
International Standard



649/1

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**Laboratory glassware — Density hydrometers for general purposes —
Part 1 : Specification**

Verrerie de laboratoire — Aréomètres à masse volumique d'usage général — Partie 1 : Spécifications

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Descriptors : glassware, laboratory glassware, hydrometers, measuring instruments, density (mass/volume), specifications, dimensions, interfacial tension, precision.

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 649/1 was developed by Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus*, and was circulated to the member bodies in September 1979.

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	

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 1 : Specification

1 Scope and field of application

This part of ISO 649 specifies requirements for five basic series of glass hydrometers of constant mass which are graduated to indicate density (kg/m^3 or g/ml) at 20 °C.

Each series comprises hydrometers which between them cover the interval 600 to 2 000 kg/m^3 or 0,6 to 2,0 g/ml . The hydrometers are graduated appropriately for use in liquids of low, medium or high surface tension.

It also specifies three sub-series of hydrometers which are graduated to indicate density at either 20 °C or 15 °C. These hydrometers have smaller tolerances on scale error, are limited to the range 600 to 1 100 kg/m^3 or 0,6 to 1,1 g/ml and are for use in liquids of low surface tension.

This International Standard does not cover hydrometers with a built-in thermometer, for which a separate International Standard is under consideration. The hydrometers comply with the requirements of ISO 387.

A table of standard categories of surface tension is given in annex A. A table of recommended stem diameters is given, for guidance in manufacture, in annex B.

Part 2 of this International Standard deals with test methods and use of density hydrometers.

2 References

ISO 387, *Hydrometers — Principles of construction and adjustment.*

ISO 649/2, *Laboratory glassware — Density hydrometers for general purposes — Part 2 : Test methods and use.*¹⁾

ISO 1768, *Glass hydrometers — Conventional value for the thermal cubic expansion coefficient (for use in the preparation of measurement tables for liquids).*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density or relative density — Hydrometer method.*

3 Basis of scale

The basis of scale shall be density (mass per unit volume) in kilograms per cubic metre (kg/m^3). The use of grams per cubic centimetre (g/cm^3), for which the symbol g/ml may be used, is accepted.

NOTE — The term millilitre (ml) is commonly used as a special name for the cubic centimetre (cm^3), in accordance with a decision of the twelfth Conférence Générale des Poids et Mesures. The term millilitre is acceptable, in general, for reference to capacities of volumetric glassware and is used in the present text.

4 Reference temperature

4.1 The reference temperature for density hydrometers, excluding the special sub-series L50SP, M50SP and S50SP, shall be 20 °C. When used in a liquid at this temperature, the hydrometer shall indicate the density of the liquid at 20 °C.

4.2 The reference temperature for density hydrometers of the special sub-series L50SP, M50SP and S50SP shall be either 20 °C or 15 °C. When used in a liquid at the appropriate temperature, the hydrometer shall indicate the density of the liquid at that temperature.

1) At present at the stage of draft. (Revision, in part, of ISO/R 649.)

5 Surface tension

The adjustment shall be related to specific capillary conditions as follows :

5.1 When the hydrometer is slightly displaced from its equilibrium position in a liquid, the stem passes through the liquid surface without causing any apparent alteration in the shape of the meniscus.

5.2 The hydrometer scale shall be adjusted either for a given liquid having a given surface tension, or for one of the standard categories of surface tension given in annex A. Except where the highest precision is required, one of the standard categories of surface tension given in annex A shall be used.

For hydrometers of the highest precision, intended for use in particular liquids (for example alcohol solutions), the surface tension values appropriate to clean surfaces of these liquids and to the actual indications of the hydrometer shall be used [see clause 14 c)].

The sub-series L50SP, M50SP and S50SP are limited to the low surface tension category.

6 Reference levels for adjustment and reading

6.1 The scale of the hydrometers shall be adjusted for readings taken at the level of the horizontal liquid surface.

NOTE — If a hydrometer having a scale so adjusted is used in an opaque liquid, readings may be taken at the top of the meniscus where it appears to meet the stem, but an appropriate correction to the level of the horizontal liquid surface should then be made. (See part 2 of this International Standard). Alternatively, hydrometers intended for use in opaque liquids may be adjusted for readings at the top of the meniscus.

6.2 The middle of the thickness of a scale line shall be taken as its definitive position.

7 Immersion

Hydrometers shall be graduated for use with the emergent stem dry, except in the immediate vicinity of the meniscus.

8 Materials and workmanship

8.1 The bulb and the stem shall be made of a suitable transparent glass, selected and processed to be as free as possible from stress and visible defects, and having a coefficient of cubical thermal expansion of $(25 \pm 2) \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ *

8.2 The loading material shall be fixed in the bottom of the hydrometer. After the finished hydrometer has been kept in a horizontal position for 1 h at 80 °C and subsequently cooled in that position, the instrument shall meet the requirements of 9.3.

8.3 The strip on which the scale and inscriptions are marked shall have a smooth matt surface. The strip shall show no evidence of charring. The strip bearing the scale shall not become discoloured or distorted when the stem is exposed for 1 h to a temperature of 80 °C.

NOTE — If a hydrometer is intended to be used at a temperature above 80 °C, the loading material and the strip bearing the scale shall meet the requirements of 8.2 and 8.3 at a temperature slightly above the temperature of use.

8.4 There shall be no loose material in the instrument.

9 Form

9.1 The outer surface shall be symmetrical about the main axis.

9.2 There shall be no abrupt changes in cross-section. The tapered design shown in figure 1 is preferred, but any design which does not permit air bubbles to be trapped is acceptable.

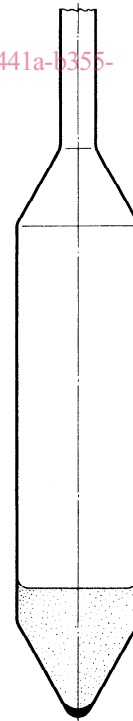


Figure 1 — Preferred design of hydrometer bulb

* This value complies with ISO 1768.

9.3 The hydrometer shall float with its axis vertical to within $1,5^\circ$ of arc.

9.4 A thermometer shall not form part of a hydrometer conforming with this International Standard (see clause 1).

10 Scale

Examples of recommended scales for the hydrometers are illustrated in figure 2.

10.1 General

10.1.1 The strip on which the scale and inscriptions are marked shall remain securely fastened in place at the temperature of use (see 8.3).

10.1.2 Appropriate means shall be incorporated for ensuring that any displacement of the scale or of the strip bearing the scale is readily apparent. Any displacement renders the instrument unsuitable for use.

10.1.3 No hydrometer shall have more than one type of scale. If a hydrometer has duplicate scales, the values indicated by them shall not significantly differ, and both scales shall comply with the requirements of clause 13.

10.1.4 The scale lines and inscriptions should preferably be black and shall be clearly and durably marked.

10.1.5 The scale shall be straight and without twist.

10.2 Graduation lines

10.2.1 The graduation lines shall be distinct and of uniform thickness not exceeding 0,2 mm. For the SP series, the thickness of the graduation lines shall not exceed 0,2 mm.

10.2.2 There shall be no evident local irregularities in the spacing of the graduation lines.

10.2.3 The graduation lines shall be perpendicular to the axis of the hydrometer.

10.2.4 The scale shall be straight and without twist.

10.2.5 The short, medium and long scale lines shall extend, respectively, at least one-fifth, one-third and one-half of the way round the circumference of the stem.

10.2.6 The highest and lowest graduation lines indicating the nominal limits of the scale shall be long lines (see 10.3.1, 10.3.2 and 10.3.3).

10.2.7 The short, medium and long lines shall each be vertically disposed so that either the mid-points, or the right hand ends or the left hand ends of all graduation lines shall lie on an

imaginary line parallel to the axis of the instrument. In the latter two cases, the vertical line may alternatively be marked.

10.3 Sequence of graduation lines

10.3.1 On hydrometer scales whose smallest interval is 1 kg/m^3 or $0,001 \text{ g/ml}$:

- a) every tenth graduation line shall be a long line;
- b) there shall be a medium line between two consecutive long lines;
- c) there shall be four short lines between consecutive medium and long lines.

10.3.2 On hydrometer scales whose smallest interval is 2 kg/m^3 or $0,2 \text{ kg/m}^3$ or $0,002 \text{ g/ml}$ or $0,000 2 \text{ g/ml}$:

- a) every fifth graduation line shall be a long line;
- b) there shall be four short lines between two consecutive long lines.

10.3.3 On hydrometer scales whose smallest interval is 5 kg/m^3 or $0,005 \text{ g/ml}$:

- a) every tenth graduation line shall be a long line;
- b) there shall be four medium lines between two consecutive long lines;
- c) there shall be one short line between two consecutive medium lines and between consecutive medium and long lines.

10.4 Figuring of graduation lines

10.4.1 Except in the case of duplicate scales, the scale shall have only one set of numbers, and the last digits of the numbers shall be vertically aligned.

10.4.2 The scale shall be figured so as to enable the value corresponding to any graduation line to be readily identified.

10.4.3 The highest and lowest graduation lines of the nominal limits shall be figured in full.

10.4.4 At least every tenth line shall be figured.

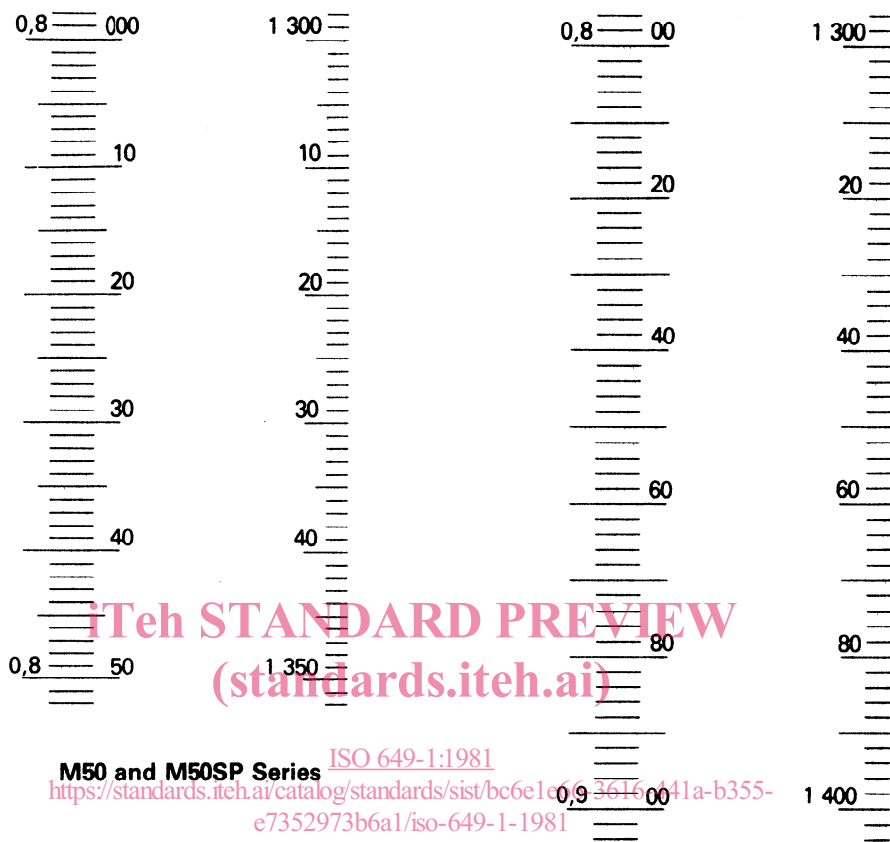
10.4.5 For density values expressed in grams per millilitre, the decimal sign shall be included for numbers expressed in full, but may be omitted from abbreviated numbers.

10.5 Extension of scale

The scale shall be extended beyond the nominal scale limits as indicated in table 1.

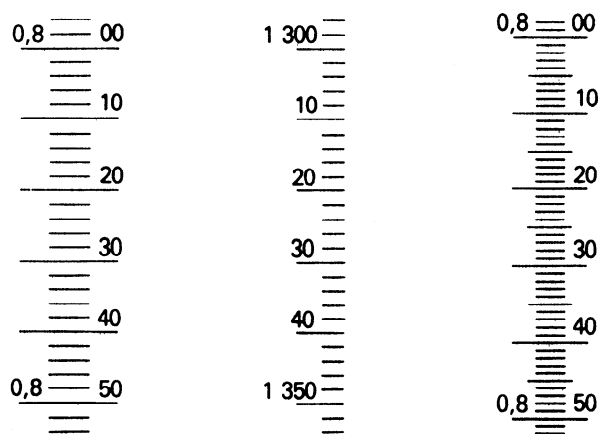


Figure 2 — Recommended scales



M50 and M50SP Series ISO 649-1:1981
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M100 Series



S50 Series

S50SP Sub-Series

for typical hydrometers

Table 1 — Principal requirements for series of hydrometers

Series	Maximum total length	Nominal range of each hydrometer		Number of scale divisions × value of the scale interval		Minimum scale length (nominal range)	Bulb diameter		Volume below lowest graduation line of nominal range		Extension of scale at each end beyond upper and lower nominal limits
		kg/m ³	g/ml	kg/m ³	g/ml		min.	max.	min.	max.	
	mm	kg/m ³	g/ml	kg/m ³	g/ml	mm	mm	mm	ml	ml	graduation lines
L20	335	20	0,020	100 × 0,2	100 × 0,000 2	105	36	40	108*	132	5 to 10
L50	335	50	0,050	100 × 0,5	100 × 0,000 5	125	23	27	50*	65	2 to 5
M50	270	50	0,050	50 × 1	50 × 0,001	70	20	24	30	45	2 to 5
M100	250	100	0,100	50 × 2	50 × 0,002	85	18	20	18	26	2 to 5
S50	190	50	0,050	25 × 2	25 × 0,002	50	18	20	18*	26	2 or 3
Special sub-series †											
L50SP	335	50	0,050	100 × 0,5	100 × 0,000 5	125	23	27	50	65	2 to 5
M50SP	270	50	0,050	50 × 1	50 × 0,001	70	20	24	30	45	2 to 5
S50SP	190	50	0,050	50 × 1	50 × 0,001	50	18	20	18*	26	2 or 3

* For the diameter of the stem to exceed 4 mm (as required by 12.4), these volumes, for hydrometers covering the range 1 700 to 2 000 kg/m³ or 1,7 to 2,0 g/ml, will be nearer the maximum value than the minimum value.

† See ISO 3675.

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11 Ranges of the series of hydrometers

Each of the five main series of hydrometer shall cover a total range of 600 to 2 000 kg/m³ or 0,600 to 2,000 g/ml, each hydrometer having a range of 20 kg/m³, 50 kg/m³ or 100 kg/m³ or 0,020 g/ml, 0,050 g/ml or 0,100 g/ml. The lower nominal limits of the scales of the L20 series hydrometers shall be 600, 620, 640, etc., or 0,600, 0,620, 0,640, etc., those of the L50, M50 and S50 series hydrometers shall be 600, 650, 700, etc., or 0,600, 0,650, 0,700, etc., and those of the M 100 series shall be 600, 700, 800, etc., or 0,600, 0,700, 0,800, etc., according to whether the scales are based on kilograms per cubic metre or grams per millilitre.

Each of the three sub-series of hydrometers shall cover a total range of 600 to 1 100 kg/m³ or 0,600 to 1,100 g/ml, each hydrometer having a range of 50 kg/m³ or 0,050 g/ml. The lower nominal limits of the scales of the L50SP, M50SP and S50SP shall be 600, 650, 700, etc., or 0,600, 0,650, 0,700, etc., according to whether the scales are based on kilograms per cubic metre or grams per millilitre.

12 Principal dimensions

12.1 The dimensions of the hydrometers shall conform with the requirements given in table 1.

12.2 The cross-section of the stem shall remain unchanged for at least 5 mm below the lowest graduation line on the scale.

12.3 The stem shall extend unchanged in diameter at least 15 mm above the uppermost graduation line on the scale.

12.4 No hydrometer shall have a stem of diameter smaller than 4,0 mm.

NOTE — For convenience in manufacture, it has been found advantageous to comply with the recommendations as to stem diameter given in annex B.

13 Accuracy

For hydrometers the maximum permitted instrument errors at any point on the scale are given in table 2. It is recommended that the hydrometers in the special sub-series be supplied with certificates of correction, when required for reference purposes.

Table 2 — Maximum permitted errors

Series	Maximum permitted error at any point on the scale	
	kg/m ³	g/ml
L20	± 0,2	± 0,000 2
L50	± 0,5	± 0,000 5
M50	± 1,0	± 0,001
M100	± 2,0	± 0,002
S50	± 2,0	± 0,002
Special sub-series		
L50SP	± 0,3	± 0,000 3
M50SP	± 0,6	± 0,000 6
S50SP	± 1,0	± 0,001 0

14 Inscriptions

The following information shall be permanently, legibly and unequivocally marked within the hydrometer :

- a) the basis of the scale, for example "kg/m³";
- b) the reference temperature of the hydrometer, for example "20 °C";
- c) 1) either a particular surface tension expressed in millinewtons per metre (for example "55 mN/m");
2) or a surface tension category as defined in annex A (for example "low S.T.");
3) or, if the instrument is adjusted for use in a particular liquid, the name of that liquid;
- d) whether the hydrometer is adjusted for readings at the top of the meniscus (i.e. for use in opaque liquids);
- e) the maker's and/or vendor's name or readily identifiable mark;
- f) identification number of the instrument, the first two digits of which may indicate the year of manufacture (for example "780001");
- g) the number of this International Standard (i.e. ISO 649/1) or the number of the corresponding national standard;
- h) the series number (for example "L50").

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