

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION R 387

PRINCIPLES OF CONSTRUCTION
AND ADJUSTMENT OF HYDROMETERS

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BRIEF HISTORY

The ISO Recommendation R 387, *Principles of Construction and Adjustment of Hydro-meters*, 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 1951 and led, in 1960, to the adoption of a Draft ISO Recommendation.

In April 1960, this Draft ISO Recommendation (No. 350) 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 :

Australia	Germany	Romania
Austria	Greece	Spain
Belgium	India	Sweden
Canada	Israel	United Kingdom
Chile	Netherlands	U.S.A.
Colombia	New Zealand	U.S.S.R.
Czechoslovakia	Poland	

Two Member Bodies opposed the approval of the Draft :

France
Japan.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in September 1964, to accept it as an ISO RECOMMENDATION.

PRINCIPLES OF CONSTRUCTION AND ADJUSTMENT OF HYDROMETERS

1. SCOPE

This ISO Recommendation is intended to provide guidance for drawing up specifications for glass hydrometers of constant mass.

2. BASIS OF SCALE

- 2.1 The scale should indicate density (mass per unit volume) in grammes per cubic centimetre (g/cm^3), for which the symbol g/ml may be used.

NOTES

1. The millilitre (ml) is commonly used as a special name for the cubic centimetre (cm^3); it is acceptable, in general, for reference to volumetric glassware in ISO Recommendations and, in particular, the abbreviation g/ml may be used for describing density hydrometers. However, for articles of high accuracy,* only the cubic centimetre (cm^3) should be used, in accordance with the decision of the Twelfth Conférence Générale des Poids et Mesures.
 2. The advantages of using density as the basis of hydrometer scales are explained in Appendix Z.
- 2.2 The use of a scale other than one based on density is not recommended but, in view of its importance in trade between various countries, the scale based on relative density** with reference to water is permitted:

$$\frac{\text{density of liquid at a specified temperature}}{\text{density of water at a specified temperature}}$$

3. REFERENCE TEMPERATURE

- 3.1 The standard reference temperature for density hydrometers should be 20°C .

NOTE. — In special circumstances, either the temperature of 15°C or the temperature of 27°C may be substituted for 20°C . When it is necessary in tropical countries to work at an ambient temperature considerably above 20°C , and these countries do not wish to use the standard reference temperature of 20°C , it is recommended that they should adopt a temperature of 27°C .

- 3.2 Where the relative density scale is used, the reference temperature should be exclusively 15.56°C (60°F).

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 10 (c) (iii)).

* That is, a precision approximately equal to or better than 1 part in 36000 (which corresponds to the difference between the cubic centimetre and the millilitre as formerly defined).
 ** The expression "relative density" complies with ISO Recommendation R 31, Part III, *Quantities and Units of Mechanics*. The expression "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 10 (d)).

- 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 coefficient of the hydrometer glass 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. SHAPE

- 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.
- 8.5 The cross-section of the stem should remain unchanged for at least 5 mm below the lowest graduation line of the scale.
- 8.6 The stem should extend at least 15 mm above the uppermost graduation line of the scale.

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 7.2).
- 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 appreciably.

9.2 Graduation lines

- 9.2.1 The graduation lines should be fine, distinct and of uniform thickness.
- 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 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 and should be at least 2 mm in length.
- 9.2.8 The distance between adjacent graduation lines should preferably be not less than 1.2 mm nor more than 2.0 mm. In no case should the distance be less than 0.8 mm nor more than 3.0 mm.

9.2.9 The scale should extend at each end beyond its nominal limits by at least two graduation lines.

9.3 Sequence of graduation lines

9.3.1 On the hydrometers whose smallest interval is 0.0001 g/ml (or 0.0001 relative density) or a decimal multiple thereof:

- (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 interval is 0.0002 g/ml (or 0.0002 relative density) or a decimal multiple thereof:

- (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 interval is 0.0005 g/ml (or 0.0005 relative density) or a decimal multiple thereof:

- (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 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. INSCRIPTIONS

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

- (a) The basis of the scale (see Note 1 of clause 2.1).
- (b) The standard reference temperature of the hydrometer.
- (c) (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.
- (d) If the hydrometer is adjusted for readings at the top of the meniscus (i.e. for use in opaque liquids), this should be indicated.
- (e) The maker's or vendor's name or mark.
- (f) An identification number of the instrument.