



SLOVENSKI STANDARD

SIST ISO 649-2:1995

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Laboratorijska steklovina - Gostotni hidrometri za splošno uporabo - 2. del: Preskusne metode in uporaba

Laboratory glassware -- Density hydrometers for general purposes -- Part 2: Test methods and use

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Verrerie de laboratoire -- Aréomètres à masse volumique d'usage général -- Partie 2:
Méthodes d'essai et d'utilisation

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International Standard



649/2

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Laboratory glassware — Density hydrometers for general purposes — Part 2 : Test methods and use

Verrerie de laboratoire — Aréomètres à masse volumique d'usage général — Partie 2 : Méthodes d'essai et d'utilisation

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 649/2 was developed by Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus*, and was circulated to the member bodies in September 1979.

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It has been approved by the member bodies of the following countries :

Australia	India	Portugal
Brazil	Italy	Romania
Canada	Korea, Rep. of	South Africa, Rep. of
Czechoslovakia	Libyan Arab Jamahiriya	Spain
France	Mexico	United Kingdom
Germany, F.R.	Netherlands	USSR
Hungary	Poland	

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No member body expressed disapproval of the document.

International Standards ISO 649/1 and ISO 649/2 cancel and replace ISO Recommendation R 649-1968, of which they constitute a technical revision.

Laboratory glassware — Density hydrometers for general purposes — Part 2 : Test methods and use

1 Scope and field of application

This part of ISO 649 specifies the test methods and use of density hydrometers for general purposes.

Part 1 of this International Standard gives the specification for density hydrometers for general purposes.

2 References

ISO 91/1, *Petroleum measurement tables — Part 1 : Tables based on reference temperatures of 15 °C and 60 °F.*¹⁾

ISO 649/1, *Laboratory glassware — Density hydrometers for general purposes — Part 1 : Specification.*

ISO 650, *Relative density 60/60 degrees F hydrometers for general purposes.*

ISO 653, *Long solid-stem thermometers for precision use.*

ISO 654, *Short solid-stem thermometers for precision use.*

ISO 655, *Long enclosed-scale thermometers for precision use.*

ISO 656, *Short enclosed-scale thermometers for precision use.*

ISO 3507, *Pyknometers.*

ISO 4788, *Laboratory glassware — Graduated measuring cylinders.*

3 Methods of determination of density by means of ISO hydrometers

3.1 General

To obtain the highest precision when using a particular hydrometer, the following general procedures should be

adhered to :

3.1.1 Read the hydrometer in the liquid at a known temperature.

3.1.2 Apply corrections (when significant) to the observed reading for :

a) the meniscus height (if the test liquid is opaque see 3.6.1);

b) the scale error of the hydrometer at the observed reading (see 3.6.2);

c) the difference between the temperature of the liquid and the standard temperature of the hydrometer (see 3.6.3);

d) the difference between the surface tension of the liquid and that for which the hydrometer is graduated (see 3.6.4).

3.2 Apparatus

3.2.1 Hydrometer

Select a hydrometer appropriate to the surface tension of the liquid to be examined. Table 3 of ISO 649/1 gives a guide to the range of liquids suitable for the appropriate hydrometer category. Surface tensions of other liquids may be obtained from appropriate tables of physical properties of substances, for example "International Critical Tables".

3.2.2 Hydrometer vessel

Select a hydrometer vessel as described in clause 6.

3.2.3 Thermometer

For high precision work, select a total immersion thermometer graduated in 0,1 °C, with a certificate of scale correction. A thermometer complying with ISO 653, ISO 654, ISO 655 or ISO 656 is suitable.

1) At present at the stage of draft. (Revision of ISO/R 91 and its Addendum 1.)

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3.3 Preliminaries

3.3.1 Clean all apparatus before use.

3.3.2 Allow the liquid to attain thermal equilibrium with its surroundings and pour it into the hydrometer vessel, allowing a small quantity to overflow if an overflow vessel is used. Avoid the formation of air bubbles in the liquid by pouring down the side of the vessel. Stir the liquid vertically with a loop stirrer, again avoiding the formation of bubbles. Record the temperature of the liquid to the nearest 0,2 °C.

3.3.3 Insert the hydrometer carefully into the liquid, holding it by the top of its stem. Release the hydrometer when it is approximately in its position of equilibrium and, if an overflow vessel is used, add a further amount of sample to the vessel by way of the filling tube until a volume approximately equal to 15 % of the nominal capacity has overflowed. A little experience soon enables the user to appreciate when the hydrometer is approaching equilibrium and to release it in such a position that the hydrometer rises or falls by only a small amount when released. This is important with viscous liquids, for otherwise excess liquid will adhere to the stem and the hydrometer will thereby be weighted down.

3.3.4 When the hydrometer is steady, press the top of the stem downwards a few millimetres beyond the position of equilibrium or, if the liquid is viscous, only one scale division, gripping the stem very lightly with a finger and thumb. Withdraw the hand and observe the meniscus as the hydrometer oscillates to equilibrium. If the stem and liquid surface are clean, the meniscus shape will remain unchanged as the hydrometer rises and falls. If the meniscus shape changes, for example if it wrinkles or is distorted by the motion of the hydrometer, lack of cleanliness is indicated and the hydrometer and vessel shall be cleaned and the test repeated with a fresh sample. This precaution becomes increasingly important with increasing surface tension of the liquid.

3.4 Reading the hydrometer

When the hydrometer, which must not be touching the side of the vessel, has settled down to its equilibrium position (in the case of viscous liquids this may take some time), record the reading as follows.

3.4.1 Transparent liquids

Record the scale reading corresponding to the plane of intersection of the horizontal liquid surface and the stem. When taking the reading, view the scale through the liquid, adjusting the line of sight so that it is in the plane of the liquid surface.

3.4.2 Opaque liquids

Record the scale reading where the meniscus merges into the stem of the hydrometer.

3.5 Reading of temperature

Immediately after taking the reading, measure the temperature of the liquid to the nearest 0,2 °C. The mean of this temperature and the initial temperature referred to in 3.3.2 shall be used in the calculation of corrections (3.6).

NOTE — This is particularly important in the case of liquids having high values of coefficient of cubical thermal expansion.

The difference between the two temperatures shall not exceed 1 °C and, if a larger difference is found, lack of thermal equilibrium is indicated and the procedure shall be repeated from 3.3.2.

3.6 Application of the corrections

3.6.1 Meniscus height

In cases where a hydrometer adjusted for readings taken at the level of the horizontal liquid surface has been read in an opaque liquid (i.e. at the line where the liquid merges into the stem of the hydrometer), it is necessary to correct the reading for the meniscus height by adding the appropriate value from table 3 or 4.

3.6.2 Instrument error

By "instrument error" is meant the difference between the reading of the hydrometer and the reading of a similar but ideal hydrometer used under precisely the same conditions. If known, the corrections for instrument error may be applied with equal validity under all conditions of use. It is, however, additional to other corrections, for example those for temperature and surface tension, which vary according to conditions of use. For many purposes it is sufficient to know that the instrument error does not exceed the maximum error permitted by clause 13 of ISO 649/1. Where greater accuracy is required, the instrument error should be known and allowed for.

In this case the hydrometer shall be tested. The linear dimension shall be checked with suitable graduated metal scales and outside micrometer calipers to verify that they comply with the requirements of clause 12 of ISO 649/1.

a) The scale of a hydrometer of the L20, L50 and L50SP series shall be calibrated on at least five points within the nominal limits, which shall include at least 80 % of the graduated interval of the scale.

Neither of the extreme points shall be further from the nearest end of the graduated scale than a distance equal to 15 % of the graduated scale.

No two adjacent points shall be further apart than a distance equal to 25 % of the graduated scale.

b) The scale of hydrometers of all other series shall be calibrated in a similar way following the same order as in a) but at three points, which shall include at least 60 % of the graduated interval of the scale.

Neither of the extreme points shall be further from the nearest end of the graduated scale than a distance equal to 25 % of the graduated scale.

No two adjacent points shall be further apart than a distance of 50 % of the graduated scale.

When the scale is tested, it shall be verified that the scale has not shifted since manufacture, and the hydrometer shall be examined subsequently, from time to time, to ascertain that there has been no displacement of the scale.

Alternatively, testing the hydrometer at one point will serve the same purpose.

3.6.3 Temperature correction

If the hydrometer reading is taken at a temperature other than the reference temperature for the hydrometer, then the reading will be in error due to the change in volume of the hydrometer between the two temperatures.

Appropriate corrections making allowance for this temperature effect are given in table 1. When positive in sign the temperature correction given is to be added to, and when

negative subtracted from, the hydrometer reading at the temperature in question. The table has been computed using a nominal coefficient of cubical thermal expansion of the glass of the hydrometer having a value of $25 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$.

3.6.4 Surface tension correction

Attention has already been drawn to the fact that the reading of a hydrometer depends to some extent on the surface tension of the liquid in which it is used. In general it is possible, by choosing a hydrometer graduated for the most appropriate of the surface tension categories available¹⁾ and having a suitable open scale, to avoid any necessity for surface tension corrections. Table 2 gives an indication of possible errors in the form of corrections which may be applied on account of difference between the surface tension of the liquid and the surface tension for which the hydrometer is adjusted. They relate to hydrometers of average dimensions permitted under this specification¹⁾.

It is important to note that the density obtained by applying this correction is that of the liquid at the temperature of observation. If the density is required at some other temperature, an allowance must be made for the expansion or contraction of the liquid with change of temperature.

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Table 1 — Correction for temperature applicable to hydrometers adjusted for a reference temperature of 20 °C or 15 °C

Unit : kg/m³ or 10⁻³ g/ml

Reference temperature		Reading								
20 °C	15 °C	kg/m ³	600	800	1 000	1 200	1 400	1 600	1 800	2 000
Temperature of liquid, °C		g/ml	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
0	—		+ 0,3	+ 0,4	+ 0,5	+ 0,6	+ 0,7	+ 0,8	+ 0,9	+ 1,0
5	0		+ 0,2	+ 0,3	+ 0,4	+ 0,5	+ 0,5	+ 0,6	+ 0,7	+ 0,8
10	5		+ 0,2	+ 0,2	+ 0,3	+ 0,3	+ 0,4	+ 0,4	+ 0,5	+ 0,5
15	10		+ 0,1	+ 0,1	+ 0,1	+ 0,2	+ 0,2	+ 0,2	+ 0,2	+ 0,3
20	15		0	0	0	0	0	0	0	0
25	20		- 0,1	- 0,1	- 0,1	- 0,2	- 0,2	- 0,2	- 0,2	- 0,3
30	25		- 0,2	- 0,2	- 0,3	- 0,3	- 0,4	- 0,4	- 0,5	- 0,5
35	30		- 0,2	- 0,3	- 0,4	- 0,5	- 0,5	- 0,6	- 0,7	- 0,8
40	35		- 0,3	- 0,4	- 0,5	- 0,6	- 0,7	- 0,8	- 0,9	- 1,0
45	40		- 0,4	- 0,5	- 0,6	- 0,8	- 0,9	- 1,0	- 1,1	- 1,3

NOTE — These corrections when applied to the hydrometer reading at t °C give the density of the liquid in kg/m³ or g/ml at t °C. They are based on the relationship

$$C = 0,000\ 025\ R (t_0 - t)$$

where

C is the correction;

R is the reading at the level of the horizontal liquid surface;

t_0 is the reference temperature;

t is the temperature of the liquid being measured.

1) See ISO 649/1.

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Table 2 — Surface tension corrections
Unit : kg/m³ or 10⁻³ g/ml

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Surface tension of liquid minus that for which the hydrometer is adjusted mN/m	Series L20 and L50SP					Series M50 and M50SP					Series M100					Series S50 and S50SP									
	Hydrometer reading					Hydrometer reading					Hydrometer reading					Hydrometer reading									
	600	1 000	1 500	2 000	2 000	600	1 000	1 500	2 000	2 000	600	1 000	1 500	2 000	2 000	600	1 000	1 500	2 000	2 000	600	1 000	1 500	2 000	
kg/m ³																									
g/ml																									
- 40	-	- 0,54	- 0,45	- 0,39	- 0,39	-	- 1,2	- 0,9	- 0,8	-	- 1,9	- 1,5	- 1,4	-	-	- 3,0	- 3,0	- 2,0	- 2,0	-	- 3,0	- 2,5	- 2,0	- 2,0	
- 30	-	- 0,41	- 0,34	- 0,30	- 0,30	-	- 0,9	- 0,7	- 0,6	-	- 1,4	- 1,1	- 1,0	-	-	- 2,0	- 2,0	- 2,0	- 2,0	-	- 2,0	- 2,0	- 2,0	- 1,5	- 1,5
- 20	-	- 0,27	- 0,22	- 0,20	- 0,20	-	- 0,6	- 0,5	- 0,4	-	- 0,9	- 0,8	- 0,7	-	-	- 2,0	- 1,0	- 1,0	- 1,0	-	- 1,5	- 1,5	- 1,0	- 1,0	- 1,0
- 10	- 0,18	- 0,14	- 0,11	- 0,10	- 0,10	- 0,3	- 0,3	- 0,2	- 0,2	- 0,6	- 0,5	- 0,4	- 0,3	-	-	- 1,0	- 1,0	- 1,0	- 1,0	-	- 1,0	- 0,5	- 0,5	- 0,5	- 0,5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+ 10	+ 0,18	+ 0,14	+ 0,11	+ 0,10	+ 0,10	+ 0,3	+ 0,3	+ 0,2	+ 0,2	+ 0,6	+ 0,5	+ 0,4	+ 0,3	+ 1,0	+ 1,0	+ 1,0	+ 1,0	+ 1,0	+ 1,0	+ 1,0	+ 1,0	+ 0,5	+ 0,5	+ 0,5	+ 0,5
+ 20	-	+ 0,27	+ 0,22	+ 0,20	+ 0,20	-	+ 0,6	+ 0,5	+ 0,4	-	+ 0,9	+ 0,8	+ 0,7	-	-	+ 2,0	+ 1,0	+ 1,0	+ 1,0	+ 1,0	+ 1,5	+ 1,5	+ 1,0	+ 1,0	+ 1,0
+ 30	-	+ 0,41	+ 0,34	+ 0,30	+ 0,30	-	+ 0,9	+ 0,7	+ 0,6	-	+ 1,4	+ 1,1	+ 1,0	-	-	+ 2,0	+ 2,0	+ 2,0	+ 2,0	+ 2,0	+ 2,5	+ 2,0	+ 1,5	+ 1,5	+ 1,5
+ 40	-	+ 0,54	+ 0,45	+ 0,39	+ 0,39	-	+ 1,2	+ 0,9	+ 0,8	-	+ 1,9	+ 1,5	+ 1,4	-	-	+ 3,0	+ 3,0	+ 3,0	+ 3,0	+ 3,0	+ 3,0	+ 2,5	+ 2,0	+ 2,0	+ 2,0

NOTE — For hydrometers not of average dimension, the surface tension allowances may differ from the above amounts by up to approximately ± 10 %.

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4 Meniscus corrections

Table 3 gives the approximate amounts to be added to readings taken where the top of the meniscus appears to meet the stem, in order to obtain the corresponding indications at the level of the horizontal liquid surface. They have been calculated for hydrometers having the mean dimensions permitted by the specification and are based on an equation due to Langberg which, rearranged, is equivalent to

$$\rho - \rho_0 = \frac{1\,000 \Delta d \sigma}{g \Delta l D \rho_0} \left(\sqrt{1 + \frac{2 g D^2 \rho_0}{1\,000 \sigma}} - 1 \right)$$

where

ρ is the density reading at the level of the horizontal liquid

surface, in kilograms per cubic metre;

ρ_0 is the density reading at the top of the meniscus, in kilograms per cubic metre;

Δd is the scale interval, in kilograms per cubic metre;

σ is the surface tension, in millinewtons per metre;

g is the acceleration due to gravity, in metres per second squared, taken as the standard acceleration of 9,806 65 m/s²;

D is the stem diameter, in millimetres;

Δl is the scale spacing, in millimetres.

Table 3 — Average meniscus corrections expressed in units of density

Unit : kg/m³ or 10⁻³ g/ml

Series of hydrometers			L20	L50 and L50SP	M50 and M50SP	M100	S50	S50SP
Value of smallest scale division			0,2	0,5	1	2	2	1
Assumed scale length (mm)			113 127	125 145	78 99	87 102	50 62	50 62
Density of liquid kg/m ³	g/ml	Surface tension (mN/m)						
600	0,600	15	0,32 0,28	0,8 0,7	1,2 1,0	2,0 2,0	2,0 1,6	1,8 1,6
800	0,800	25	0,36 0,32	0,8 0,7	1,4 1,0	2,4 2,0	2,0 1,6	2,0 1,6
1 000	1,000	35	0,36 0,32	0,8 0,7	1,4 1,0	2,4 2,0	2,0 1,6	2,2 1,6
		55	0,44 0,40	1,0 0,8	1,6 1,2	2,8 2,4	2,4 2,0	
		75	0,48 0,44	1,0 0,9	1,8 1,4	3,2 2,8	2,8 2,4	
1 500	1,500	35	0,32 0,28	0,7 0,6	1,0 0,8	1,6 1,6	2,0 1,2	
		55	0,36 0,32	0,8 0,7	1,2 1,0	2,4 2,0	2,0 1,6	
		75	0,40 0,36	0,9 0,8	1,4 1,0	2,8 2,4	2,4 2,0	
2 000	2,000	55	0,32 0,28	0,7 0,6	1,0 1,0	2,0 1,6	2,0 1,6	
		75	0,36 0,32	0,8 0,7	1,2 1,0	2,4 2,0	2,4 1,6	

NOTES

- Those requiring to know the corrections for meniscus height more closely than can be obtained from the above table of average values may derive them, having regard to the diameter of the stem of the particular hydrometer concerned, from table 4 which is also computed from Langberg's equation.
- Table 3 has been calculated for the scale lengths indicated on the third line. The left-hand and right-hand entries refer, respectively, to the lower and upper limits of the range of scale lengths normally found in practice for hydrometers complying with the requirements of ISO 649/1.
- The corrections have been rounded off to the nearest one-fifth off the scale interval.

Table 4 — Average meniscus correction expressed in units of length

Unit : 1 mm

Density of liquid		Surface tension mN/m	Stem diameter mm			
kg/m ³	g/ml		4	5	6	7
600	0,6	15	1,7	1,8	1,9	1,9
700	0,7	20	1,8	1,9	2,0	2,0
800	0,8	25	1,9	2,0	2,0	2,1
900	0,9	30	1,9	2,0	2,1	2,2
1 000	1,0	35	1,9	2,1	2,1	2,2
		55	2,2	2,4	2,5	2,6
1 300	1,3	35	1,8	1,9	1,9	2,0
		55	2,1	2,2	2,3	2,4
1 500	1,5	55	2,0	2,1	2,2	2,3
2 000	2,0	55	1,8	1,9	1,9	2,0