $P_1$ = 169.2715 g at 21.65°C

3.Calculation of the mass of the air contained in the pycnometer:

- $m$ = 0.0012 (P1 - P)
- $m$ = 0.0012 x 101.4802
- $m$ = 0.1218 g

4. Characteristics to be retained:

- Tare of the empty pycnometer: P – $m$
- P - $m$ = 67.7913 – 0.1218
- P - $m$ = 67.6695 g
- Volume at 20 °C = [$P_1$ - (P - $m$)] x $F_{t°c}$
- $F_{21.65°C}$= 1.002140
- $V_{°20c}$ = (169.2715 – 67.6695) x 1.002140
- $V_{20°C}$= 101.8194 mL
- Water mass at 20 °C: $V_{20°C}$ x 0.998203
- $M_{20°c}$= 101.6364 g
- Mass of the tare bottle: $T_0$
- $T_0$ = 171.9160 g

B/Determination of the density at 20 °C and 20 °C/20 °C specific gravity of a dry wine:

$T_1$= 171.9178

$d$T = 171.9178 – 171.9160 = 0.0018 g

P – m + dT = 67.6695 + 0.0018 = 67.6713 g

$P_2$= 169.2799 at 18°C

$$\rho^{18\,°C} = \frac{169.2799 - 67.6713}{101.8194}$$

$$\rho^{18\,°C} = 0.99793\ \mathrm{g/cm^3}$$

$$d_{20°C}^{20°C} = \frac{0.99734}{0.998203} = 0.99913$$

A.7.2. Measurement by pycnometer on a single-pan balance

A/ Establishment of the pycnometer constants

1. Weighing of the clean, dry pycnometer:

- P = 67.7913 g

2. Weighing of the water-filled pycnometer at $t$ °C:

- $P_1$ = 169.2715 g at 21.65°C

3. Calculation of the mass of the air contained in the pycnometer:

- $m$ = 0.0012 (P1 - P)
- $m$ = 0.0012 x 101.4802
- $m$ = 0.1218 g

4. Characteristics to be retained:

- Tare of the empty pycnometer: P – $m$
- P - $m$ = 67.7913 – 0.1218
- P - $m$ = 67.6695 g
- Volume at 20 °C = [$P_1$ - (P - $m$)] x $F_{t°C}$
- $F_{21.65°C}$= 1.002140

- $V_{20°C}$= (169.2715 – 67.6695) x 1.002140
- $V_{20°c}$= 101.8194 mL
- Water mass at 20°C: $V_{20°c}$ x 0.998203
- $M_{20\,°C}$ = 101.6364 g
- Mass of the tare bottle: $T_0$
- $T_0$= 171.9160 g

B/ Determination of the density at 20 °C and 20 °C/20 °C specific gravity of a dry wine:

- $T_1$ = 171.9178
- *d*T = 171.9178 – 171.9160 = 0.0018 g
- P - *m* + *d*T = 67.6695 + 0.0018 = 67.6713 g
- $P_2$= 169.2799 at 18°C

$$\rho^{18\,°C} = \frac{169.2799 - 67.6713}{101.8194}$$

$$\rho^{18\,°C} = 0.99793\ \mathrm{g/cm^3}$$

**Method B:Density at 20 °C and specific gravity at 20 °C measured by electronic densimetry using a frequency oscillator (Type I method)**

**B.1. Principle**

The density of the wine or must is measured by electronic densimetry using a frequency oscillator. The principle consists of measuring the period of oscillation of a tube containing the sample undergoing electromagnetic stimulation. The density is related to the period of oscillation by the following formula:

$$\rho = T^2 \times \left(\frac{C}{4\pi^2 V}\right) - \left(\frac{M}{V}\right) (1)$$

□ = density of the sample

T = period of induced vibration

M = mass of empty tube

C = spring constant

V = volume of vibrating sample

This relationship is in the form □ = A $T^2$ – B(2), so there is a linear relationship between the density and the period squared. The constants A and B are specific to each oscillator and are estimated by measuring the period of fluids of known density.

**B.2. Reagents and products**

B.2.1. Reference fluids

Two reference fluids are used to adjust the densimeter. The densities of the reference fluids should encompass the densities of the wines or musts to be analysed. A spread of greater than 0.01000 g/cm$^3$ between the densities of the reference fluids is recommended.

The reference fluids used to measure the density of the wines or musts by electronic densimetry are as follows:

- dry air (unpolluted),
- Type II water for analytical usage (ISO standard 3696), or of equivalent analytical purity,
- hydro-alcoholic solutions, wines or musts whose densities have been determined by a different Type I method, for which the uncertainty does not exceed 0.00005 g/cm$^3$ at the temperature of 20.00 ± 0.05 °C,
- solutions calibrated with traceability to the International System of Units, with viscosities of less than 2 mm$^2$/s, for which the uncertainty does not exceed 0.00005 g/cm$^3$ at the temperature of 20.00 ± 0.05 °C.

B.2.2. Cleaning and drying products

Use products that ensure the perfectly clean and dried state of the measuring cell, according to the residues and manufacturer's indications. For example:

- detergents, acids, etc.,
- organic solvents: 96% vol. ethanol, pure acetone, etc.

**B.3. Apparatus and equipment**

B.3.1. Electronic densimeter with frequency oscillator

The electronic densimeter consists of the following elements:

- a measuring cell consisting of a measuring tube and a temperature controller,

- a system for setting up an oscillation tube and measuring the period of oscillation,
- a digital display and possibly a calculator,
- sample injector syringe, autosampler or other equivalent system.

The densimeter is placed on a perfectly stable support isolated from all vibrations.

B.3.2. Temperature control of the measuring cell

Locate the measuring tube in a temperature-controlled system. Temperature stability should be better than ± 0.02 °C.

It is necessary to control the temperature of the measuring cell when the densimeter makes this possible, because this strongly influences the determination results. The density of a hydro-alcoholic solution with an alcoholic strength by volume (ABV) of 10% vol. is 0.98471 g/cm$^3$ at 20 °C and 0.98447 g/cm$^3$ at 21 °C, equating to a spread of 0.00024 g/cm$^3$.

The test temperature is 20 °C. Measure the cell temperature with a resolution thermometer accurate to less than 0.01 °C and with traceability to national standards. This should enable a temperature measurement with an uncertainty of better than ± 0.07 °C.

B.3.3. Calibration of the apparatus

The apparatus should be calibrated before using it for the first time, then periodically or if the verification is not satisfactory. The objective is to use two reference fluids to calculate the constants A and B [see formula (2), B.1]. To carry out the calibration in practice, refer to the user manual of the apparatus. In principle, this calibration is carried out with dry air (taking into account the atmospheric pressure) and very pure water (B.2.1).

B.3.4. Calibration verification

In order to verify the calibration, the density of the reference fluids is measured.

Every day of use, a density check of the air is carried out. A difference between the theoretical density and observed density of more than 0.00008 g/cm$^3$ may indicate that the tube is clogged. In that case, it should be cleaned. After cleaning, verify the air density again. If the verification is not conclusive, adjust the apparatus.

Check the density of the water; if the difference between the theoretical density and the density observed is greater than 0.00008 g/cm$^3$, adjust the apparatus.

If verification of the cell temperature is difficult, it is possible to directly check the density of a hydro-alcoholic solution of comparable density to those of the samples analysed.

B.3.5. Checks

When the difference between the theoretical density of the reference solution (known with an uncertainty of $\pm$ 0.00005 g/cm$^3$) and the measured density is above 0.00008 g/cm$^3$, the calibration of the apparatus should be checked.

**B.4. Procedure**

Before measuring, if necessary, clean and dry the cell with acetone or absolute alcohol and dry air. Rinse the cell with the sample.

Inject the sample into the cell (using a syringe, autosampler or other equivalent system) so that it is filled completely. While filling, check that all air bubbles have been removed. The sample should be homogenous and not contain any solid particles. Where necessary, filter to remove any suspended matter before analysis.

If there is a lighting system available that makes it possible to verify the absence of bubbles, turn it off quickly after checking because the heat generated by the lamp can influence the measuring temperature (for apparatus with a permanent lighting system, this statement is not applicable).

The operator should ensure that the temperature of the measuring cell is stable.

Once the reading has been stabilised, record the density, $\rho_{20°C}$.

If the apparatus only provides the period, the density can be calculated from the A and B constants (refer to the instructions for the equipment or Annex I of the method OIV-MA-AS312-01A).

**B.5. Expression of results**

The density is expressed in g/cm$^3$ to 5 decimal places.

**B.6. Precision parameters**

The precision parameters are detailed in Table 4 of Annex II.

Repeatability:

- r = 0.00011 g/cm$^3$

Reproducibility:

- R = 0.00025 g/cm$^3$

**Method C: Density at 20 °C and specific gravity at 20 °C measured using a hydrostatic balance (Type I Method)**

**C.1. Principle**

The density of wine or musts can be measured by densimetry with a hydrostatic balance following the Archimedes principle, by which any body immersed in a fluid experiences an upwards force equal to the weight of the displaced fluid.

**C.2. Reagents and products**

C.2.1. Type II water for analytical usage (ISO 3696 standard), or of equivalent purity

C.2.2. Floater-washing solution (sodium hydroxide, 30 % m/v)

To prepare a 100-mL solution weigh 30 g of sodium hydroxide and fill using 96% vol. ethanol.

**C.3. Apparatus and materials**

Normal laboratory apparatus, particularly:

C.3.1. Single-pan hydrostatic balance accurate to the nearest 1 mg

C.3.2. Floater with at least 20 mL volume, specifically adapted for the balance, suspended by a thread with a diameter of less than or equal to 0.1 mm

C.3.3. Cylindrical test tube with level indicator. The floater should be able to fit entirely within the test tube volume below the level indicator; only the hanging thread should break the surface of the liquid. The cylindrical test tube should have an inside diameter at least 6 mm greater than that of the floater.

C.3.4. Thermometer (or temperature-measurement probe) with degree and 10$^{th}$-of-a-degree graduations, from 10°C to 40°C, calibrated to ± 0.06 °C

C.3.5. Masses calibrated by an accredited body.

**C.4. Procedure**

After each measurement, the floater and the test tube should be cleaned with distilled water, wiped with soft laboratory paper that does not lose its fibres and rinsed with solution whose density is to be determined. These measurements should be carried out once the apparatus has reached a stable level in order to limit alcohol loss through evaporation.

C.4.1. Calibration of the apparatus

C.4.1.1. Balance calibration

While balances usually have internal calibration systems, hydrostatic balances should be calibrated with weights with traceability to the International System of Units.

C.4.1.2. Floater calibration

Fill the cylindrical test tube up to the level indicator with water (C.2.1) whose temperature is between 15 °C and 25 °C, but preferably at 20°C.

Plunge the floater and the thermometer into the liquid, shake, note down the density on the apparatus and, if necessary, adjust the reading in order for it to be equal to that of the water at the measurement temperature.

C.4.1.3. Verification using a solution of known density

Fill the cylindrical test tube up to the level indicator with a solution of known density at a temperature of between 15°C and 25 °C, preferably at 20°C.

Immerse the floater and the thermometer in the liquid, stir, read the density of the liquid indicated by the apparatus and record the density and the temperature where the density is measured at $t$ °C ($\rho_t$).

If necessary, correct ρusing a ρt density table of hydro-alcoholic mixtures (Table II in Annex I).

The density determined in this way should be identical to the previously determined density.

*Note*: This solution of known density can also replace water for floater calibration.

C.4.2. Determination of the density

Pour the test sample into the cylindrical test tube up to the level indicator.

Plunge the floater and the thermometer into the liquid, shake and note down the density on the apparatus. Note the temperature if the density is measured at $t$°C (ρt).

Correct ρt using a ρt density table of hydro-alcoholic mixtures (Table II in the Annex).

C.4.3. Cleaning of the floater and cylindrical test tube

Plunge the floater into the washing solution in the test tube.

Allow to soak for one hour while turning the floater regularly.

Rinse with tap water, then with distilled water.

Wipe with soft laboratory paper that does not lose its fibres.

Carry out these operations when the floater is used for the first time and then on a regular basis when necessary.

**C.5. Expression of results**

The density is expressed in g/cm$^3$ to 5 decimal places.

**C.6. Precision parameters**

The precision parameters are detailed in Table 4 of Annex II.

- r = 0.00025 g/cm$^3$
- R = 0.00067 g/cm$^3$

**Method D: Density measured by hydrometry (Type IV Method)**

**D.1. Principle**

The density and specific gravity at 20 °C are determined for the test sample by hydrometry following the Archimedes principle. A weighted cylinder equipped with a graduated stem is more or less immersed into the liquid sample whose density is to be determined. The density of the liquid is read directly on the graduation of the stem at the level of the meniscus.

**D.2. Apparatus**

D.2.1. Hydrometer

Hydrometers should meet ISO requirements relating to their dimensions and graduations.

They should have a cylindrical body and a circular stem with a cross-section of at least 3 mm in diameter. For dry wines, they should be graduated in g/cm$^3$ from 0.983 to 1.003, with graduation marks at every 0.001 and 0.0002 interval. All of the marks at 0.001 intervals should be separated from the next by at least 5 mm. For the measurement of the specific gravity of dealcoholized wines, liqueur wines and musts, a set of 5 hydrometers are to be used, graduated (in g/cm$^3$) from 1.000-1.030; 1.030-1.060; 1.060-1.090; 1.090-1.120; 1.120-1.150. These hydrometers are to be graduated for density at 20 °C by marks and intervals of no greater than 0.001 and 0.0005, with all the marks at the 0.001 intervals being separated from the next by at least 3 mm.

These hydrometers should be graduated so that they can be read at 'top of the meniscus'. The indication of the graduation in density at 20 °C or specific gravity at 20 °C, and of the reading at the top of the meniscus, is to be given either on the graduated scale, or on a strip of paper attached to the bulb.

This apparatus should be calibrated with traceability to the International System of Units.

D.2.2. Thermometer graduated to intervals of no greater than 0.5 °C, calibrated with traceability to the International System of Units.

D.2.3. Measuring cylinder with dimensions that allow for the immersion of the thermometer and the hydrometer without contact with the sides, held vertically.

**D.3. Measurement method**

Place 250mL of the test sample (4) in the measuring cylinder (D.2.3) and insert the hydrometer and thermometer. Stir the sample and wait 1 minute to allow temperature equilibration, then read the thermometer. Remove the thermometer and, after 1 minute of rest, read the apparent density at *t*°C on the stem of the hydrometer.

Correct the apparent density as read at *t*°C for the effect of the temperature, using the tables in Annex I applying to dry wines (Table V), natural and concentrated musts (Table VI) and liqueur wines (Table VII).

**D.4. Expression of results**

The density is expressed in $g/cm^3$ to 4 decimal places

Annexes

Annex I Tables

TABLE I

F factors by which the mass of the water in the *Pyrex pycnometer* at *t* °C has to be multiplied to calculate the volume of the pycnometer at 20 °C

| *t* °C | F | *t* °C | F | *t* °C | F | *t* °C | F | *t* °C | F | *t* °C | F | *t* °C | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10.0 | 1.000398 | 13.0 | 1.000691 | 16.0 | 1.001097 | 19.0 | 1.001608 | 22.0 | 1.002215 | 25.0 | 1.002916 | 28.0 | 1.003704 |
| .1 | 1.000406 | .1 | 1.000703 | .1 | 1.001113 | .1 | 1.001627 | .1 | 1.002238 | .1 | 1.002941 | .1 | 1.003731 |
| .2 | 1.000414 | .2 | 1.000714 | .2 | 1.001128 | .2 | 1.001646 | .2 | 1.002260 | .2 | 1.002966 | .2 | 1.003759 |
| .3 | 1.000422 | .3 | 1.000726 | .3 | 1.001144 | .3 | 1.001665 | .3 | 1.002282 | .3 | 1.002990 | .3 | 1.003797 |
| .4 | 1.000430 | .4 | 1.000738 | .4 | 1.001159 | .4 | 1.001684 | .4 | 1.002304 | .4 | 1.003015 | .4 | 1.003815 |
| 10.5 | 1.000439 | 13.5 | 1.000752 | 16.5 | 1.001175 | 19.5 | 1.001703 | 22.5 | 1.002326 | 25.5 | 1.003041 | 28.5 | 1.003843 |
| .6 | 1.000447 | .6 | 1.000764 | .6 | 1.001191 | .6 | 1.001722 | .6 | 1.002349 | .6 | 1.003066 | .6 | 1.003871 |
| .7 | 1.000456 | .7 | 1.000777 | .7 | 1.001207 | .7 | 1.001741 | .7 | 1.002372 | 3 | 1.003092 | .7 | 1.003899 |
| .8 | 1.000465 | .8 | 1.000789 | .8 | 1.001223 | .8 | 1.001761 | .8 | 1.002394 | .8 | 1.003117 | .8 | 1.003928 |
| .9 | 1.000474 | .9 | 1.000803 | .9 | 1.001239 | 9 | 1.001780 | .9 | 1.002417 | .9 | 1.003143 | .9 | 1.003956 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11.0 | 1.000483 | 14.0 | 1.000816 | 17.0 | 1.001257 | 20.0 | 1.001800 | 23.0 | 1.002439 | 26.0 | 1.003168 | 29.0 | 1.003984 |
| .1 | 1.000492 | .1 | 1.000829 | .1 | 1.001273 | .1 | 1.001819 | .1 | 1.002462 | .1 | 1.003194 | .1 | 1.004013 |
| .2 | 1.000501 | .2 | 1.000842 | .2 | 1.001286 | .2 | 1.001839 | .2 | 1.002485 | 1 | 1.003222 | 2 | 1.004042 |
| 3 | 1.000511 | 3 | 1.000855 | 3 | 1.001306 | .3 | 1.001959 | .3 | 1.002508 | .3 | 1.003247 | .3 | 1.004071 |
| .4 | 1.000520 | .4 | 1.000868 | .4 | 1.001323 | .4 | 1.001880 | .4 | 1.002531 | .4 | 1.003273 | .4 | 1.004099 |
| 11.5 | 1.000530 | 14.5 | 1.000882 | 17.5 | 1.001340 | 20.5 | 1.001900 | 23.5 | 1.002555 | 26.5 | 1.003299 | 29.5 | 1.004128 |
| .6 | 1.000540 | .6 | 1.000895 | .6 | 1.001357 | .6 | 1.001920 | .6 | 1.002578 | .6 | 1.003326 | .6 | 1.004158 |
| .7 | 1.000550 | .7 | 1.000909 | .7 | 1.001374 | .7 | 1.001941 | 3 | 1.002602 | .7 | 1.003352 | .7 | 1.004187 |
| .8 | 1.000560 | .8 | 1.000923 | .8 | 1.001391 | .8 | 1.001961 | .8 | 1.002625 | .8 | 1.003379 | .8 | 1.004216 |
| .9 | 1.000570 | .9 | 1.000937 | .9 | 1.001409 | .9 | 1.001982 | .9 | 1.002649 | .9 | 1.003405 | .9 | 1.004245 |
| 12.0 | 1.000580 | 15.0 | 1.000951 | 18.0 | 1.001427 | 21.0 | 1.002002 | 24.0 | 1.002672 | 27.0 | 1.003432 | 30.0 | 1.004275 |
| .1 | 1.000591 | .1 | 1.000965 | .1 | 1.001445 | .1 | 1.002023 | .1 | 1.002696 | .1 | 1.003459 | | |
| .2 | 1.000601 | .2 | 1.000979 | .2 | 1.001462 | .2 | 1.002044 | .2 | 1.002720 | .2 | 1.003485 | | |
| .3 | 1.000612 | .3 | 1.000993 | .3 | 1.001480 | .3 | 1.002065 | .3 | 1.002745 | .3 | 1.003513 | | |
| .4 | 1.000623 | .4 | 1.001008 | .4 | 1.001498 | .4 | 1.002086 | .4 | 1.002769 | .4 | 1.003540 | | |
| 12.5 | 1.000634 | 15.5 | 1.001022 | 18.5 | 1.001516 | 21.5 | 1.002107 | 24.5 | 1.002793 | 27.5 | 1.003567 | | |
| .6 | 1.000645 | .6 | 1.001037 | .6 | 1.001534 | .6 | 1.002129 | .6 | 1.002817 | .6 | 1.003594 | | |
| .7 | 1.000656 | .7 | 1.001052 | .7 | 1.001552 | .7 | 1.002151 | .7 | 1.002842 | .7 | 1.003621 | | |
| .8 | 1.000668 | .8 | 1.001067 | .8 | 1.001570 | .8 | 1.002172 | .8 | 1.002866 | .8 | 1.003649 | | |
| .9 | 1.000679 | .9 | 1.001082 | .9 | 1.001589 | .9 | 1.002194 | .9 | 1.002891 | .9 | 1.003676 | | |

TABLE II

Temperature corrections, c, required for the density of dry wines and dealcoholised wines,

measured using a Pyrex-glass pycnometer at °C, in order to correct to 20 °C.

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | | Alcoholic strength | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Temperature in °C | 10 | 1.59 | 1.64 | 1.67 | 1.71 | 1.77 | 1.84 | 1.91 | 2.01 | 2.11 | 2.22 | 2.34 | 2.46 | 2.60 | 2.73 | 2.88 | 3.03 | 3.19 | 3.35 | 3.52 | 3.70 | 3.87 | 4.06 | 4.25 | 4.44 |
| | 11 | 1.48 | 1.53 | 1.56 | 1.60 | 1.64 | 1.70 | 1.77 | 1.86 | 1.95 | 2.05 | 2.16 | 2.27 | 2.38 | 2.51 | 2.63 | 2.77 | 2.91 | 3.06 | 3.21 | 3.36 | 3.53 | 3.69 | 3.86 | 4.03 |
| | 12 | 1.36 | 1.40 | 1.43 | 1.46 | 1.50 | 1.56 | 1.62 | 1.69 | 1.78 | 1.86 | 1.96 | 2.05 | 2.16 | 2.27 | 2.38 | 2.50 | 2.62 | 2.75 | 2.88 | 3.02 | 3.16 | 3.31 | 3.46 | 3.61 |
| | 13 | 1.22 | 1.26 | 1.28 | 1.32 | 1.35 | 1.40 | 1.45 | 1.52 | 1.59 | 1.67 | 1.75 | 1.83 | 1.92 | 2.01 | 2.11 | 2.22 | 2.32 | 2.44 | 2.55 | 2.67 | 2.79 | 2.92 | 3.05 | 3.18 |
| | 14 | 1.08 | 1.11 | 1.13 | 1.16 | 1.19 | 1.23 | 1.27 | 1.33 | 1.39 | 1.46 | 1.52 | 1.60 | 1.67 | 1.75 | 1.94 | 1.93 | 2.03 | 2.11 | 2.21 | 2.31 | 2.42 | 2.52 | 2.63 | 2.74. |
| | 15 | 0.92 | 0.96 | 0.97 | 0.99 | 1.02 | 1.05 | 1.09 | 1.13 | 1.19 | 1.24 | 1.30 | 1.36 | 1.42 | 1.48 | 1.55 | 1.63 | 1.70 | 1.78 | 1.86 | 1.95 | 2.03 | 2.12 | 2.21 | 2.30 |
| | 16 | 0.76 | 0.79 | 0.80 | 0.81 | 0.94 | 0.86 | 0.89 | 0.93 | 0.97 | 1.01 | 1.06 | 1.10 | 1.16 | 1.21 | 1.26 | 1.32 | 1.38 | 1.44 | 1.51 | 1.57 | 1.64 | 1.71 | 1.78 | 1.85 |
| | 17 | 0.59 | 0.61 | 0.62 | 0.63 | 0.65 | 0.67 | 0.69 | 0.72 | 0.75 | 0.78 | 0.81 | 0.85 | 0.88 | 0.95 | 0.96 | 1.01 | 1.05 | 1.11 | 1.15 | 1.20 | 1.25 | 1.30 | 1.35 | 1.40 |
| | 18 | 0.40 | 0.42 | 0.42 | 0.43 | 0.44 | 0.46 | 0.47 | 0.49 | 0.51 | 0.53 | 0.55 | 0.57 | 0.60 | 0.63 | 0.65 | 0.68 | 0.71 | 0.74 | 0.77 | 0.81 | 0.84 | 0.87 | 0.91 | 0.94 |
| | 19 | 0.21 | 0.21 | 0.22 | 0.22 | 0.23 | 0.23 | 0.24 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 | 0.30 | 0.32 | 0.33 | 0.34 | 0.36 | 0.37 | 0.39 | 0.41 | 0.42 | 0.44 | 0.46 | 0.47 |
| | 20 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 0.21 | 0.22 | 0.22 | 0.23 | 0.23 | 0.24 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 | 0.30 | 0.31 | 0.32 | 0.34 | 0.36 | 0.37 | 0.38 | 0.40 | 0.41 | 0.43 | 0.44 | 0.46 | 0.48 |
| | 22 | 0.44 | 0.45 | 0.46 | 0.47 | 0.48 | 0.49 | 0.51 | 0.52 | 0.54 | 0.56 | 0.59 | 0.61 | 0.63 | 0.66 | 0.69 | 0.71 | 0.74 | 0.77 | 0.80 | 0.83 | 0.87 | 0.90 | 0.93 | 0.97 |
| | 23 | 0.68 | 0.70 | 0.71 | 0.72 | 0.74 | 0.76 | 0.78 | 0.80 | 0.83 | 0.86 | 0.90 | 0.93 | 0.96 | 1.00 | 1.03 | 1.08 | 1.13 | 1.17 | 1.22 | 1.26 | 1.31 | 1.37 | 1.41 | 1.46 |
| | 24 | 0.93 | 0.96 | 0.97 | 0.99 | 1.01 | 1.03 | 1.06 | 1.10 | 1.13 | 1.18 | 1.22 | 1.26 | 1.31 | 1.36 | 1.41 | 1.47 | 1.52 | 1.58 | 1.64 | 1.71 | 1.77 | 1.84 | 1.90 | 1.97 |
| | 25 | 1.19 | 1.23 | 1.25 | 1.27 | 1.29 | 1.32 | 1.36 | 1.40 | 1.45 | 1.50 | 1.55 | 1.61 | 1.67 | 1.73 | 1.80 | 1.86 | 1.93 | 2.00 | 2.08 | 2.16 | 2.24 | 2.32 | 2.40 | 2.48 |
| | 26 | 1.47 | 1.51 | 1.53 | 1.56 | 1.59 | 1.62 | 1.67 | 1.72 | 1.77 | 1.83 | 1.90 | 1.96 | 2.03 | 2.11 | 2.19 | 2.27 | 2.35 | 2.44 | 2.53 | 2.62 | 2.72 | 2.81 | 2.91 | 3.01 |
| | 27 | 1.75 | 1.80 | 1.82 | 1.85 | 1.89 | 1.93 | 1.98 | 2.04 | 2.11 | 2.18 | 2.25 | 2.33 | 2.41 | 2.50 | 2.59 | 2.68 | 2.78 | 2.88 | 2.98 | 3.09 | 3.20 | 3.31 | 3.42 | 3.33 |
| | 28 | 2.04 | 2.10 | 2.13 | 2.16 | 2.20 | 2.25 | 2.31 | 2.38 | 2.45 | 2.53 | 2.62 | 2.70 | 2.80 | 2.89 | 3.00 | 3.10 | 3.21 | 3.32 | 3.45 | 3.57 | 3.69 | 3.82 | 3.94 | 4.07 |
| | 29 | 2.34 | 2.41 | 2.44 | 2.48 | 2.53 | 2.58 | 2.65 | 2.72 | 2.81 | 2.89 | 2.99 | 3.09 | 3.19 | 3.30 | 3.42 | 3.53 | 3.65 | 3.78 | 3.92 | 4.05 | 4.19 | 4.33 | 4.47 | 4.61 |
| | 30 | 2.66 | 2.73 | 2.77 | 2.81 | 2.86 | 2.92 | 3.00 | 3.08 | 3.17 | 3.27 | 3.37 | 3.48 | 3.59 | 3.72 | 3.84 | 3.97 | 4.11 | 4.25 | 4.40 | 4.55 | 4.70 | 4.85 | 4.92 | 5.17 |

*Note:* This table can be used to convert the density $d^t_{20}$ to $d^{20}_{20}$

TABLE III

Temperature corrections, *c*, required for the density of natural or concentrated musts,

measured using a Pyrex-glass pycnometer at *t* °C, in order to correct to 20 °C

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | | Density | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.05 | 1.06 | 1.07 | 1.08 | 1.09 | 1.10 | 1.11 | 1.12 | 1.13 | 1.14 | 1.15 | 1.16 | 1.18 | 1.20 | 1.22 | 1.24 | 1.26 | 1.28 | 1.30 | 1.32 | 1.34 | 1.36 |
| Temperature in °C | 10 | 2.31 | 2.48 | 2.66 | 2.82 | 2.99 | 3.13 | 3.30 | 3.44 | 3.59 | 3.73 | 3.88 | 4.01 | 4.28 | 4.52 | 4.76 | 4.98 | 5.18 | 5.42 | 5.56 | 5.73 | 5.90 | 6.05 |
| | 11 | 2.12 | 2.28 | 2.42 | 2.57 | 2.72 | 2.86 | 2.99 | 3.12 | 3.25 | 3.37 | 3.50 | 3.62 | 3.85 | 4.08 | 4.29 | 4148 | 4.67 | 4.84 | 5.00 | 5.16 | 5.31 | 5.45 |
| | 12 | 1.92 | 2.06 | 2.19 | 2.32 | 2.45 | 2.58 | 2.70 | 2.92 | 2.94 | 3.04 | 3.15 | 3.26 | 3.47 | 3.67 | 3.85 | 4.03 | 4.20 | 4.36 | 4.51 | 4.65 | 478 | 4.91 |
| | 13 | 1.72 | 1.84 | 1.95 | 2.06 | 2.17 | 2.27 | 2.38 | 2.48 | 2.58 | 2.69 | 2.78 | 2.89 | 3.05 | 3.22 | 3.39 | 3.55 | 3.65 | 3.84 | 3.98 | 4.11 | 4.24 | 4.36 |
| | 14 | 1.52 | 1.62 | 1.72 | 1.81 | 1.90 | 2.00 | 2.09 | 2.17 | 2.26 | 2.34 | 2.43 | 2.51 | 2.66 | 2.82 | 2.96 | 3.09 | 3.22 | 3.34 | 3.45 | 3.56 | 3.67 | 3.76 |
| | 15 | 1.28 | 1.36 | 1.44 | 1.52 | 1.60 | 1.67 | 1.75 | 1.82 | 1.89 | 1.96 | 2.04 | 2.11 | 2.24 | 2.36 | 2.48 | 2.59 | 2.69 | 2.79 | 2.88 | 2.97 | 3.03 | 3.10 |
| | 16 | 1.05 | 1.12 | 1.18 | 1.25 | 1.31 | 1.37 | 1.43 | 1.49 | 1.55 | 1.60 | 1.66 | 1.71 | 1.81 | 1.90 | 2.00 | 2.08 | 2.16 | 2.24 | 2.30 | 2.37 | 2.43 | 2.49 |
| | 17 | 0.80 | 0.86 | 0.90 | 0.95 | 1.00 | 1.04 | 1.09 | 1.13 | 1.18 | 1.22 | 1.26 | 1.30 | 1.37 | 1.44 | 1.51 | 1.57 | 1.62 | 1.68 | 1.72 | 1.76 | 1.80 | 1.84 |
| | 18 | 0.56 | 0.59 | 0.62 | 0.66 | 0.68 | 0.72 | 0.75 | 0.77 | 0.80 | 0.83 | 0.85 | 0.88 | 0.93 | 0.98 | 1.02 | 1.05 | 1.09 | 1.12 | 1.16 | 1.19 | 1.21 | 1.24 |
| | 19 | 0.29 | 0.31 | 0.32 | 0.34 | 0.36 | 0.37 | 0.39 | 0.40 | 0.42 | 0.43 | 0.44 | 0.45 | 0.48 | 0.50 | 0.52 | 0.54 | 0.56 | 0.57 | 0.59 | 0.60 | 0.61 | 0.62 |
| | 20 | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 0.29 | 0.30 | 0.32 | 0.34 | 0.35 | 0.37 | 0.38 | 0.40 | 0.41 | 0.42 | 0.44 | 0.46 | 0.48 | 0.50 | 0.53 | 0.56 | 0.58 | 0.59 | 0.60 | 0.61 | 0.62 | 0.62 |
| | 22 | 0.58 | 0.61 | 0.64 | 0.67 | 0.70 | 0.73 | 0.76 | 0.79 | 0.81 | 0.84 | 0.87 | 0.90 | 0.96 | 1.03 | 1.05 | 1.09 | 1.12 | 1.15 | 1.18 | 1.20 | 1.22 | 1.23 |
| | 23 | 0.89 | 0.94 | 0.99 | 1.03 | 1.08 | 1.12 | 1.16 | 1.20 | 1.25 | 1.29 | 1.33 | 1.37 | 1.44 | 1.51 | 1.57 | 1.63 | 1.67 | 1.73 | 1.77 | 1.80 | 1.82 | 1.94 |
| | 24 | 1.20 | 1.25 | 1.31 | 1.37 | 1.43 | 1.49 | 1.54 | 1.60 | 1.66 | 1.71 | 1.77 | 1.82 | 1.92 | 2.01 | 2.10 | 2.17 | 2.24 | 2.30 | 2.36 | 2.40 | 2.42 | 2.44 |
| | 25 | 1.51 | 1.59 | 1.66 | 1.74 | 1.81 | 1.88 | 1.95 | 2.02 | 2.09 | 2.16 | 2.23 | 2.30 | 2.42 | 2.53 | 2.63 | 2.72 | 2.82 | 2.89 | 2.95 | 2.99 | 3.01 | 3.05 |
| | 26 | 1.84 | 1.92 | 2.01 | 2.10 | 2.18 | 2.26 | 2.34 | 2.42 | 2.50 | 2.58 | 2.65 | 2.73 | 2.87 | 3.00 | 3.13 | 3.25 | 3.36 | 3.47 | 3.57 | 3.65 | 372 | 3.79 |
| | 27 | 2.17 | 2.26 | 2.36 | 2.46 | 2.56 | 2.66 | 2.75 | 2.84 | 2.93 | 3.01 | 3.10 | 3.18 | 3.35 | 3.50 | 3.66 | 3.80 | 3.93 | 4.06 | 4.16 | 4.26 | 4.35 | 4.42 |
| | 28 | 2.50 | 2.62 | 2.74 | 2.85 | 2.96 | 3.07 | 3.18 | 3.28 | 3.40 | 3.50 | 3.60 | 3.69 | 3.87 | 4.04 | 4.21 | 4.36 | 4.50 | 4.64 | 4.75 | 4.86 | 4.94 | 5.00 |
| | 29 | 2.86 | 2.98 | 3.10 | 3.22 | 3.35 | 3.47 | 3.59 | 3.70 | 3.82 | 3.93 | 4.03 | 4.14 | 4.34 | 4.53 | 4.72 | 4.89 | 5.05 | 5.20 | 5.34 | 5.46 | 5.56 | 5.64 |
| | 30 | 3.20 | 3.35 | 3.49 | 3.64 | 3.77 | 3.91 | 4.05 | 4.17 | 4.30 | 4.43 | 4.55 | 4.67 | 4.90 | 5.12 | 5.39 | 5.51 | 5.68 | 5.94 | 5.96 | 6.09 | 6.16 | 6.22 |

*Note:* This table can be used to convert the density $d^t_{20}$ to $d^{20}_{20}$

TABLE IV

Temperature corrections, *c*, required for the density of liqueur wines, measured using a Pyrex-glass pycnometer at *t* °C, in order to correct to 20 °C

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | | 13% vol. wines | | | | | | | 15% vol. wines | | | | | | | 17% vol. wines | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Density | | | | | | | Density | | | | | | | Density | | | | | | |
| | | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 |
| Temperature in °C | 10 | 2.36 | 2.71 | 3.06 | 3.42 | 3.72 | 3.96 | 4.32 | 2.64 | 2.99 | 3.36 | 3.68 | 3.99 | 4.30 | 4.59 | 2.94 | 3.29 | 3.64 | 3.98 | 4.29 | 4.60 | 4.89 |
| | 11 | 2.17 | 2.49 | 2.80 | 2.99 | 3.39 | 3.65 | 3.90 | 2.42 | 2.73 | 3.05 | 3.34 | 3.63 | 3.89 | 4.15 | 2.69 | 3.00 | 3.32 | 3.61 | 3.90 | 4.16 | 4.41 |
| | 12 | 1.97 | 2.25 | 2.53 | 2.79 | 3.05 | 3.29 | 3.52 | 2.19 | 2.47 | 2.75 | 3.01 | 3.27 | 3.51 | 3.73 | 2.42 | 2.70 | 2.98 | 3.24 | 3.50 | 3.74 | 3.96 |
| | 13 | 1.78 | 2.02 | 2.25 | 2.47 | 2.69 | 2.89 | 3.09 | 1.97 | 2.21 | 2.44 | 2.66 | 2.87 | 3.08 | 3.29 | 2.18 | 2.42 | 2.64 | 2.87 | 3.08 | 3.29 | 3.49 |
| | 14 | 1.57 | 1.78 | 1.98 | 2.16 | 2.35 | 2.53 | 2.70 | 1.74 | 1.94 | 2.14 | 2.32 | 2.52 | 2.69 | 2.86 | 1.91 | 2.11 | 2.31 | 2.50 | 2.69 | 2.86 | 3.03 |
| | 15 | 1.32 | 1.49 | 1.66 | 1.82 | 1.97 | 2.12 | 2.26 | 1.46 | 1.63 | 1.79 | 1.95 | 2.10 | 2.25 | 2.39 | 1.60 | 1.77 | 1.93 | 2.09 | 2.24 | 2.39 | 2.53 |
| | 16 | 1.08 | 1.22 | 1.36 | 1.48 | 1.61 | 1.73 | 1.84 | 1.18 | 1.32 | 1.46 | 1.59 | 1.71 | 1.83 | 1.94 | 1.30 | 1.44 | 1.58 | 1.71 | 1.83 | 1.95 | 2.06 |
| | 17 | 0.83 | 0.94 | 1.04 | 1.13 | 1.22 | 1.31 | 1.40 | 0.91 | 1.02 | 1.12 | 1.21 | 1.30 | 1.39 | 1.48 | 1.00 | 1.10 | 1.20 | 1.30 | 1.39 | 1.48 | 1.56 |
| | 18 | 0.58 | 0.64 | 0.71 | 0.78 | 0.84 | 0.89 | 0.95 | 0.63 | 0.69 | 0.76 | 0.83 | 0.89 | 0.94 | 1.00 | 0.69 | 0.75 | 0.82 | 0.89 | 0.95 | 1.00 | 1.06 |
| | 19 | 0.30 | 0.34 | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 | 0.33 | 0.37 | 0.40 | 0.43 | 0.46 | 0.49 | 0.52 | 0.36 | 0.39 | 0.42 | 0.46 | 0.49 | 0.52 | 0.54 |
| | 20 | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 0.30 | 0.33 | 0.36 | 0.40 | 0.43 | 0.46 | 0.49 | 0.33 | 0.36 | 0.39 | 0.43 | 0.46 | 0.49 | 0.51 | 0.35 | 0.39 | 0.42 | 0.45 | 0.48 | 0.51 | 0.54 |
| | 22 | 0.60 | 0.67 | 0.73 | 0.80 | 0.85 | 0.91 | 0.98 | 0.65 | 0.72 | 0.78 | 0.84 | 0.90 | 0.96 | 1.01 | 0.71 | 0.78 | 0.84 | 0.90 | 0.96 | 1.01 | 1.07 |
| | 23 | 0.93 | 1.02 | 1.12 | 1.22 | 1.30 | 1.39 | 1.49 | 1.01 | 1.10 | 1.20 | 1.29 | 1.38 | 1.46 | 1.55 | 1.10 | 1.19 | 1.29 | 1.38 | 1.46 | 1.55 | 1.63 |
| | 24 | 1.27 | 1.39 | 1.50 | 1.61 | 1.74 | 1.84 | 1.95 | 1.37 | 1.49 | 1.59 | 1.72 | 1.84 | 1.95 | 2.06 | 1.48 | 1.60 | 1.71 | 1.83 | 1.95 | 2.06 | 2.17 |
| | 25 | 1.61 | 1.75 | 1.90 | 2.05 | 2.19 | 2.33 | 2.47 | 1.73 | 1.87 | 2.02 | 2.17 | 2.31 | 2.45 | 2.59 | 1.87 | 2.01 | 2.16 | 2.31 | 2.45 | 2.59 | 2.73 |
| | 26 | 1.94 | 2.12 | 2.29 | 2.47 | 2.63 | 2.79 | 2.95 | 2.09 | 2.27 | 2.44 | 2.62 | 2.78 | 2.94 | 3.10 | 2.26 | 2.44 | 2.61 | 2.79 | 2.95 | 3.11 | 3.26 |
| | 27 | 2.30 | 2.51 | 2.70 | 2.90 | 3.09 | 3.27 | 3.44 | 2.48 | 2.68 | 2.87 | 3.07 | 3.27 | 3.45 | 3.62 | 2.67 | 2.88 | 3.07 | 3.27 | 3.46 | 3.64 | 3.81 |
| | 28 | 2.66 | 2.90 | 3.13 | 3.35 | 3.57 | 3.86 | 4.00 | 2.86 | 3.10 | 3.23 | 3.55 | 3.77 | 3.99 | 4.20 | 3.08 | 3.31 | 3.55 | 3.76 | 3.99 | 4.21 | 4.41 |
| | 29 | 3.05 | 3.31 | 3.56 | 3.79 | 4.04 | 4.27 | 4.49 | 3.28 | 3.53 | 3.77 | 4.02 | 4.26 | 4.49 | 4.71 | 3.52 | 3.77 | 4.01 | 4.26 | 4.50 | 4.73 | 4.95 |
| | 30 | 3.44 | 3.70 | 3.99 | 4.28 | 4.54 | 4.80 | 5.06 | 3.68 | 3.94 | 4.23 | 4.52 | 4.79 | 5.05 | 5.30 | 3.95 | 4.22 | 4.51 | 4.79 | 5.07 | 5.32 | 5.57 |

TABLE IV (continued)

Temperature corrections, *c*, required for the density of liqueur wines, measured using a Pyrex-glass pycnometer at *t* °C, in order to correct to 20 °C

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | | 19% vol. wines | | | | | | | 21% vol. wines | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Density | | | | | | | Density | | | | | | |
| | | 1.000 | 1.020 | 1.040 | 1.060 | 1.000 | 1.100 | 1.120 | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 |
| Temperature in °C | 10 | 3.27 | 3.62 | 3.97 | 4.30 | 4.62 | 4.92 | 5.21 | 3.62 | 3.97 | 4.32 | 4.66 | 4.97 | 5.27 | 5.56 |
| | 11 | 2.99 | 3.30 | 3.61 | 3.90 | 4.19 | 4.45 | 4.70 | 3.28 | 3.61 | 3.92 | 4.22 | 4.50 | 4.76 | 5.01 |
| | 12 | 2.68 | 2.96 | 3.24 | 3.50 | 3.76 | 4.00 | 4.21 | 2.96 | 3.24 | 3.52 | 3.78 | 4.03 | 4.27 | 4.49 |
| | 13 | 2.68 | 2.96 | 3.24 | 3.50 | 3.76 | 4.00 | 4.21 | 2.96 | 3.24 | 3.52 | 3.78 | 4.03 | 4.27 | 4.49 |
| | 14 | 2.11 | 2.31 | 2.51 | 2.69 | 2.88 | 3.05 | 3.22 | 2.31 | 2.51 | 2.71 | 2.89 | 3.08 | 3.25 | 3.43 |
| | 15 | 1.76 | 1.93 | 2.09 | 2.25 | 2.40 | 2.55 | 2.69 | 1.93 | 2.10 | 2.26 | 2.42 | 2.57 | 2.72 | 2.86 |
| | 16 | 1.43 | 1.57 | 1.70 | 1.83 | 1.95 | 2.08 | 2.18 | 1.56 | 1.70 | 1.84 | 1.97 | 2.09 | 2.21 | 2.32 |
| | 17 | 1.09 | 1.20 | 1.30 | 1.39 | 1.48 | 1.57 | 1.65 | 1.20 | 1.31 | 1.41 | 1.50 | 1.59 | 1.68 | 1.77 |
| | 18 | 0.76 | 0.82 | 0.88 | 0.95 | 1.01 | 1.06 | 1.12 | 0.82 | 0.88 | 0.95 | 1.01 | 1.08 | 1.13 | 1.18 |
| | 19 | 0.39 | 0.42 | 0.45 | 0.49 | 0.52 | 0.55 | 0.57 | 0.42 | 0.46 | 0.49 | 0.52 | 0.55 | 0.58 | 0.61 |
| | 20 | | | | | | | | | | | | | | |
| | 21 | 0.38 | 0.42 | 0.45 | 0.48 | 0.51 | 0.54 | 0.57 | 0.41 | 0.45 | 0.48 | 0.51 | 0.54 | 0.57 | 0.60 |
| | 22 | 0.78 | 0.84 | 0.90 | 0.96 | 1.02 | 1.07 | 1.13 | 0.84 | 0.90 | 0.96 | 1.02 | 1.08 | 1.14 | 1.19 |
| | 23 | 1.19 | 1.28 | 1.38 | 1.47 | 1.55 | 1.64 | 1.72 | 1.29 | 1.39 | 1.48 | 1.57 | 1.65 | 1.74 | 1.82 |
| | 24 | 1.60 | 1.72 | 1.83 | 1.95 | 2.06 | 2.18 | 2.29 | 1.73 | 1.85 | 1.96 | 2.08 | 2.19 | 2.31 | 2.42 |
| | 25 | 2.02 | 2.16 | 2.31 | 2.46 | 2.60 | 2.74 | 2.88 | 2.18 | 2.32 | 2.47 | 2.62 | 2.76 | 2.90 | 3.04 |
| | 26 | 2.44 | 2.62 | 2.79 | 2.96 | 3.12 | 3.28 | 3.43 | 2.53 | 2.81 | 2.97 | 3.15 | 3.31 | 3.47 | 3.62 |
| | 27 | 2.88 | 3.08 | 3.27 | 3.42 | 3.66 | 3.84 | 4.01 | 3.10 | 3.30 | 3.47 | 3.69 | 3.88 | 4.06 | 4.23 |
| | 28 | 3.31 | 3.54 | 3.78 | 4.00 | 4.22 | 4.44 | 4.64 | 3.56 | 3.79 | 4.03 | 4.25 | 4.47 | 4.69 | 4.89 |
| | 29 | 3.78 | 4.03 | 4.27 | 4.52 | 4.76 | 4.99 | 5.21 | 4.06 | 4.31 | 4.55 | 4.80 | 5.04 | 5.27 | 5.48 |
| | 30 | 4.24 | 4.51 | 4.80 | 5.08 | 5.36 | 5.61 | 5.86 | 4.54 | 4.82 | 5.11 | 5.39 | 5.66 | 5.91 | 6.16 |

TABLE V

Temperature corrections, c, required for the density of dry wines and dealcoholised dry wines,
measured using an ordinary-glass pycnometer or hydrometer at t °C, in order to correct to 20 °C

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | | Alcoholic strength | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | | |
| Temperature in °C | 10 | 1.45 | 1.51 | 1.55 | 1.58 | 1.64 | 1.76 | 1.78 | 1.89 | 1.98 | 2.09 | 2.21 | 2.34 | 2.47 | 2.60 | 2.75 | 2.93 | 3.06 | 3.22 | 3.39 | 3.57 | 3.75 | 3.93 | 4.12 | 4.31 | | |
| | 11 | 1.35 | 1.40 | 1.43 | 1.47 | 1.52 | 1.58 | 1.65 | 1.73 | 1.83 | 1.93 | 2.03 | 2.15 | 2.26 | 2.38 | 2.51 | 2.65 | 2.78 | 2.93 | 3.08 | 3.24 | 3.40 | 3.57 | 3.73 | 3.90 | | |
| | 12 | 1.24 | 1.28 | 1.31 | 1.34 | 1.39 | 1.44 | 1.50 | 1.58 | 1.66 | 1.75 | 1.84 | 1.94 | 2.04 | 2.15 | 2.26 | 2.38 | 2.51 | 2.63 | 2.77 | 2.91 | 3.05 | 3.19 | 3.34 | 3.49 | | |
| | 13 | 1.12 | 1.16 | 1.18 | 1.21 | 1.25 | 1.30 | 1.35 | 1.42 | 1.49 | 1.56 | 1.64 | 1.73 | 1.82 | 1.91 | 2.01 | 2.11 | 2.22 | 2.33 | 2.45 | 2.57 | 2.69 | 2.81 | 2.95 | 3.07 | | |
| | 14 | 0.99 | 1.03 | 1.05 | 1.07 | 1.11 | 1.14 | 1.19 | 1.24 | 1.31 | 1.37 | 1.44 | 1.52 | 1.59 | 1.67 | 1.75 | 1.84 | 1.93 | 2.03 | 2.13 | 2.23 | 2.33 | 2.44 | 2.55 | 2.66 | | |
| | 15 | 0.86 | 0.89 | 0.90 | 0.92 | 0.95 | 0.98 | 1.02 | 1.07 | 1.12 | 1.17 | 1.23 | 1.29 | 1.35 | 1.42 | 1.49 | 1.56 | 1.63 | 1.71 | 1.80 | 1.88 | 1.96 | 2.05 | 2.14 | 2.23 | | |
| | 16 | 0.71 | 0.73 | 0.74 | 0.76 | 0.78 | 0.81 | 0.84 | 0.87 | 0.91 | 0.95 | 0.99 | 1.05 | 1.10 | 1.15 | 1.21 | 1.27 | 1.33 | 1.39 | 1.45 | 1.52 | 1.59 | 1.66 | 1.73 | 1.80 | | |
| | 17 | 0.55 | 0.57 | 0.57 | 0.59 | 0.60 | 0.62 | 0.65 | 0.67 | 0.70 | 0.74 | 0.77 | 0.81 | 0.84 | 0.88 | 0.92 | 0.96 | 1.01 | 1.05 | 1.10 | 1.15 | 1.20 | 1.26 | 1.31 | 1.36 | | |
| | 18 | 0.38 | 0.39 | 0.39 | 0.40 | 0.41 | 0.43 | 0.44 | 0.46 | 0.48 | 0.50 | 0.52 | 0.55 | 0.57 | 0.60 | 0.62 | 0.65 | 0.68 | 0.71 | 0.74 | 0.78 | 0.81 | 0.85 | 0.88 | 0.91 | | |
| | 19 | 0.19 | 0.20 | 0.20 | 0.21 | 0.21 | 0.22 | 0.23 | 0.24 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 | 0.30 | 0.32 | 0.33 | 0.34 | 0.36 | 0.38 | 0.39 | 0.41 | 0.43 | 0.44 | 0.46 | | |
| | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 0.21 | 0.22 | 0.22 | 0.23 | 0.23 | 0.24 | 0.25 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 | 0.31 | 0.32 | 0.34 | 0.35 | 0.36 | 0.38 | 0.39 | 0.41 | 0.43 | 0.44 | 0.46 | 0.48 | | |
| | 22 | 0.43 | 0.45 | 0.45 | 0.46 | 0.47 | 0.49 | 0.50 | 0.52 | 0.54 | 0.56 | 0.58 | 0.60 | 0.62 | 0.65 | 0.68 | 0.71 | 0.73 | 0.77 | 0.80 | 0.83 | 0.86 | 0.89 | 0.93 | 0.96 | | |
| | 23 | 0.67 | 0.69 | 0.70 | 0.71 | 0.72 | 0.74 | 0.77 | 0.79 | 0.82 | 0.85 | 0.88 | 0.91 | 0.95 | 0.99 | 1.03 | 1.07 | 1.12 | 1.16 | 1.21 | 1.25 | 1.30 | 1.35 | 1.40 | 1.45 | | |
| | 24 | 0.91 | 0.93 | 0.95 | 0.97 | 0.99 | 1.01 | 1.04 | 1.07 | 1.11 | 1.15 | 1.20 | 1.24 | 1.29 | 1.34 | 1.39 | 1.45 | 1.50 | 1.56 | 1.62 | 1.69 | 1.76 | 1.82 | 1.88 | 1.95 | | |
| | 25 | 1.16 | 1.19 | 1.21 | 1.23 | 1.26 | 1.29 | 1.33 | 1.37 | 1.42 | 1.47 | 1.52 | 1.57 | 1.63 | 1.70 | 1.76 | 1.83 | 1.90 | 1.97 | 2.05 | 2.13 | 2.21 | 2.29 | 2.37 | 2.45 | | |
| | 26 | 1.42 | 1.46 | 1.49 | 1.51 | 1.54 | 1.58 | 1.62 | 1.67 | 1.73 | 1.79 | 1.85 | 1.92 | 1.99 | 2.07 | 2.14 | 2.22 | 2.31 | 2.40 | 2.49 | 2.58 | 2.67 | 2.77 | 2.86 | 2.96 | | |
| | 27 | 1.69 | 1.74 | 1.77 | 1.80 | 1.83 | 1.88 | 1.93 | 1.98 | 2.05 | 2.12 | 2.20 | 2.27 | 2.35 | 2.44 | 2.53 | 2.63 | 272 | 2.82 | 2.93 | 3.04 | 3.14 | 3.25 | 3.37 | 3.48 | | |
| | 28 | 1.97 | 2.03 | 2.06 | 2.09 | 2.14 | 2.19 | 2.24 | 2.31 | 2.38 | 2.46 | 2.55 | 2.63 | 2.73 | 2.83 | 2.93 | 3.03 | 3.14 | 3.26 | 3.38 | 3.50 | 3.62 | 3.75 | 3.85 | 4.00 | | |
| | 29 | 2.26 | 2.33 | 2.37 | 2.41 | 2.45 | 2.50 | 2.57 | 2.64 | 2.73 | 2.82 | 2.91 | 2.99 | 3.11 | 3.22 | 3.34 | 3.46 | 3.58 | 3.70 | 3.84 | 3.97 | 4.11 | 4.25 | 4.39 | 4.54 | | |
| | 30 | 2.56 | 2.64 | 2.67 | 2.72 | 2.77 | 2.83 | 2.90 | 2.98 | 3.08 | 3.18 | 3.28 | 3.38 | 3.50 | 3.62 | 3.75 | 3.88 | 4.02 | 4.16 | 4.30 | 4.46 | 4.61 | 4.76 | 4.92 | 5.07 | | |

*Note:* This table can be used to convert the density $d^t_{20}$ to $d^{20}_{20}$

TABLE VI

Temperature corrections, c, required for the density of concentrated musts, measured using an ordinary-glass pycnometer or hydrometer at t °C, in order to correct to 20 °C.

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | Density |
|---|---|

| | | 1.05 | 1.06 | 1.07 | 1.08 | 1.09 | 1.10 | 1.11 | 1.12 | 1.13 | 1.14 | 1.15 | 1.16 | 1.18 | 1.20 | 1.22 | 1.24 | 1.26 | 1.28 | 1.30 | 1.32 | 1.34 | 1.36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature in °C | 10 | 2.17 | 2.34 | 2.52 | 2.68 | 2.85 | 2.99 | 3.16 | 3.29 | 3.44 | 3.58 | 3.73 | 3.86 | 4.13 | 4.36 | 4.60 | 4.82 | 5.02 | 5.25 | 5.39 | 5.56 | -5.73 | 5.87 |
| | 11 | 2.00 | 2.16 | 2.29 | 2.44 | 2.59 | 2.73 | 2.86 | 2.99 | 3.12 | 3.24 | 3.37 | 3.48 | 3.71 | 3.94 | 4.15 | 4.33 | 4.52 | 4.69 | 4.85 | 5.01 | 5.15 | 5.29 |
| | 12 | 1.81 | 1.95 | 2.08 | 2.21 | 2.34 | 2.47 | 2.58 | 2.70 | 2.82 | 2.92 | 3.03 | 3.14 | 3.35 | 3.55 | 3.72 | 3.90 | 4.07 | 4.23 | 4.37 | 4.52 | 4.64 | 4.77 |
| | 13 | 1.62 | 1.74 | 1.85 | 1.96 | 2.07 | 2.17 | 2.28 | 2.38 | 2.48 | 2.59 | 2.68 | 2.77 | 2.94 | 3.11 | 3.28 | 3.44 | 3.54 | 3.72 | 3.86 | 3.99 | 4.12 | 4.24 |
| | 14 | 1.44 | 1.54 | 1.64 | 1.73 | 1.82 | 1.92 | 2.00 | 2.08 | 2.17 | 2.25 | 2.34 | 2.42 | 2.57 | 2.73 | 2.86 | 2.99 | 3.12 | 3.24 | 3.35 | 3.46 | 3.57 | 3.65 |
| | 15 | 1.21 | 1.29 | 1.37 | 1.45 | 1.53 | 1.60 | 1.68 | 1.75 | 1.82 | 1.89 | 1.97 | 2.03 | 2.16 | 2.28 | 2.40 | 2.51 | 2.61 | 2.71 | 2.80 | 2.89 | 2.94 | 3.01 |
| | 16 | 1.00 | 1.06 | 1.12 | 1.19 | 1.25 | 1.31 | 1.37 | 1.43 | 1.49 | 1.54 | 1.60 | 1.65 | 1.75 | 1.84 | 1.94 | 2.02 | 2.09 | 2.17 | 2.23 | 2.30 | 2.36 | 2.42 |
| | 17 | 0.76 | 0.82 | 0.86 | 0.91 | 0.96 | 1.00 | 1.05 | 1.09 | 1.14 | 1.18 | 1.22 | 1.25 | 1.32 | 1.39 | 1.46 | 1.52 | 1.57 | 1.63 | 1.67 | 1.71 | 1.75 | 1.79 |
| | 18 | 0.53 | 0.56 | 0.59 | 0.63 | 0.65 | 0.69 | 0.72 | 0.74 | 0.77 | 0.80 | 0.82 | 0.85 | 0.90 | 0.95 | 0.99 | 1.02 | 1.05 | 1.09 | 1.13 | 1.16 | 1.18 | 1.20 |
| | 19 | 0.28 | 0.30 | 0.31 | 0.33 | 0.35 | 0.36 | 0.38 | 0.39 | 0.41 | 0.42 | 0.43 | 0.43 | 0.46 | 0.48 | 0.50 | 0.52 | 0.54 | 0.55 | 0.57 | 0.58 | 0.59 | 0.60 |
| | 20 | | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 0.28 | 0.29 | 0.31 | 0.33 | 0.34 | 0.36 | 0.37 | 0.39 | 0.40 | 0.41 | 0.43 | 0.44 | 0.46 | 0.48 | 0.51 | 0.54 | 0,56 | 0.57 | 0.58 | 0.59 | 0.60 | 0.60 |
| | 22 | 0.55 | 0.58 | 0.61 | 0.64 | 0.67 | 0.70 | 0.73 | 0.76 | 0.78 | 0.81 | 0.84 | 0.87 | 0.93 | 0.97 | 1.02 | 1.06 | 1.09 | 1.12 | 1.15 | 1.17 | 1.19 | 1.19 |
| | 23 | 0.85 | 0.90 | 0.95 | 0.99 | 1.04 | 1.08 | 1.12 | 1.16 | 1.21 | 1.25 | 1.29 | 1.32 | 1.39 | 1.46 | 1.52 | 1.58 | 1.62 | 1.68 | 1.72 | 1.75 | 1.77 | 1.79 |
| | 24 | 1.15 | 1.19 | 1.25 | 1.31 | 1.37 | 1.43 | 1.48 | 1.54 | 1.60 | 1.65 | 1.71 | 1.76 | 1.86 | 1.95 | 2.04 | 2.11 | 2.17 | 2.23 | 2.29 | 2.33 | 2.35 | 2.37 |
| | 25 | 1.44 | 1.52 | 1.59 | 1.67 | 1.74 | 1.81 | 1.88 | 1.95 | 2.02 | 2.09 | 2.16 | 2.22 | 2.34 | 2.45 | 2.55 | 2.64 | 2.74 | 2.81 | 7.87 | 2.90 | 2.92 | 2.96 |
| | 26 | 1.76 | 1.84 | 1.93 | 2.02 | 2.10 | 2.18 | 2.25 | 2.33 | 2.41 | 2.49 | 2.56 | 2.64 | 2.78 | 2.91 | 3.03 | 3.15 | 3.26 | 3.37 | 3.47 | 3.55 | 3.62 | 3.60 |
| | 27 | 2.07 | 2.16 | 2.26 | 2.36 | 2.46 | 2.56 | 2.65 | 2.74 | 2.83 | 2.91 | 3.00 | 3.07 | 3.24 | 3.39 | 3.55 | 3.69 | 3.82 | 3.94 | 4.04 | 4.14 | 4.23 | 4.30 |
| | 28 | 2.39 | 2.51 | 2.63 | 2.74 | 2.85 | 2.96 | 3.06 | 3.16 | 3.28 | 3.38 | 3.48 | 3.57 | 3.75 | 3.92 | 4.08 | 4.23 | 4.37 | 4.51 | 4.62 | 4.73 | 4.80 | 4.86 |
| | 29 | 2.74 | 2.86 | 2.97 | 3.09 | 3.22 | 3.34 | 3.46 | 3.57 | 3.69 | 3.90 | 3.90 | 4.00 | 4.20 | 4.39 | 4.58 | 4.74 | 4.90 | 5.05 | 5.19 | 5.31 | 5.40 | 5.48 |
| | 30 | 3.06 | 3.21 | 3.35 | 3.50 | 3.63 | 3.77 | 3.91 | 4.02 | 4.15 | 4.28 | 4.40 | 4.52 | 4.75 | 4.96 | 5.16 | 5.35 | 5.52 | 5.67 | 5.79 | 5.91 | 5.99 | 6.04 |

*Note:* This table can be used to convert the density $d_{20}^{t}$ to $d_{20}^{20}$

TABLE VII

Temperature corrections, c, required for the density of liqueur wines, measured using an ordinary-glass pycnometer or hydromete at t °C, in order to correct to 20 °C

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | 13% vol. wines | | | | | | | 15% vol. wines | | | | | | | 17% vol. wines | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Density | | | | | | | Density | | | | | | | Density | | | | | | |
| | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 2.24 | 2.58 | 2.93 | 3.27 | 3.59 | 3.89 | 4.18 | 2.51 | 2.85 | 3.20 | 3.54 | 3.85 | 4.02 | 4.46 | 2.81 | 3.15 | 3.50 | 3.84 | 4.15 | 4.45 | 4.74 |
| | 11 | 2.06 | 2.37 | 2.69 | 2.97 | 3.26 | 3.53 | 3.78 | 2.31 | 2.61 | 2.93 | 3.21 | 3.51 | 3.64 | 4.02 | 2.57 | 2.89 | 3.20 | 3.49 | 3.77 | 4.03 | 4.28 |
| | 12 | 1.87 | 2.14 | 2.42 | 2.67 | 2.94 | 3.17 | 3.40 | 2.09 | 2.36 | 2.64 | 2.90 | 3.16 | 3.27 | 3.61 | 2.32 | 2.60 | 2.87 | 3.13 | 3.39 | 3.63 | 3.84 |
| | 13 | 1.69 | 1.93 | 2.14 | 2.37 | 2.59 | 2.80 | 3.00 | 1.88 | 2.12 | 2.34 | 2.56 | 2.78 | 2.88 | 3.19 | 2.09 | 2.33 | 2.55 | 2.77 | 2.98 | 3.19 | 3.39 |
| | 14 | 1.49 | 1.70 | 1.90 | 2.09 | 2.27 | 2.44 | 2.61 | 1.67 | 1.86 | 2.06 | 2.25 | 2.45 | 2.51 | 2.77 | 1.83 | 2.03 | 2.23 | 2.42 | 2.61 | 2.77 | 2.94 |
| | 15 | 1.25 | 1.42 | 1.59 | 1.75 | 1.90 | 2.05 | 2.19 | 1.39 | 1.56 | 1.72 | 1.88 | 2.03 | 2.11 | 2.32 | 1.54 | 1.71 | 1.87 | 2.03 | 2.18 | 2.32 | 2.47 |
| | 16 | 1.03 | 1.17 | 1.30 | 1.43 | 1.55 | 1.67 | 1.78 | 1.06 | 1.27 | 1.40 | 1.53 | 1.65 | 1.77 | 1.88 | 1.25 | 1.39 | 1.52 | 1.65 | 1.77 | 1.89 | 2.00 |
| | 17 | 0,80 | 0.90 | 1.00 | 1.09 | 1.17 | 1.27 | 1.36 | 0.87 | 0.98 | 1.08 | 1.17 | 1.26 | 1.35 | 1.44 | 0.96 | 1.06 | 1.16 | 1.26 | 1.35 | 1.44 | 1.52 |
| | 18 | 0.54 | 0.61 | 0.68 | 0.75 | 0,81 | 0.86 | 0.92 | 0.60 | 0.66 | 0.73 | 0.80 | 0.85 | 0.91 | 0.97 | 0.66 | 0.72 | 0.79 | 0.86 | 0.92 | 0,97 | 1.03 |
| | 19 | 0.29 | 0.33 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.32 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.51 | 0.35 | 0.38 | 0.41 | 0.45 | 0.48 | 0.51 | 0.53 |
| | 20 | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 0.29 | 0.32 | 0.35 | 0.39 | 0.42 | 0.45 | 0,47 | 0.32 | 0.35 | 0.38 | 0.42 | 0.45 | 0.48 | 0.50 | 0.34 | 0.38 | 0.41 | 0.44 | 0.47 | 0,50 | 0.53 |
| | 22 | 0.57 | 0.64 | 0.70 | 0.76 | 0.82 | 0.88 | 0.93 | 0.63 | 0.69 | 0.75 | 0.81 | 0.87 | 0.93 | 0.99 | 0.68 | 0,75 | 0.81 | 0.87 | 0.93 | 0.99 | 1.04 |
| | 23 | 0.89 | 0,98 | 1.08 | 1.17 | 1.26 | 1.34 | 1.43 | 0,97 | 1.06 | 1.16 | 1.25 | 1.34 | 1.42 | 1.51 | 1.06 | 1.15 | 1.25 | 1.34 | 1.42 | 1.51 | 1.59 |
| | 24 | 1.22 | 1.34 | 1.44 | 1.56 | 1.68 | 1.79 | 1.90 | 1.32 | 1.44 | 1.54 | 1.66 | 1.78 | 1.89 | 2.00 | 1.43 | 1.56 | 1.65 | 1.77 | 1.89 | 2.00 | 2.11 |
| | 25 | 1.61 | 1.68 | 1.83 | 1.98 | 2.12 | 2.26 | 2.40 | 1.66 | 1.81 | 1.96 | 2.11 | 2.25 | 2.39 | 2.52 | 1.80 | 1.94 | 2.09 | 2.24 | 2.39 | 2.52 | 2.66 |
| | 26 | 1.87 | 2.05 | 2.22 | 2.40 | 2.56 | 2.71 | 2.87 | 2.02 | 2.20 | 2.37 | 2.54 | 2.70 | 2.85 | 3.01 | 2.18 | 2.36 | 2.53 | 2.71 | 2.86 | 3.02 | 3.17 |
| | 27 | 2.21 | 2.42 | 2.60 | 2.80 | 3.00 | 3.18 | 3.35 | 2.39 | 2.59 | 2.78 | 2.98 | 3.17 | 3.35 | 3.52 | 2.58 | 2.78 | 2.97 | 3.17 | 3.36 | 3.54 | 3.71 |
| | 28 | 2.56 | 2.80 | 3.02 | 3.25 | 3.47 | 3.67 | 3.89 | 2.75 | 2.89 | 3.22 | 3.44 | 3.66 | 3.96 | 4.07 | 2.97 | 3.21 | 3.44 | 3.66 | 3.88 | 4.09 | 4.30 |
| | 29 | 2.93 | 3.19 | 3.43 | 3.66 | 3.91 | 4.14 | 4.37 | 3.16 | 3.41 | 3.65 | 3.89 | 4.13 | 4.36 | 4.59 | 3.40 | 3.66 | 3.89 | 4.13 | 4.38 | 4.61 | 4.82 |
| Temperature in °C | 30 | 3.31 | 3.57 | 3.86 | 4.15 | 4.41 | 4.66 | 4.92 | 3.55 | 3.81 | 4.10 | 4.38 | 4.66 | 4.90 | 5.16 | 3.82 | 4.08 | 4.37 | 4.65 | 4.93 | 5.17 | 5.42 |

TABLE VII (continued)

Temperature corrections, c, required for the density of liqueur wines, measured using an ordinary-glass pycnometer or hydrometer at °C, in order to correct to 20 °C.

$$\rho_{20} = \rho_t \pm \frac{c}{1000}$$

- if t°C is lower than 20°C

+ if t°C is higher than 20°C

| | 19% vol. wines | | | | | | | 21% vol. wines | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Density | | | | | | | Density | | | | | | |
| | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 | 1.000 | 1.020 | 1.040 | 1.060 | 1.080 | 1.100 | 1.120 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature in °C | 10 | 3.14 | 3.48 | 3.83 | 4.17 | 4.48 | 4.78 | 5.07 | 3.50 | 3.84 | 4.19 | 4.52 | 4.83 | 5.12 | 5.41 |
| | 11 | 2.87 | 3.18 | 3.49 | 3.78 | 4.06 | 4.32 | 4.57 | 3.18 | 3.49 | 3.80 | 4.09 | 4.34 | 4.63 | 4.88 |
| | 12 | 2.58 | 2.96 | 3.13 | 3.39 | 3.65 | 3.88 | 4.10 | 2.86 | 3.13 | 3.41 | 3.67 | 3.92 | 4.15 | 4.37 |
| | 13 | 2.31 | 2.55 | 2.77 | 2.99 | 3.20 | 3.41 | 3.61 | 2.56 | 2.79 | 3.01 | 3.23 | 3.44 | 3.65 | 3.85 |
| | 14 | 2.03 | 2.23 | 2.43 | 2.61 | 2.80 | 2.96 | 3.13 | 2.23 | 2.43 | 2.63 | 2.81 | 3.00 | 3.16 | 3.33 |
| | 15 | 1.69 | 1.86 | 2.02 | 2.18 | 2.33 | 2.48 | 2.62 | 1.86 | 2.03 | 2.19 | 2.35 | 2.50 | 2.65 | 2.80 |
| | 16 | 1.38 | 1.52 | 1.65 | 1.78 | 1.90 | 2.02 | 2.13 | 1.51 | 1.65 | 1.78 | 1.91 | 2.03 | 2.15 | 2.26 |
| | 17 | 1.06 | 1.16 | 1.26 | 1 .35 | 1.44 | 1.53 | 1.62 | 1.15 | 1.25 | 1.35 | 1.45 | 1.54 | 1.63 | 1.71 |
| | 18 | 0,73 | 0.79 | 0.85 | 0.92 | 0.98 | 1.03 | 1.09 | 0.79 | 0.85 | 0.92 | 0.98 | 1.05 | 1.10 | 1.15 |
| | 19 | 0.38 | 0.41 | 0.44 | 0.48 | 0.51 | 0.52 | 0.56 | 0.41 | 0.44 | 0.47 | 0.51 | 0.54 | 0.57 | 0.59 |
| | 20 | | | | | | | | | | | | | | |
| | 21 | 0.37 | 0.41 | 0.44 | 0.47 | 0.50 | 0.53 | 0.56 | 0.41 | 0.44 | 0.47 | 0.51 | 0.54 | 0.57 | 0.59 |
| | 22 | 0.75 | 0.81 | 0.87 | 0.93 | 0.99 | 1.04 | 1.10 | 0.81 | 0.88 | 0.94 | 1.00 | 1.06 | 1.10 | 1.17 |
| | 23 | 1.15 | 1.30 | 1.34 | 1.43 | 1.51 | 1.60 | 1.68 | 1.25 | 1.34 | 1.44 | 1.63 | 1.61 | 1.70 | 1.78 |
| | 24 | 1.55 | 1.67 | 1.77 | 1.89 | 2.00 | 2.11 | 2.23 | 1.68 | 1.80 | 1.90 | 2.02 | 2.13 | 2.25 | 2.36 |
| | 25 | 1.95 | 2.09 | 2.24 | 2.39 | 2.53 | 2.67 | 2.71 | 2.11 | 2.25 | 2.40 | 2.55 | 2.69 | 2.83 | 2.97 |
| | 26 | 2.36 | 2.54 | 2.71 | 2.89 | 3.04 | 3.20 | 3.35 | 2.55 | 2.73 | 2.90 | 3.07 | 3.22 | 3.38 | 3.54 |
| | 27 | 2.79 | 2.99 | 3.18 | 3.38 | 3.57 | 3.75 | 3.92 | 3.01 | 3.20 | 3.40 | 3.59 | 3.78 | 3.96 | 4.13 |
| | 28 | 3.20 | 3.44 | 3.66 | 3.89 | 4.11 | 4.32 | 4.53 | 3.46 | 3.69 | 3.93 | 4.15 | 4.36 | 4.58 | 4.77 |
| | 29 | 3.66 | 3.92 | 4.15 | 4.40 | 4.64 | 4.87 | 5.08 | 3.95 | 4.20 | 4.43 | 4.68 | 4.92 | 5.15 | 5.36 |
| | 30 | 4.11 | 4.37 | 4.66 | 4.94 | 5.22 | 5.46 | 5.71 | 4.42 | 4.68 | 4.97 | 5.25 | 5.53 | 5.77 | 6.02 |

Annex II

***Comparison of results for the methods of measurement of density using a frequency oscillator (Method B) and using a hydrostatic balance (Method C)***

Using samples with densities between 0.992 and 1.012 g/cm$^3$, the repeatability and reproducibility were measured using an inter-laboratory test. The densities of the different samples as measured using a hydrostatic balance and using electronic densimetry were compared, including the repeatability and reproducibility values derived from the multi-year inter-comparison tests performed on a large scale.

**1. Samples**

Wines with different densities and alcoholic strengths prepared monthly on an industrial scale, taken from a stock of bottles stored under normal conditions, and supplied anonymously to the laboratories.

**2. Laboratories**

Laboratories participating in the monthly tests organised by *Unione Italiana Vini* (Verona, Italy) according to ISO 5725 (UNI 9225) regulations and the International Harmonized Protocol for the Proficiency Testing of Analytical Chemical Laboratories produced by the AOAC, ISO and IUPAC, and ISO 43 and ILAC G13 guidelines. An annual report is provided by the above-mentioned organisation to all participants.

**3. Apparatus**

1. An electronic hydrostatic balance (with precision to 5 decimal places), equipped if possible with a data-processing device.
2. An electronic densimeter, equipped if possible with an autosampler.

**4. Analyses**

According to the rules for the validation of methods of analysis, each sample was analysed twice consecutively to determine the alcoholic strength.

**5. Results**

Table 1 shows the results of the measurements obtained by the laboratories using a hydrostatic balance.

Table 2 shows the results obtained by the laboratories using an electronic densimeter.

**6. Evaluation of results**

1. The test results were examined for evidence of individual systemic error ($p<0.025$) using Cochran's and Grubbs' tests successively, according to the procedures described in the internationally accepted Protocol for the Design, Conduct and

Interpretation of Method-Performance Studies.

6.2. *Repeatability (r) et reproducibility (R)*

Calculations for repeatability (r) and reproducibility (R) as defined by the protocol were carried out on the results remaining after the removal of outliers. When assessing a new method, there is often no validated reference or statutory method to compare precision criteria; 'predicted' levels of precision and therefore used to compare the precision data obtained from collaborative tests. These predicted levels are calculated from the Horwitz formula. Comparison of the test results and the predicted levels give an indication as to whether the method is sufficiently precise for the level of analyte being measured. The Horwitz predicted value is calculated from the Horwitz equation.

$$RSD_R = 2^{(1-0.5\ logC)}$$

where C is the measured concentration of analyte expressed as a decimal (e.g. 1 g/100 g = 0.01).

The Horrat value gives a comparison of the actual precision measured with the precision predicted by the Horwitz formula for the method and at the particular level of concentration of the analyte. It is calculated as follows:

HoR = $RSD_R$(measured)/$RSD_R$(Horwitz)

6.3 *Inter-laboratory reproducibility*

A Horrat value of 1 usually indicates satisfactory reproducibility, whereas a value of more than 2 usually indicates unsatisfactory reproducibility, i.e. reproducibility that is too variable for analytical purposes or where the variation obtained is greater than that predicted for the type of method employed. Hor is also calculated and used to measure intra-laboratory reproducibility, using the following approximation:

$RSD_r$(Horwitz) = 0.66 $RSD_R$(Horwitz) (this assumes the approximation that r = 0.66 R)

CrD95 is the critical difference for a 95% probability level. It is calculated according to Resolution OIV-MA-AS1-08.

Table 3 shows the differences between the measurements obtained by laboratories using an electronic densimeter and those using a hydrostatic balance.

6.4 *Precision parameters*

Table 4 shows the overall averages for the precision parameters calculated from all monthly tests carried out between January 2008 and December 2010

Table 1: Results obtained by laboratories that conducted tests using a hydrostatic balance (HB)

| Sample | Average | Total no. of values | No. of selected values | Repeatability | $s_r$ | $RSD_r$ | Hor | Reproducibility | $s_R$ | RSDRcalc | HoR | No. of repet. | CrD95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01/08 | 0.995491 | 130 | 120 | 0.0001701 | 0.0000607 | 0.0061016 | 0.0046193 | 0.0005979 | 0.0002135 | 0.0214502 | 0.0107178 | 2 | 0.0004141 |
| 02/08 | 1.011475 | 146 | 125 | 0.0004714 | 0.0001684 | 0.0166457 | 0.0126320 | 0.0008705 | 0.0003109 | 0.0307366 | 0.0153947 | 2 | 0.0005686 |
| 03/08 | 0.992473 | 174 | 161 | 0.0001470 | 0.0000525 | 0.0052898 | 0.0040029 | 0.0004311 | 0.0001540 | 0.0155140 | 0.0077482 | 2 | 0.0002959 |
| 04/08 | 0.993147 | 172 | 155 | 0.0002761 | 0.0000986 | 0.0099274 | 0.0075130 | 0.0005446 | 0.0001945 | 0.0195839 | 0.0097818 | 2 | 0.0003595 |
| 05/08 | 1.004836 | 150 | 138 | 0.0001882 | 0.0000672 | 0.0066905 | 0.0050723 | 0.0007495 | 0.0002677 | 0.0266373 | 0.0133283 | 2 | 0.0005215 |
| 06/08 | 0.993992 | 152 | 136 | 0.0001486 | 0.0000531 | 0.0053391 | 0.0040411 | 0.0005302 | 0.0001894 | 0.0190506 | 0.0095167 | 2 | 0.0003675 |
| 07/08 | 0.992447 | 162 | 150 | 0.0002660 | 0.0000950 | 0.0095709 | 0.0072424 | 0.0006046 | 0.0002159 | 0.0217575 | 0.0108664 | 2 | 0.0004063 |
| 08/08 | 0.992210 | 162 | 151 | 0.0002619 | 0.0000935 | 0.0094281 | 0.0071341 | 0.0006309 | 0.0002253 | 0.0227108 | 0.0113420 | 2 | 0.0004265 |
| 09/08 | 1.002600 | 148 | 131 | 0.0001093 | 0.0000390 | 0.0038920 | 0.0029496 | 0.0007000 | 0.0002500 | 0.0249341 | 0.0124719 | 2 | 0.0004919 |
| 10/08 | 0.994482 | 174 | 152 | 0.0001228 | 0.0000439 | 0.0044105 | 0.0033385 | 0.0004250 | 0.0001518 | 0.0152645 | 0.0076259 | 2 | 0.0002942 |
| 11/08 | 0.992010 | 136 | 125 | 0.0000909 | 0.0000325 | 0.0032742 | 0.0024775 | 0.0004256 | 0.0001520 | 0.0153217 | 0.0076516 | 2 | 0.0002975 |
| 01/09 | 0.994184 | 174 | 152 | 0.0001655 | 0.0000591 | 0.0059435 | 0.0044987 | 0.0005439 | 0.0001942 | 0.0195384 | 0.0097606 | 2 | 0.0003756 |
| 02/09 | 0.992266 | 118 | 101 | 0.0001742 | 0.0000622 | 0.0062682 | 0.0047431 | 0.0005210 | 0.0001861 | 0.0187534 | 0.0093658 | 2 | 0.0003580 |
| 03/09 | 0.991886 | 164 | 135 | 0.0001850 | 0.0000661 | 0.0066603 | 0.0050395 | 0.0004781 | 0.0001707 | 0.0172136 | 0.0085963 | 2 | 0.0003251 |
| 04/09 | 0.993632 | 180 | 150 | 0.0001523 | 0.0000544 | 0.0054754 | 0.0041440 | 0.0004270 | 0.0001525 | 0.0153476 | 0.0076664 | 2 | 0.0002922 |
| 05/09 | 1.011061 | 116 | 100 | 0.0003659 | 0.0001307 | 0.0129234 | 0.0098067 | 0.0008338 | 0.0002978 | 0.0294527 | 0.0147508 | 2 | 0.0005605 |
| 06/09 | 0.992063 | 114 | 105 | 0.0002923 | 0.0001044 | 0.0105238 | 0.0079631 | 0.0005257 | 0.0001877 | 0.0189240 | 0.0094507 | 2 | 0.0003418 |
| 07/09 | 0.992708 | 172 | 155 | 0.0002892 | 0.0001033 | 0.0104040 | 0.0078732 | 0.0006156 | 0.0002199 | 0.0221478 | 0.0110617 | 2 | 0.0004106 |
| 08/09 | 0.993064 | 136 | 127 | 0.0002926 | 0.0001045 | 0.0105224 | 0.0079632 | 0.0007520 | 0.0002686 | 0.0270446 | 0.0135081 | 2 | 0.0005112 |
| 09/09 | 1.005285 | 118 | 110 | 0.0002946 | 0.0001052 | 0.0104661 | 0.0079352 | 0.0007226 | 0.0002581 | 0.0256704 | 0.0128454 | 2 | 0.0004892 |
| 10/09 | 0.992905 | 150 | 132 | 0.0002234 | 0.0000798 | 0.0080358 | 0.0060812 | 0.0004498 | 0.0001607 | 0.0161803 | 0.0080815 | 2 | 0.0002978 |
| 11/09 | 0.994016 | 142 | 127 | 0.0001896 | 0.0000677 | 0.0068114 | 0.0051555 | 0.0004739 | 0.0001693 | 0.0170278 | 0.0085062 | 2 | 0.0003214 |
| 01/10 | 0.994734 | 170 | 152 | 0.0002125 | 0.0000759 | 0.0076288 | 0.0057748 | 0.0005406 | 0.0001931 | 0.0194104 | 0.0096975 | 2 | 0.0003672 |
| 02/10 | 0.993177 | 120 | 110 | 0.0002210 | 0.0000789 | 0.0079467 | 0.0060140 | 0.0005800 | 0.0002071 | 0.0208565 | 0.0104175 | 2 | 0.0003950 |
| 03/10 | 0.992799 | 148 | 136 | 0.0002277 | 0.0000813 | 0.0081923 | 0.0061995 | 0.0015157 | 0.0005413 | 0.0545262 | 0.0272335 | 2 | 0.0010657 |
| 04/10 | 0.995420 | 172 | 157 | 0.0002644 | 0.0000944 | 0.0094866 | 0.0071819 | 0.0006286 | 0.0002245 | 0.0225542 | 0.0112693 | 2 | 0.0004244 |
| 05/10 | 1.002963 | 120 | 108 | 0.0007086 | 0.0002531 | 0.0252330 | 0.0191244 | 0.0013667 | 0.0004881 | 0.0486677 | 0.0243447 | 2 | 0.0008991 |
| 06/10 | 0.992546 | 120 | 113 | 0.0001737 | 0.0000620 | 0.0062506 | 0.0047300 | 0.0005435 | 0.0001941 | 0.0195567 | 0.0097673 | 2 | 0.0003744 |
| 07/10 | 0.992831 | 174 | 152 | 0.0003003 | 0.0001073 | 0.0108031 | 0.0081753 | 0.0006976 | 0.0002492 | 0.0250959 | 0.0125344 | 2 | 0.0004699 |
| 08/10 | 0.993184 | 144 | 130 | 0.0001799 | 0.0000642 | 0.0064674 | 0.0048945 | 0.0005951 | 0.0002125 | 0.0213984 | 0.0106882 | 2 | 0.0004111 |
| 09/10 | 1.012293 | 114 | 103 | 0.0002265 | 0.0000809 | 0.0079907 | 0.0060647 | 0.0014586 | 0.0005209 | 0.0514596 | 0.0257772 | 2 | 0.0010251 |
| 10/10 | 0.992289 | 154 | 136 | 0.0006386 | 0.0002281 | 0.0229860 | 0.0173933 | 0.0007033 | 0.0002512 | 0.0253124 | 0.0126415 | 2 | 0.0003812 |
| 11/10 | 0.994649 | 130 | 112 | 0.0002902 | 0.0001036 | 0.0104200 | 0.0078876 | 0.0005287 | 0.0001888 | 0.0189830 | 0.0094838 | 2 | 0.0003445 |

Table 2: Results obtained by laboratories that conducted tests using an electronic densimeter (ED)

| Sample | Average | Total no. of values | No. of selected values | Repeatability | $s_r$ | $RSD_r$ | Hor | Reproducibility | $s_R$ | RSDRcalc | HoR | No. of repet. | CrD95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01/08 | 0.995504 | 114 | 108 | 0.0000755 | 0.0000270 | 0.0027085 | 0.0020505 | 0.0001571 | 0.0000561 | 0.0056361 | 0.0028162 | 2 | 0.0001045 |
| 02/08 | 1.011493 | 132 | 125 | 0.0001921 | 0.0000686 | 0.0067837 | 0.0051480 | 0.0004435 | 0.0001584 | 0.0156582 | 0.0078426 | 2 | 0.0002985 |
| 03/08 | 0.992491 | 138 | 118 | 0.0000746 | 0.0000266 | 0.0026830 | 0.0020303 | 0.0002745 | 0.0000980 | 0.0098776 | 0.0049332 | 2 | 0.0001905 |
| 04/08 | 0.993129 | 132 | 120 | 0.0001230 | 0.0000439 | 0.0044247 | 0.0033486 | 0.0002863 | 0.0001023 | 0.0102965 | 0.0051429 | 2 | 0.0001929 |
| 05/08 | 1.004892 | 136 | 116 | 0.0000926 | 0.0000331 | 0.0032893 | 0.0024937 | 0.0004777 | 0.0001706 | 0.0169785 | 0.0084955 | 2 | 0.0003346 |
| 06/08 | 0.994063 | 142 | 123 | 0.0000558 | 0.0000199 | 0.0020051 | 0.0015177 | 0.0001776 | 0.0000634 | 0.0063791 | 0.0031867 | 2 | 0.0001224 |
| 07/08 | 0.992498 | 136 | 125 | 0.0000822 | 0.0000294 | 0.0029576 | 0.0022381 | 0.0002094 | 0.0000748 | 0.0075368 | 0.0037641 | 2 | 0.0001423 |
| 08/08 | 0.992270 | 130 | 115 | 0.0000515 | 0.0000184 | 0.0018537 | 0.0014027 | 0.0001665 | 0.0000595 | 0.0059940 | 0.0029935 | 2 | 0.0001149 |
| 09/08 | 1.002603 | 136 | 121 | 0.0000821 | 0.0000293 | 0.0029236 | 0.0022157 | 0.0003328 | 0.0001189 | 0.0118565 | 0.0059306 | 2 | 0.0002318 |
| **10/08** | **0.994493** | **128** | **117** | **0.0000667** | **0.0000238** | **0.0023954** | **0.0018132** | **0.0001429** | **0.0000510** | **0.0051309** | **0.0025633** | **2** | **0.0000954** |
| 11/08 | 0.992017 | 118 | 104 | 0.0000842 | 0.0000301 | 0.0030309 | 0.0022933 | 0.0001962 | 0.0000701 | 0.0070644 | 0.0035279 | 2 | 0.0001322 |
| 01/09 | 0.994216 | 148 | 131 | 0.0000830 | 0.0000297 | 0.0029832 | 0.0022580 | 0.0001551 | 0.0000554 | 0.0055712 | 0.0027832 | 2 | 0.0001015 |
| 02/09 | 0.992251 | 104 | 88 | 0.0000947 | 0.0000338 | 0.0034097 | 0.0025801 | 0.0002846 | 0.0001017 | 0.0102451 | 0.0051165 | 2 | 0.0001956 |
| 03/09 | 0.991875 | 126 | 108 | 0.0001271 | 0.0000454 | 0.0045777 | 0.0034637 | 0.0002067 | 0.0000738 | 0.0074421 | 0.0037165 | 2 | 0.0001316 |
| 04/09 | 0.993654 | 134 | 114 | 0.0001166 | 0.0000416 | 0.0041899 | 0.0031711 | 0.0002043 | 0.0000730 | 0.0073417 | 0.0036673 | 2 | 0.0001322 |
| 05/09 | 1.011035 | 128 | 104 | 0.0002388 | 0.0000853 | 0.0084361 | 0.0064016 | 0.0003554 | 0.0001269 | 0.0125542 | 0.0062875 | 2 | 0.0002211 |
| 06/09 | 0.992104 | 116 | 106 | 0.0001005 | 0.0000359 | 0.0036178 | 0.0027375 | 0.0003169 | 0.0001132 | 0.0114088 | 0.0056976 | 2 | 0.0002184 |
| 07/09 | 0.992720 | 144 | 140 | 0.0001579 | 0.0000564 | 0.0056815 | 0.0042995 | 0.0002916 | 0.0001042 | 0.0104923 | 0.0052404 | 2 | 0.0001905 |
| 08/09 | 0.993139 | 110 | 102 | 0.0001175 | 0.0000420 | 0.0042242 | 0.0031969 | 0.0003603 | 0.0001287 | 0.0129577 | 0.0064721 | 2 | 0.0002479 |
| 09/09 | 1.005276 | 112 | 108 | 0.0001100 | 0.0000393 | 0.0039070 | 0.0029622 | 0.0003522 | 0.0001258 | 0.0125134 | 0.0062617 | 2 | 0.0002429 |
| 10/09 | 0.992912 | 122 | 111 | 0.0000705 | 0.0000252 | 0.0025365 | 0.0019195 | 0.0002122 | 0.0000758 | 0.0076315 | 0.0038117 | 2 | 0.0001458 |
| 11/09 | 0.994031 | 128 | 118 | 0.0000718 | 0.0000256 | 0.0025784 | 0.0019516 | 0.0001639 | 0.0000585 | 0.0058883 | 0.0029415 | 2 | 0.0001102 |
| 01/10 | 0.994752 | 144 | 136 | 0.0000773 | 0.0000276 | 0.0027765 | 0.0021017 | 0.0001787 | 0.0000638 | 0.0064144 | 0.0032046 | 2 | 0.0001203 |
| 02/10 | 0.993181 | 108 | 98 | 0.0001471 | 0.0000525 | 0.0052893 | 0.0040029 | 0.0001693 | 0.0000605 | 0.0060884 | 0.0030410 | 2 | 0.0000945 |
| 03/10 | 0.992665 | 140 | 127 | 0.0001714 | 0.0000612 | 0.0061683 | 0.0046678 | 0.0002378 | 0.0000849 | 0.0085559 | 0.0042732 | 2 | 0.0001447 |
| 04/10 | 0.995502 | 142 | 128 | 0.0001175 | 0.0000419 | 0.0042138 | 0.0031901 | 0.0002320 | 0.0000829 | 0.0083248 | 0.0041596 | 2 | 0.0001532 |
| 05/10 | 1.002851 | 130 | 119 | 0.0001195 | 0.0000427 | 0.0042555 | 0.0032253 | 0.0002971 | 0.0001061 | 0.0105815 | 0.0052930 | 2 | 0.0002014 |
| 06/10 | 0.992607 | 106 | 99 | 0.0001228 | 0.0000438 | 0.0044172 | 0.0033427 | 0.0002226 | 0.0000795 | 0.0080092 | 0.0040001 | 2 | 0.0001449 |
| 07/10 | 0.992871 | 160 | 150 | 0.0001438 | 0.0000513 | 0.0051712 | 0.0039134 | 0.0003732 | 0.0001333 | 0.0134258 | 0.0067057 | 2 | 0.0002539 |
| 08/10 | 0.993235 | 104 | 93 | 0.0000895 | 0.0000320 | 0.0032182 | 0.0024356 | 0.0002458 | 0.0000878 | 0.0088399 | 0.0044154 | 2 | 0.0001680 |
| 09/10 | 1.012328 | 112 | 105 | 0.0000870 | 0.0000311 | 0.0030692 | 0.0023295 | 0.0003395 | 0.0001213 | 0.0119781 | 0.0060001 | 2 | 0.0002361 |
| 10/10 | 0.992308 | 128 | 115 | 0.0000606 | 0.0000216 | 0.0021811 | 0.0016504 | 0.0001635 | 0.0000584 | 0.0058845 | 0.0029388 | 2 | 0.0001116 |
| 11/10 | 0.994683 | 120 | 108 | 0.0001127 | 0.0000402 | 0.0040450 | 0.0030620 | 0.0001597 | 0.0000570 | 0.0057339 | 0.0028647 | 2 | 0.0000979 |

Table 3: Comparison of results from the hydrostatic balance (BH) and from the electronic densimeter (ED)

| Density – Hydrostatic balance | Density – Frequency oscillator | Comparison |
|---|---|---|

| Sample | Average value | Total values | Selected values | Sample | Average value | Total values | Selected values | Δ(BH-DE) |
|---|---|---|---|---|---|---|---|---|
| 01/08 | 0.995491 | 130 | 120 | 01/08 | 0.995504 | 114 | 108 | -0.000013 |
| 02/08 | 1.011475 | 146 | 125 | 02/08 | 1.011493 | 132 | 125 | -0.000018 |
| 03/08 | 0.992473 | 174 | 161 | 03/08 | 0.992491 | 138 | 118 | -0.000018 |
| 04/08 | 0.993147 | 172 | 155 | 04/08 | 0.993129 | 132 | 120 | 0.000018 |
| 05/08 | 1.004836 | 150 | 138 | 05/08 | 1.004892 | 136 | 116 | -0.000056 |
| 06/08 | 0.993992 | 152 | 136 | 06/08 | 0.994063 | 142 | 123 | -0.000071 |
| 07/08 | 0.992447 | 162 | 150 | 07/08 | 0.992498 | 136 | 125 | -0.000051 |
| 08/08 | 0.992210 | 162 | 151 | 08/08 | 0.992270 | 130 | 115 | -0.000060 |
| 09/08 | 1.002600 | 148 | 131 | 09/08 | 1.002603 | 136 | 121 | -0.000003 |
| 10/08 | 0.994482 | 174 | 152 | 10/08 | 0.994493 | 128 | 117 | -0.000011 |
| 11/08 | 0.992010 | 136 | 125 | 11/08 | 0.992017 | 118 | 104 | -0.000007 |
| 01/09 | 0.994184 | 174 | 152 | 01/09 | 0.994216 | 148 | 131 | -0.000031 |
| 02/09 | 0.992266 | 118 | 101 | 02/09 | 0.992251 | 104 | 88 | 0.000015 |
| 03/09 | 0.991886 | 164 | 135 | 03/09 | 0.991875 | 126 | 108 | 0.000011 |
| 04/09 | 0.993632 | 180 | 150 | 04/09 | 0.993654 | 134 | 114 | -0.000022 |
| 05/09 | 1.011061 | 116 | 100 | 05/09 | 1.011035 | 128 | 104 | 0.000026 |
| 06/09 | 0.992063 | 114 | 105 | 06/09 | 0.992104 | 116 | 106 | -0.000041 |
| 07/09 | 0.992708 | 172 | 155 | 07/09 | 0.992720 | 144 | 140 | -0.000012 |
| 08/09 | 0.993064 | 136 | 127 | 08/09 | 0.993139 | 110 | 102 | -0.000075 |
| 09/09 | 1.005285 | 118 | 110 | 09/09 | 1.005276 | 112 | 108 | 0.000009 |
| 10/09 | 0.992905 | 150 | 132 | 10/09 | 0.992912 | 122 | 111 | -0.000008 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11/09 | 0.994016 | 142 | 127 | 11/09 | 0.994031 | 128 | 118 | -0.000015 |
| 01/10 | 0.994734 | 170 | 152 | 01/10 | 0.994752 | 144 | 136 | -0.000018 |
| 02/10 | 0.993177 | 120 | 110 | 02/10 | 0.993181 | 108 | 98 | -0.000005 |
| 03/10 | 0.992799 | 148 | 136 | 03/10 | 0.992665 | 140 | 127 | 0.000134 |
| 04/10 | 0.995420 | 172 | 157 | 04/10 | 0.995502 | 142 | 128 | -0.000082 |
| 05/10 | 1.002963 | 120 | 108 | 05/10 | 1.002851 | 130 | 119 | 0.000112 |
| 06/10 | 0.992546 | 120 | 113 | 06/10 | 0.992607 | 106 | 99 | -0.000061 |
| 07/10 | 0.992831 | 174 | 152 | 07/10 | 0.992871 | 160 | 150 | -0.000040 |
| 08/10 | 0.993184 | 144 | 130 | 08/10 | 0.993235 | 104 | 93 | -0.000052 |
| 09/10 | 1.012293 | 114 | 103 | 09/10 | 1.012328 | 112 | 105 | -0.000035 |
| 10/10 | 0.992289 | 154 | 136 | 10/10 | 0.992308 | 128 | 115 | -0.000019 |
| 11/10 | 0.994649 | 130 | 112 | 11/10 | 0.994683 | 120 | 108 | -0.000035 |
| | | | | | | average | Δ(BH-DE) | -0.0000162 |
| | | | | | | standard deviation | Δ(BH-DE) | 0.0000447 |

Table 4: Precision parameters

| | *Hydrostatic balance (BH)* | *Electronic densimeter (ED)* |
|---|---|---|
| No. of selected values | 4347 | 3800 |
| min | 0.99189 g/cm$^3$ | 0.99187 g/cm$^3$ |
| max | 1.01229 g/cm$^3$ | 1.01233 g/cm$^3$ |
| R | 0.00067 g/cm$^3$ | 0.00025 g/cm$^3$ |
| $s_R$ | 0.00024 g/cm$^3$ | 0.000091 g/cm$^3$ |

| | | |
|---|---|---|
| R% | 0.067% | 0.025% |
| r | 0.00025 g/cm$^3$ | 0.00011 g/cm$^3$ |
| $s_r$ | 0.000090 g/cm$^3$ | 0.000038 g/cm$^3$ |
| r% | 0.025% | 0.011% |

*Key:*
*n*: *number of selected values*
*min: lower limit of the measurement range*
*max: upper limit of the measurement range*
*r: repeatability*
*$s_r$: repeatability standard deviation*
*r%: relative repeatability (r x 100 / average value)*
*R: reproducibility*
*$s_R$: reproducibility standard deviation*
*R%: relative reproducibility (R x 100 / average value)*

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