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IS 3104-1 (1982): Density hydrometers, Part I: Requirements
[CHD 10: Glassware]



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IS : 3104 (Part 1) - 1982
(Reraffirmed 2008)

Indian Standard

**SPECIFICATION FOR
DENSITY HYDROMETERS**

PART I REQUIREMENTS

(First Revision)

First Reprint MARCH 1994

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**BUREAU OF INDIAN STANDARDS
MANAK BHAVAN. 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002**

**AMENDMENT NO. 1 FEBRUARY 2003
TO
IS 3104 (PART 1) : 1982 SPECIFICATION FOR
DENSITY HYDROMETERS**

PART 1 REQUIREMENTS

(First Revision)

(Page 5, clause 4.2.1, line 3) — Substitute '0.50 g/ml' for '0.60 g/ml'.

(CHD 10)

Reprography Unit, BIS, New Delhi, India

Indian Standard
**SPECIFICATION FOR
DENSITY HYDROMETERS**
PART I REQUIREMENTS
(First Revision)

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Indian Standard
**SPECIFICATION FOR
DENSITY HYDROMETERS**

PART I REQUIREMENTS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part I) (First Revision) was adopted by the Indian Standards Institution on 28 January 1982, after the draft finalized by the Laboratoryware and Related Apparatus Sectional Committee had been approved by the Chemical Division Council.

0.2 This standard was first published in 1965. However, with the revision of ISO 649-1968 'Laboratory glassware-Density hydrometers for general Purposes' issued by the International Organization for Standardization (ISO), the Committee responsible for the preparation of the standard decided to revise it with a view to aligning it with the international standard.

0.3 In this revision, the standard has been prepared in two parts. Part I covers requirements of hydrometers and Part II covers methods of test and use of these hydrometers.

0.4 Part I covers eight series of hydrometers comprising five main series and three special sub-series. Each of the five main series comprises hydrometers which cover the density interval 600 to 2 000 kg m³ or 0.6 to 2.0 g/ml (*see 11.1*). These hydrometers are graduated to indicate density at 20° C and are appropriate for use in liquids of low, medium and high surface tension. The hydrometers of the three special sub-series are graduated to indicate density at either 20 or 15°C, have smaller tolerances, are limited to the range 600 to 1 100 kg m³ or 0.6 to 1.1 g/ml and are meant for use in liquids of low surface tension.

0.5 While preparing this standard, need was felt to have reference temperature of 27°C. However, this has not been possible at present, as calibration tables are not available for 27°C. Therefore, this standard would be reviewed to change the reference temperature from 20 to 27°C at an opportune time.

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0.6 In this standard, a table of standard categories of surface tension is given in Appendix A; and a table of recommended stem diameters is given in Appendix B for the guidance of manufacturers.

1. SCOPE

1.1 This standard (Part I) specifies requirements for glass hydrometers having constant mass and graduated to indicate density (kg/m^3 or g/ml) at 20°C .

NOTE — Hydrometers of Special sub-series (see **0.4** and **4.2**) shall be graduated to indicate density at either 20 or 15°C .

1.1.1 This standard does not cover hydrometers with built-in thermometers.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions in addition to those given in IS : 1382-1981*, shall apply.

2.1 Density — The mass in kilograms per cubic metre (kg/m^3) or in grams per millilitre (or cubic centimetre) (g/ml or g/cm^3) of a liquid at a specified temperature.

2.2 Stem — The thin tubing containing the scale.

2.3 Bulb — The wider portion of the hydrometer containing the loading material.

3. BASIS OF SCALE

3.1 The basis of the 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 special name for cubic centimetre (cm^3), in accordance with a decision of the twelfth Conference General 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. SERIES AND RANGES

4.1 Series — There shall be five main series of hydrometers, namely, L20, L50, M50, M100 and S50.

4.1.1 There shall also be three special sub-series of hydrometers, namely, L50SP, M50SP and S50SP.

*Glossary of terms relating to glass industry (*first revision*).

4.2 Ranges — Each of the five main series of hydrometers 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, 0.700, 0.800, etc, according to whether the scales are based on kilograms per cubic metre or grams per millilitre.

4.2.1 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 0.60 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.

5. REFERENCE TEMPERATURE

5.1 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.

5.2 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.

6. SURFACE TENSION

6.0 General — The adjustment shall be related to the following specific capillary conditions.

6.1 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.

6.2 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 Appendix A. Except where the highest precision is required, one of the standard categories of surface tension given in Appendix A shall be used.

6.2.1 For hydrometers of the highest precision, intended for use in particular liquids, for example, alcohol solutions, the surface tension

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values appropriate to clean surfaces of these liquids and to the actual indications of the hydrometer shall be used [see 14.1 (c)].

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

7. REFERENCE LEVELS FOR ADJUSTMENT AND READING

7.1 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 II of this standard). Alternatively, hydrometers intended for use in opaque liquids may be adjusted for readings at the top of the meniscus.

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

8. IMMERSION

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

9. MATERIALS

9.1 Bulb and Stem — 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 $(25 \pm 2) \times 10^{-6} (\text{°C})^{-1}$.

9.2 Loading Material — 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 10.3.

9.3 Scale Strip — The strip on which the scale and inscriptions are marked shall have a smooth matt surface. The strip shall show no evidence of charring, and 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 9.2 and 9.3 at a temperature slightly above the temperature of use.

10. WORKMANSHIP AND FINISH

10.1 The outer surface of the hydrometers shall be symmetrical about the main axis.

10.2 There shall be no abrupt changes in their cross section (*see* Fig, 1).

NOTE — The tapered design shown in Fig. 1 is preferred, but any design which does not permit air bubbles to be trapped is acceptable.

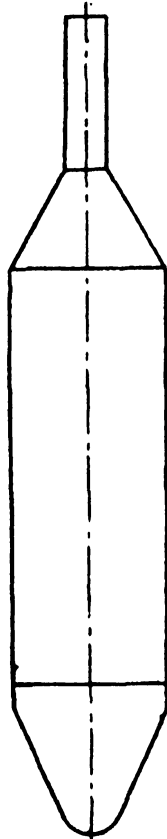


FIG. 1 PREFERRED DESIGN OF HYDROMETER BULB???

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

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

10.5 The hydrometer shall float with its axis vertical to within 1.5° of arc.

10.6 There shall be no loose material in the instrument.

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10.7 The strip on which the scale and inscriptions are marked shall remain securely fastened in place at the temperature of use (*see* **9.3**).

10.8 The scale shall be straight and without twist.

10.9 Appropriate means shall be incorporated for ensuring that any displacement of the scale or of the strip bearing the scale is readily apparent.

NOTE.— Any displacement renders the instrument unsuitable for use.

11. PRINCIPAL DIMENSIONS

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

11.2 Stem diameter of the hydrometers shall be not less than 40 mm.

NOTE— For convenience in manufacture, it has been found advantageous to comply with the recommended stem diameters given in Table 2.

12. SCALE

12.0 General — 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 **13**.

12.1 Recommended scales for the hydrometers are illustrated in Fig. 2.

12.2 Graduation Lines

12.2.1 The graduation lines shall be distinct and of uniform thickness not exceeding 0.2 mm or one-fifth of the distance between the centres of adjacent lines, whichever is less. For the SP series, the thickness of the graduation lines shall not exceed 0.2 mm or one-sixth of the distance between the centres of adjacent lines, whichever is less.

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

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

12.2.4 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.

12.2.5 The highest and lowest graduation lines indicating the nominal limits of the scale shall be long lines (*see* **12.3.1**, **12.3.2** and **12.3.3**).

TABLE 1 PRINCIPAL DIMENSIONAL REQUIREMENTS FOR HYDROMETERS

(Clauses 11.1 and 12.5)

SERIES	MAXI-MUM TOTAL LENGTH OF EACH HYDRO-METER	NOMINAL RANGE	NUMBER OF SCALE DIVISIONS × VALUE OF THE SCALE INTERNAL	MINIMUM SCALE LENGTH (NOMINAL RANGE)	BULB DIA-METER		VOLUME BELOW LOWEST GRADUATION LINE AT EACH END BEYOND UPPER AND LOWER NOMINAL LIMITS	EXTENSION OF SCALE AT EACH END BEYOND UPPER AND LOWER NOMINAL LIMITS			
					Min	Max					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	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*											
L30SP	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 11.2) 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.

TABLE 2 RECOMMENDED STEM DIAMETERS

(Clause 11.2)

UPPER LIMIT OF NOMINAL RANGE		SERIES L20, L50 AND L50SP	SERIES M50, M100 AND M50SP	SERIES S50 AND S50SP
(1)	(2)	(3)	(4)	(5)
kg/m ³	g/ml	mm	mm	mm
600	0.6	6.5	7.1	6.4
700	0.7	6.1	6.6	5.9
800	0.8	5.7	6.2	5.5
900	0.9	5.4	5.8	5.2
1 000	1.0	5.1	5.5	4.9
1 100	1.1	4.9	5.3	4.7
1 200	1.2	4.7	5.0	4.5
1 300	1.3	4.5	4.8	4.3
1 400	1.4	4.3	4.7	4.2
1 500	1.5	4.2	4.5	4.0
1 600	1.6	4.0	4.4	4.0
1 700	1.7	4.0	4.2	4.0
1 800	1.8	4.0	4.1	4.0
1 900	1.9	4.0	4.0	4.0

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

12.3 Sequence of Graduation Lines

12.3.1 On hydrometer scales whose smallest interval is 1 kg/m³ or 1 g/ml:

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

12.3.2 On hydrometer scales whose smallest interval is 2 kg/m³, or 2 g/ml:

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

12.3.3 On hydrometer scales whose smallest interval is 5 kg/m³ or 5 g/ml:

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

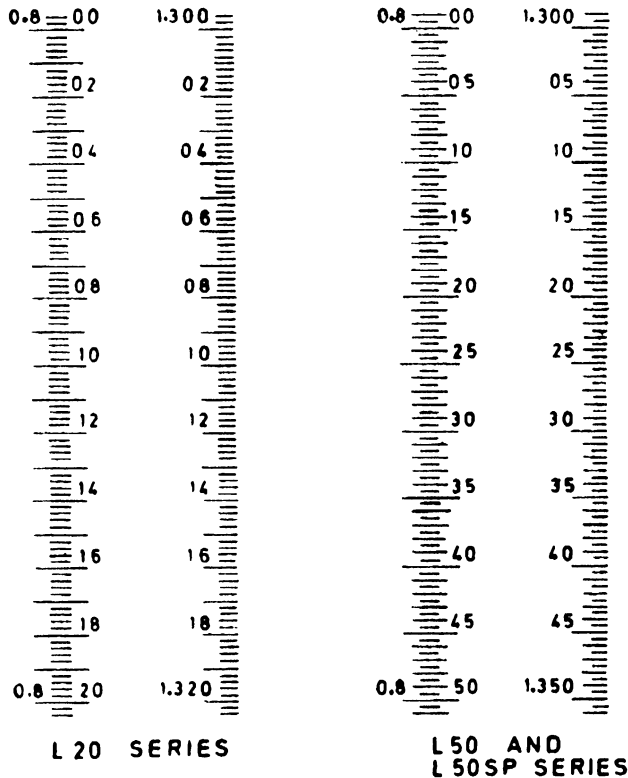


FIG. 2 RECOMMENDED SCALES FOR TYPICAL HYDROMETERS — *Contd*

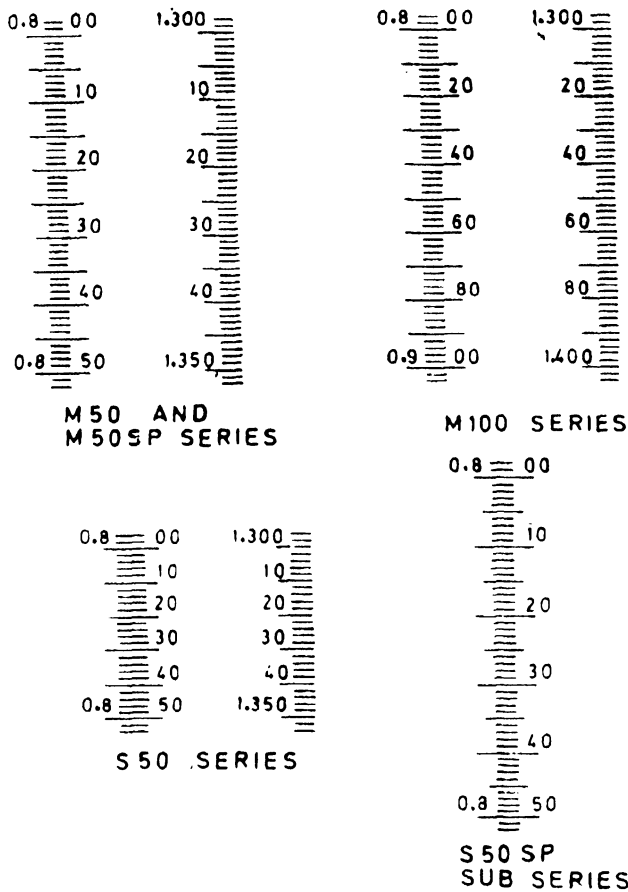


FIG. 2 RECOMMENDED SCALES FOR TYPICAL HYDROMETERS

12.4 Figuring of Graduation Lines

12.4.0 General — The scale lines and inscriptions should preferably be black and shall be clearly and durably marked.

12.4.1 The scale shall have only one set of numbers and the last digits of the numbers shall be vertically aligned (*see* Fig. 2).

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

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

12.4.4 At least every tenth line shall be figured.

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

12.5 Extension of Scale — The scale shall be extended beyond the nominal scale limits, as indicated in col 12 of Table 1.

13. ACCURACY

13.1 For the hydrometers the maximum instrument errors at any point on the scale when determined in accordance with the method given in Part II of this standard shall not exceed the values given in Table 3. It is recommended that the hydrometers in the special sub-series be supplied with certificates of correction, when required for reference purposes.

TABLE 3 MAXIMUM PERMITTED ERRORS

SERIES	MAXIMUM PERMITTED ERROR AT ANY POINT ON THE SCALE	
	(2)	(3)
	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	± 0.5	± 0.000 6
S50SP	± 1.0	± 0.001 0

14. MARKING AND PACKING

14.1 Marking — The following inscriptions shall be permanently, legibly and unequivocally marked within the hydrometer:

- a) the basis of the scale, for example, 'kg/m³';

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- b) the standard reference temperature of the hydrometer, for example, '20°C';
- c)
 - i) either a particular surface tension expressed in millinewtons per metre, for example, '55 mN/m'; or
 - ii) surface tension category as defined in Appendix A, for example, 'Mow S.T.'; or
 - iii) if the instrument is adjusted for use in a particular liquid, the name of that liquid;
- d) whether the hydrometer is adjusted for reading at the top of the meniscus, for example, 'for use in opaque liquids';
- e) the maker's and/or vendor's name or his recognized trade-mark, if any;
- f) identification number of the instrument, the first two digits of which may indicate the year of manufacture, for example, '820001'; and
- g) the series number, for example, 'L50'.

14.1.1 The hydrometers may also be marked with the Standard Mark.

14.1.2 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

14.2 Packing — The hydrometers shall be suitably packed to provide safety in storage and transportation, as agreed to between the purchaser and the supplier.

15. SAMPLING AND TESTS

15.1 Samples to determine conformity of hydrometers to the requirements of this specification shall be drawn and tested as prescribed in Appendix B and Part II of this standard respectively.

APPENDIX A

(Clause 6.2)

STANDARD CATEGORIES OF SURFACE TENSION FOR HYDROMETERS

A-0. GENERAL

A-0.1 The standard categories of surface tension given in Table 4 are adopted for hydrometers for technical use, so as to provide a precise basis for adjustment and verification and to permit the attainment of the appropriate accuracy in measurements in the liquids indicated. The adoption of these surface tension categories does not preclude the use of other surface tensions as the basis of or for the adjustment of hydrometers, provided such surface tensions are marked, in millinewtons per metre, within the hydrometers or reference is made to the type of the liquid (*see* 14.1.0).

A-0.2 If surfaces of aqueous solutions (except those of acetic acid and of nitric acid of density greater than 1.3 g/ml) are specially cleaned, for example, by overflow, then the surface tension is increased to approximately 75 mN/m.

APPENDIX B

(Clause 15.1)

SAMPLING OF DENSITY HYDROMETERS

B-1. SCALE OF SAMPLING

B-1.1 Lot — All the hydrometers of same size, same series/sub-series and same range, shall be grouped together to constitute a lot.

B-1.2 For ascertaining the conformity of the lot to the requirements of the specification, samples shall be tested from each lot separately.

B-1.3 The number of samples to be taken from a lot shall depend on the size of the lot and shall be according to Table 5.

B-1.3.1 The hydrometers in the sample shall be selected at random from the lot. In order to ensure the randomness of selection, procedures given in IS : 4905-1968* may be followed.

*Methods for random sampling.

TABLE 4 STANDARD CATEGORIES OF SURFACE TENSION
(Clause 6.2 and Appendix A)

CATEGORY	DENSITY		SURFACE TENSION mN/m					EXAMPLES OF LIQUIDS TO WHICH The CATEGORY IS APPROPRIATE
	(2) kg/m ³	(3) g/ml	(4)	(3)	(6)	(7)	(8)	
Low	600 700 800 900	Increment 0.6 0.7 0.8 0.9	kg/m ³ 0 g/ml 0.00 15 20 25 30	20 16 21 26 31	40 17 22 27 32	60 18 23 28 33	80 19 24 29 34	(9) Organic liquids generally (including ethers, petroleum distillates, coal tar distillates), and all types of oils
	1 000 to 1 300 inclusive	100 to 130 inclusive		35				Acetic acid solutions, the free surfaces of which have not been specially cleaned
Medium	600 to 940 inclusive	0.60 to 0.94 inclusive		35				Aqueous solutions (including those of ethyl and methyl alcohol, but excluding acetic acid solutions), the free surfaces of which have not been specially cleaned
	950	0.96		35				
	970	0.97		40				
	960 990	0.98 0.99		45 50				
	1 000 to 2 000 inclusive	100 to 200 inclusive		55				Nitric acid solutions of density greater than 1 300 kg/m ³ or 1.3 g/ml, whether the free surfaces of which have been specially cleaned or not
High	1 000 to 2 000 inclusive	100 to 200 inclusive		75				Aqueous solutions, the surfaces of which have been specially cleaned, except: (a) nitric acid of density greater than 1 300 kg/m ³ or 1.3 g/ml, (b) acetic acid solutions*

*Acetic acid solutions show extreme variability of surface tension.

TABLE 5 SCALE OF SAMPLING

NO. OF HYDROMETERS IN THE LOT	SAMPLE SIZE
(1)	(2)
Up to 25	10
26 „ 50	16
51 „ 100	26
101 and above	41

B-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

B-2.1 Accuracy — From the hydrometers selected in the sample according to **B-1.3.1**, the number of hydrometers given in col 2 of Table 5 shall be randomly selected and tested for accuracy. A hydrometer not satisfying the requirements for accuracy shall be considered as defective.

6-2.1.1 The lot shall be considered to have satisfied the requirements for accuracy if the number of defectives found in the sample is less than or equal to the corresponding acceptance number given in col 3 of Table 6.

TABLE 6 NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

NO. OF HYDRO- METERS IN THE LOT	ACCURACY		CHARACTERISTICS OTHER THAN ACCURACY				
	Sample Size	Acceptance Number	Sample No.	Sample Size	Cumula- tive Sample Size	Accept- ance Number	Rejct- ion
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Up to 25	5	0	First	5	5	0	2
			Second	5	10	1	2
26 to 50	8	0	First	8	8	0	2
			Second	8	16	1	2
51 to 100	13	0	First	13	13	0	2
			Second	13	26	1	2
101 and above	20	1	First	20	20	0	3
			Second	20	40	3	4

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B-2.2 The lot having met the requirements for accuracy shall be tested for other requirements of the specification. For this purpose, the hydrometers tested for accuracy and found satisfactory according to **B-2.1** and the hydrometers remaining in the sample drawn according to Table 5 shall be used. A hydrometer failing to satisfy any of these requirements shall be considered as defective.

B-2.2.1 The lot shall be declared as conforming to these requirements if the number of defectives found in the first sample is less than or equal to the corresponding acceptance number given in col 7 of Table 6.

B-2.2.2 The lot shall be rejected without further testing if the number of defectives found in the first sample is greater than or equal to the corresponding rejection number given in col 8 of Table 6.

B-2.2.3 If, however, the number of defectives found in the first sample lies between the corresponding acceptance and rejection numbers given in col 7 and 8 of Table 6, the number of hydrometers given in col 5 of Table 6 against the second sample shall be taken and tested for all these requirements. The lot shall be declared as conforming to these requirements if the number of defectives found in the cumulative sample is less than or equal to the corresponding acceptance number given in col 7 of Table (3), otherwise not.

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 331 01 31
331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :

	<i>Telephone</i>
Central : Manak Bhavan, 9, Bahadur Shah Zafar Marg, NEW DELHI 110002	{ 331 01 31 331 13 75 37 86 62
* Eastern : 1/14 C.I.T. Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	53 16 40
Southern : C.I.T. Campus, IV Cross Road, MADRAS 600113	235 23 15
† Western : Manakalaya, E9 MIDC, Marol, Andheri (East), BOMBAY 400093	632 92 95

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Patliputra Industrial Estate, PATNA 800013	26 23 05
C/o Smt. Sunita Mirakhar, 66 D/C Annexe, Gandhi Nagar, JAMMU (TAWI) 180004	—
T. C. No. 14/1421, University P. O., Palayam, THIRUVANANTHAPURAM 695034	6 21 04
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