UDC 531.75

Ref. No.: ISO / R 650 - 1968 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 650

RELATIVE DENSITY 60/60 °F HYDROMETERS FOR GENERAL PURPOSES

1st EDITION

February 1968

For each individual country the only valid standard is the national standard of that country.

Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 650, *Relative density 60/60 °F hydrometers for general purposes*, was drawn up by Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question by the Technical Committee began in 1954 and led, in 1959, to the adoption of a Draft ISO Recommendation.

In November 1963, this Draft ISO Recommendation (No. 687) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Argentina	Greece	Switzerland
Australia	Hungary	Turkey
Austria	India	U.A.R.
Belgium	Israel	United Kingdom
Brazil	Korea, Rep. of	U.S.A.
Bulgaria	Netherlands	U.S.S.R.
Chile	New Zealand	Yugoslavia
Colombia	Poland	
Czechoslovakia	Spain	

Two Member Bodies opposed the approval of the Draft:

France
Germany

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in February 1968, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 650 February 1968

RELATIVE DENSITY 60/60 °F HYDROMETERS FOR GENERAL PURPOSES

1. SCOPE

This ISO Recommendation specifies requirements for five basic series of glass hydrometers of constant mass which indicate relative density 60/60 °F with reference to water and comply with ISO Recommendation R 387, *Principles of construction and adjustment of hydrometers*. The dimensions of the hydrometers have been chosen in such a way as to lead to convenience in use and economy in manufacture.

2. BASIS OF SCALE

2.1 The scale should indicate relative density * 60/60 °F with reference to water.

NOTE. — The relative density 60/60 °F of a liquid with reference to water is the ratio

$$\frac{\text{density of the liquid at 60 °F}}{\text{density of water at 60 °F}}$$

2.2 The use of a scale other than one based on density (mass per unit volume) is not in general recommended but, in view of its importance in trade between various countries, the scale based on relative density with reference to water is accepted.

3. REFERENCE TEMPERATURE

The standard reference temperature for the hydrometers should be 60 °F. When used in a liquid at this temperature, the hydrometer should indicate the relative density of the liquid at 60 °F with reference to water at 60 °F.

NOTE. — For the purposes of this ISO Recommendation, the standard reference temperature 60 °F can be taken as equal to 15.56 °C.

4. SURFACE TENSION

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

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

4.2 The hydrometer should be adjusted with regard to surface tension. Except where the highest precision is required, one of the standard categories of surface tension given in Annex A should be used.

For hydrometers of the highest precision, intended for use in particular liquids (e.g. alcohol solutions), the surface tension values appropriate to clean surfaces of these liquids and to the actual indications of the hydrometer should be used (see clause 13 (*b*) (iii)).

* The expression " relative density " complies with ISO Recommendation R 31, Part III, *Quantities and units of mechanics*. The term " specific gravity " is often used in English instead of " relative density ", when the reference substance is water.

5. REFERENCE LEVELS FOR ADJUSTMENT AND READING

5.1 Hydrometers should preferably be adjusted for readings taken at the level of the horizontal liquid surface. If a hydrometer 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 appropriate correction to the level of the horizontal liquid surface should then be made.

To avoid the necessity for making such corrections, hydrometers intended for use in opaque liquids may alternatively be adjusted for readings taken at the top of the meniscus where it appears to meet the stem. If a hydrometer is so adjusted, this should be clearly indicated on the scale (see clause 13 (*c*)).

NOTE. — Appropriate corrections are given in Annex C.

5.2 The middle of the thickness of a scale line should be taken as its definitive position.

6. IMMERSION

In order that the readings of the hydrometer should be correct, the emergent stem should be dry except in the immediate vicinity of the meniscus.

7. MATERIALS AND WORKMANSHIP

7.1 The bulb and the stem should be made of transparent glass as free as possible from strain and visible defects.

NOTE. — Various measurement tables for liquids have been drawn up on the basis of using hydrometers made of glass having a particular thermal expansion coefficient. When the actual expansion of the hydrometer departs significantly from the particular value which underlies the measurement tables, an appropriate correction should be made.

7.2 Where the loading material is solid, it should be fixed in the bottom part of the hydrometer and should not in general soften if heated to 80 °C; if, however, a hydrometer is likely to be used at a temperature higher than 70 °C, the loading material should have a softening point which is higher than 80 °C. The material should not deteriorate in use. Where mercury is the loading material, it should be confined in the bottom part of the hydrometer.

7.3 There should be no loose material elsewhere in the instrument.

7.4 The scale lines and inscriptions should preferably be black and should be clearly and permanently marked.

7.5 The strip on which the scale and inscriptions are marked should have a smooth surface. The scale should show no evidence of charring. When the stem is exposed to a temperature of 80 °C, or such higher temperature at which the hydrometer will be used, for the time necessary to carry out a determination, the strip bearing the scale should not become discoloured or distorted.

8. FORM

8.1 The outer surface should be symmetrical about the main axis.

8.2 There should be no abrupt changes in cross-section. The tapered design shown in the Figure below is preferred, but any design which does not permit air bubbles to be trapped is acceptable.

FIGURE. — **Preferred design of hydrometer bulb**

8.3 The hydrometer should float with its axis essentially vertical. 1.5° is suggested as the maximum permissible deviation.

8.4 A thermometer should not form part of a hydrometer of high sensitivity.

9. SCALE

9.1 General

9.1.1 The strip on which the scale and inscriptions are marked should remain securely fastened in place at the temperature of use (see clause 7.5).

9.1.2 Appropriate means should be incorporated for ensuring that any displacement of the scale or of the strip bearing the scale is readily apparent. No displacement should be tolerated.

9.1.3 No hydrometer should have more than one type of scale. If a hydrometer has two scales of the same type, the values indicated by them should not differ.

9.2 Graduation lines

9.2.1 The graduation lines should be distinct and of uniform thickness not exceeding 0.2 mm.

9.2.2 There should be no evident local irregularities in the spacing of the graduation lines.

9.2.3 The graduation lines should be perpendicular to the axis of the hydrometer.

9.2.4 The scale should be straight and without twist.

9.2.5 A line parallel to the axis of the instrument and indicating the front of the scale is permitted.

9.2.6 The highest and lowest graduation lines indicating the nominal limits of the scale should be long lines (see clauses 9.3.1 (*a*), 9.3.2 (*a*) and 9.3.3 (*a*)).

9.2.7 The shortest scale lines should extend at least one-fifth of the way round the circumference of the stem.

9.3 Sequence of graduation lines

9.3.1 On the hydrometers whose smallest scale division is 0.001 relative density:

(*a*) Every tenth graduation line should be a long line.

(*b*) There should be a medium line between two consecutive long lines.

(*c*) There should be four short lines between consecutive medium and long lines.

9.3.2 On the hydrometers whose smallest scale division is 0.0002 or 0.002 relative density:

(*a*) Every fifth graduation line should be a long line.

(*b*) There should be four short lines between two consecutive long lines.

9.3.3 On the hydrometers whose smallest scale division is 0.0005 relative density:

(*a*) Every tenth graduation line should be a long line.

(*b*) There should be four medium lines between two consecutive long lines.

(*c*) There should be one short line between two consecutive medium lines and between consecutive medium and long lines.

9.4 Figuring of graduation lines

9.4.1 The scale should have only one set of numbers.

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

9.4.3 The highest and lowest graduation lines of the nominal limits of the scale should be figured in full.

9.4.4 At least every tenth line should be figured.

9.4.5 The decimal sign should be included for numbers expressed in full, but may be omitted from abbreviated numbers.

10. SERIES OF HYDROMETERS (see Table 1)

Each of the five series of hydrometers covers a total range of 0.600 to 2.000 relative density, each hydrometer having a range of 0.020, 0.050 or 0.100 relative density. The lower nominal limits of the scales of the L20 series hydrometers should be 0.600, 0.620, 0.640 etc., those of the L50, M50 and S50 series hydrometers should be 0.600, 0.650, 0.700 etc., and those of the M100 series hydrometers should be 0.600, 0.700, 0.800 etc.

TABLE 1. — **Requirements for series of hydrometers**

Series	Maximum total length	Nominal range of each hydrometer	Number of scale divisions and 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
					min.	max.	min.	max.	
	mm	relative density	relative density	mm	mm	mm	ml	ml	graduation lines
L20	335	0.020	100×0.0002	105	36	40	108*	132	5 to 10
L50	335	0.050	100×0.0005	125	23	27	50*	65	2 to 5
M50	270	0.050	50×0.001	70	20	24	30	45**	2 to 5
M100	250	0.100	50×0.002	85	18	20	18	26	2 to 5
S50	190	0.050	25×0.002	40	18	20	18	26	2 or 3

* These minimum volumes below the scale are affected by the recommended limits on stem diameter (see Annex B).

** In some countries and in special circumstances, the maximum volume below the scale may be that appropriate to the L50 series.

11. PRINCIPAL DIMENSIONS

11.1 The dimensions of the hydrometers should conform to the requirements given in Table 1.

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

11.3 The stem should extend at least 15 mm above the uppermost graduation line on the scale.

11.4 No hydrometer should have a stem of smaller diameter than 4.0 mm.

NOTE. — For maximum ease and advantage in manufacture, it has been found preferable to comply with the stem diameter recommended in Annex B.

12. ACCURACY

The maximum permitted errors in accuracy for the hydrometers are given in Table 2.

TABLE 2. — **Maximum permitted errors**

Series	Maximum permitted error at any point on the scale relative density
L20	±0.0002
L50	±0.0005
M50	±0.001
M100	±0.002
S50	±0.002

13. INSCRIPTIONS

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

(*a*) An inscription to indicate the basis of the scale.

(*b*) (i) Either a particular surface tension expressed in dynes per centimetre (e.g. "55 dyn/cm");
(ii) or a surface tension category as defined in Annex A (e.g. " low S.T.");
(iii) or a particular liquid.

(*c*) If the hydrometer is adjusted for readings at the top of the meniscus (i.e. for use in opaque liquids), this should be indicated.

(*d*) The series number (e.g. "L50").

(*e*) The maker's or vendor's name or mark.

(*f*) An identification number of the instrument.

ANNEX A

STANDARD CATEGORIES OF SURFACE TENSION FOR HYDROMETERS

The following standard categories of surface tension are adopted for hydrometers for technical use, so as to provide a precise basis of adjustment and verification and to permit the attainment of appropriate accuracy in hydrometric measurements in the liquids indicated. The adoption of these surface tension categories does not preclude the use of other surface tensions as the basis for the adjustment of hydrometers, provided such surface tensions are marked, in dynes per centimetre, on the hydrometers. Attention is drawn to the provision that, if desired, the name of the liquid for which the hydrometer is intended can be marked on the hydrometer, instead of a surface tension category or a precise surface tension.

NOTE. — Owing to the extreme variability of the surface tension of acetic acid solutions with clean surfaces, these solutions have not been included in the Table.

TABLE. — **Standard surface tension categories**

Category	Relative density	0.00 0.02 0.04 0.06 0.08	Liquids to which the category is appropriate
Low		Surface tension (dyn/cm)	
	0.6	15 16 17 18 19	Organic liquids generally (including ethers, petroleum distillates, coaltar distillates), and all types of oils.
	0.7	20 21 22 23 24	
	0.8	25 26 27 28 29	
	0.9	30 31 32 33 34	
	1.00 to 1.30 inclusive	35	Acetic acid solutions, the surfaces of which has not been specially cleaned.
Medium	0.60 to 0.94 inclusive	As for the " low " category above	Aqueous solutions (including those of ethyl and methyl alcohol, but excluding acetic acid solutions), the surfaces of which have not been specially cleaned, e.g. as by overflow.
	0.96	35	
	0.97	40	
	0.98	45	
	0.99	50	
	1.00 to 2.00 inclusive	55	Nitric acid solutions of density greater than 1.3 g/ml, whether specially cleaned or not.
High	1.00 to 2.00 inclusive	75	Aqueous solutions, the surfaces of which have been specially cleaned, e.g. by overflow, except (1) nitric acid solutions of density greater than 1.3 g/ml; (2) acetic acid solutions.