MATERIAL STANDARD

FOR

LABORATORY GLASSWARE

AND

RELATED APPARATUS

CONTENTS :

PAGE No.

APPENDICES:

1. SCOPE

This Standard covers the minimum requirements for laboratory glasswares and related apparatus which are used in Iranian Oil Industries.

2. REFERENCES

Throughout this Standard the following standards are referred to. The editions of these standards that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor:

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO 383 (1976)	"Laboratory Glassware-Interchangeable Conical Ground Joints"
ISO 385/2 (1984)	"Laboratory Glassware-Burettes-Burettes for Which No Waiting Time is Specified"
ISO 386 (1977)	"Liquid-in-Glass Laboratory Thermometers-Principles of Design, Construction and Use"
ISO 648 (1977)	"Laboratory Glassware-One-Mark Pipettes"
ISO 695 (1991)	"Glass-Resistance to Attack by a Boiling Aqueous Solution of Mixed Alkali-Method of Test and Classification"
ISO 719 (1985)	"Glass-Hydrolytic Resistance of Glass Grains at 98°C-Method of Test and Classification"
ISO 1042 (1983)	"Laboratory Glassware-One-Mark Volumetric Flasks"
ISO 1769 (1975)	"Laboratory Glassware-Pipettes-Color Coding"
ISO 1773 (1973)	"Laboratory Glassware-Boiling Flasks"
ISO 3585 (1991)	"Borosilicate Glass 3.3-Properties"
ISO 3819 (1985)	"Laboratory Glassware-Bakers"
ISO 4787 (1984)	"Laboratory Glassware-Volumetric Glassware-Methods for Use and Testing of Capacity"
ISO 4791/1 (1985)	"Laboratory Apparatus-Vocabulary Relating to Apparatus Made Essentially from Glass, Porcelain or Vitreous Silica"
ISO 4794 (1982)	"Laboratory Glassware-Methods for Assessing the Chemical Resistance of Enamels Used for Color Coding and Color Marking"
ISO 4799 (1978)	"Laboratory Glassware-Condensers"
ISO 4800 (1977)	"Laboratory Glassware-Separating Funnels and Dropping Funnels"
ISO 4801 (1979)	"Glass Alcoholmeters and Alcohol Hydrometers not Incorporating a Thermometer"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

ASTM E 1-88	Standard Specification for "ASTM Thermometers"

ASTM E 123-78 (Re-approved in 1984) Standard Specification for "Apparatus for Determination of Water by Distillation"

ASTM E 193-64 (Re-approved in 1988) Standard Specification for "Micro Pipettes"

3. DEFINITIONS AND TERMINOLOGY

For the purpose of this Standard in addition to the definitions below, the definitions given in ISO 4791/7 shall apply.

3.1 Capacity

The capacity of a volumetric glassware is defined as the volume of water at 20°C, expressed in cm^3 and/or milliliter, contained by the glassware, when filled to the graduation line.

Note:

Where, the reference temperature is 27°C "if specified" this value shall be substituted for 20°C.

3.2 Delivery Time

The delivery time is defined as the time occupied by the descent of the water meniscus from the upper line to the lowest graduation line. The delivery time is determined with the stopcock "if any" fully open and with the jet not in contact with the side of the receiving vessel.

3.3 Waiting Time

The waiting time, is defined as the period of time to be observed after the stopcock "if any" has been closed and before the final reading has been taken.

3.4 Alcoholometer

An instrument which indicates:

- The alcoholic strength by mass, or
- the alcoholic strength by volume, of a mixture of water and ethanol.

3.5 Solid-Stem Thermometer

Thermometer having a thick-walled capillary stem, on which the scale is etched or marked.

3.6 Enclosed-Scale Thermometer

Thermometer having a capillary stem adjacent to a separate strip bearing the scale, both being enclosed in a protective sheath.

3.7 Contraction Chamber

An enlargement of the bore of the stem of a thermometer which serves to reduce its length, or to prevent contraction of the liquid column into the bulb.

3.8 Density of an Ethanol-Water Mixture at 20°C

The mass of unit volume of the mixture at 20°C. It is expressed in kilograms per cubic meter.

3.9 Volumetric Accuracy

Where two classes of accuracy are required;

- The higher grade shall be designated "Class A"; or fine class.
- The lower grade shall be designated "Class B"; or coarse class.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. SPECIFIC REQUIREMENTS

5.1 General Requirements for Volumetric Glasswares

5.1.1 The numerical values of limits of volumetric error for articles shall comply with specified values in this Standard which for general purposes will be chosen from the R "10 series of preferred numbers.

5.1.2 Where two classes of accuracy are required and permitted values of volumetric error are not specified for one of those classes, then the limits of volumetric error permitted for Class B shall in general, be approximately twice those permitted for Class A; However for all articles having a scale, the maximum permitted volumetric error for either class of accuracy shall not exceed the volume equivalent of the smallest scale division.

5.1.3 Material

Volumetric glassware shall be constructed of glass of suitable chemical and thermal properties. It shall be as free as possible from visible defects and shall be reasonably free from internal stress.

If Alkali resistance glass is required, the loss in mass per total surface area of the glass "when tested for 3 hours in a boiling aqueous of sodium carbonate and sodium hydroxide" shall comply with Table 1. Test method, shall be in accordance with ISO 695.

TABLE 1 - LIMIT VALUES IN THE ALKALI RESISTANCE TEST

CLASS	CHARACTERISTICS	LOSS IN MASS PER TOTAL SURFACE AREA AFTER 3h mg/dm² 1)
A1	Low Attack	Up to 75
A2	Slight Attack	Above 75 up to 175
A3	High Attack	Above 175

1) mg/dm² denotes the glass loss under certain circumstances in milligram divided by deci square meter.

5.1.4 Shape

5.1.4.1 All articles shall be of a shape which will facilitate emptying and drainage, and should preferably be of circular cross-section.

5.1.4.2 The shape of articles shall be so designed that articles are convenient and satisfactory for its intended use.

5.1.4.3 All articles shall be sufficiently robust in construction to withstand normal usage and the wall thickness shall show no gross departure from uniformity.

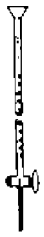
5.1.5 The numerical values of capacity of articles of volumetric glassware for general purposes should preferably be chosen from the series 10, 20, 25 and 50, or a decimal multiple or submultiple thereof.

5.1.6 The numerical value of the volume equivalents of the smallest division on articles having a scale shall be chosen from the series 1, 2 and 5, or a decimal multiple or submultiple thereof. Some typical shapes of different laboratory glasswares are given in Fig. 1:

Conical Shoulder Regent Bottle, Narrow or Wide Mouth

Aspirator Bottle

Bulb Burette

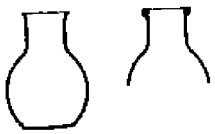


Burette with Funnel

Graduated Pipette (Adjusted for Delivery Down to Jet)

One-Mark (Bulb) Pipette

Conical Flask (Erlenmeyer Flask) (Narrow or Wide Mouth)



Short Wide Neck, Flat Bottom Flask

SOME TYPICAL SHAPES OF DIFFERENT LABORATORY GLASSWARES
Fig. 1

(to be continued)

Straight Bore Stopcock

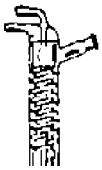
Straight Bore Stopcock, with Capillary Side Arms

Hollow Stopper

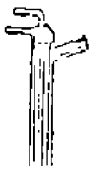
Flat Head Stopper

Tall Form Beaker (Berzelius Beaker)

Conical Beaker (Phillips Beaker)



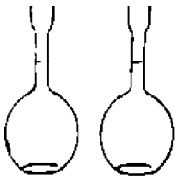
Friedrichs Condenser



Hopkins Condenser

Funnel

Looped-Stem Funnel



Regnault Pyknometer

Reischauer Pyknometer

Fig. 1 (continued)

5.1.7 Stability

Vessels provided with a flat base shall stand firmly thereon without rocking when placed on a level surface and, unless specified otherwise, the axis of the graduated portion of the vessel should be vertical. Vessels shall not topple when placed empty on a surface inclined 15° to the horizontal.

Vessels provided with a base which is not circular shall meet this requirement in all directions.

5.1.8 Delivery jet

5.1.8.1 Delivery jets if any should be strongly constructed with a smooth and gradual taper without any sudden constriction at the orifice.

5.1.8.2 The end of the jet shall be finished by one of the methods listed below in order of preference:

- **a)** smoothly ground square with the axis slightly beveled on the outside and fire-polished;
- **b)** smoothly ground square with the axis and slightly beveled on the outside;
- **c)** cut square with the axis and fire-polished.

A fire-polished finish reduces the danger of chipping in use, but anyhow should not result undue stress.

5.1.8.3 The jet should form an integral part of an article intended for Class A and should preferably form an integral part of an article intended for Class B.

5.1.9 Stoppers

5.1.9.1 Glass stoppers should preferably be ground so as to be interchangeable, in which case the ground portions shall comply with ISO 383. If individually fitted, they shall be well ground so as to prevent leakage, preferably with a taper of approximately 1/10.

5.1.9.2 Stoppers of a suitably inert plastics material may be permitted as an alternative to glass. In such cases, the glass socket into which the stopper fits should preferably comply with ISO 383.

5.1.10 Stopcocks or similar devices

5.1.10.1 Stopcocks and similar devices shall be designed to permit smooth and precise control of outflow and to prevent a rate of leakage greater than that allowed in this Standard for the specific article.

5.1.10.2 Stopcocks and similar devices shall be made from glass or from suitable inert plastics material.

5.1.10.3 All-glass stopcocks shall have the key and barrel finely ground preferably to a taper of 1/10.

5.1.10.4 Glass stopcock barrels to receive plastics keys shall be polished internally.

5.1.10.5 Stopcock components may be fitted with suitable retaining devices.

5.1.11 Graduation lines

Graduation lines shall be clean, permanent lines of uniform thickness.

5.1.11.1 A maximum thickness of graduation line shall be specified appropriate to the particular article and its class of accuracy. This thickness shall not exceed one-half of the linear equivalent of the limit of volumetric error.

5.1.11.2 On articles having a scale, the specified maximum thickness of lines shall not exceed one-quarter of the minimum distance between centers of adjacent lines.

5.1.11.3 All graduation lines shall lie in planes at right angles to the longitudinal axis of the graduated portion of the article. On articles provided with a flat base, the graduation lines shall therefore lie in planes parallel to the base.

5.1.11.4 In general, graduation lines should be confined to cylindrical portions of an article's cross-section. In special circumstances, preferably for Class B articles only where specified, graduation lines may be provided on a parallel side portion of non-circular cross-section or on a conical or tapered portion of the article.

5.1.11.5 On articles not having a scale, all graduation lines should extend completely round the circumference of the article, except that a gap, not exceeding 10% of the circumference, is permitted. In the case of an article which is restricted as to the normal direction of viewing in use, this gap should be at the right or left of the normal direction of view.

5.1.12 Scales

5.1.12.1 Spacing of graduation lines

5.1.12.1.1 There should be no evident irregularity in the spacing of graduation lines (except in special cases where the scale is on a conical or tapered portion of the article).

5.1.12.1.2 The minimum distance between the centers of adjacent graduation lines shall be not less, in relation to diameter, than that calculated from the formula.

(0.8 + 0.0 D) m

Where D is the maximum permitted internal diameter of the tube in millimeters.

5.1.12.2 Length of graduation lines (see Fig. 2)

5.1.12.2.1 On articles of circular cross-section having a scale, the length of the graduation lines shall be varied so as to be clearly distinguishable and shall be in accordance with one of the provisions of 5.1.12.2.2, 5.1.12.2.3 or 5.1.12.2.4 as specified in specific requirements.

5.1.12.2.2 Graduation pattern I

a) The length of the short lines should be approximately, but not less than, 50% of the circumference of the article.

b) The length of the medium lines should be approximately 65% of the circumference of the article and should extend symmetrically at each end beyond the end of the short lines.

c) The long lines should extend completely round the circumference of the article, but a gap, not exceeding 10% of the circumference, is permitted (see 5.1.11.5).

5.1.12.2.3 Graduation pattern II

a) The length of the short lines should be not less than 10% and not more than 20% of the circumference of the article.

b) The length of the medium lines should be approximately 1.5 times the length of the short lines and should extend symmetrically at each end beyond the end of the short lines.

c) The long lines should extend completely round the circumference of the article, but a gap, not exceeding 10% of the circumference, may be permitted (see 5.1.11.5).

5.1.12.2.4 Graduation pattern III

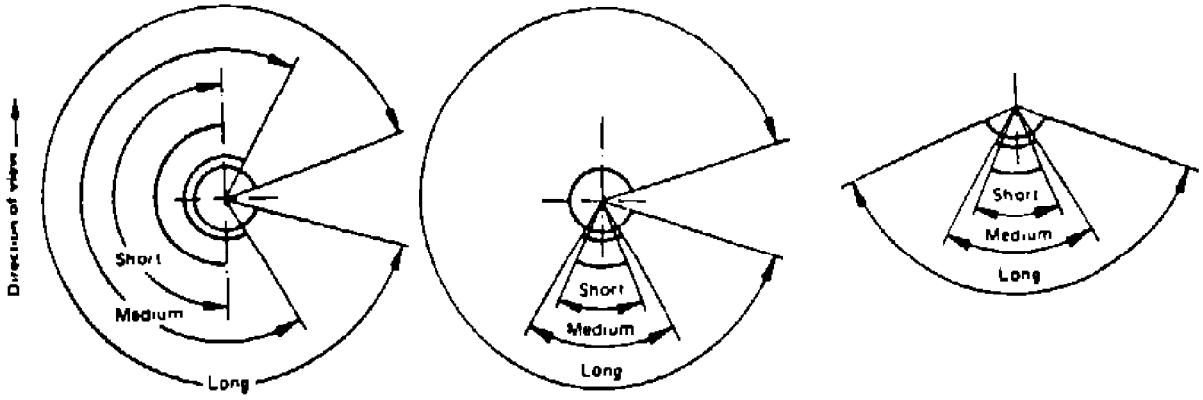
a) The length of the short lines should be not less than 10% and not more than 20% of the circumference of the article.

b) The length of the medium lines should be approximately 1.5 times the length of the short lines and should extend symmetrically at each end beyond the ends of the short lines.

c) The length of the long lines should be not less than twice the length of the short lines and should extend symmetrically at each end beyond the ends of the short and medium lines.

Note:

Any other graduation pattern or any modification on given patterns needs written permission of Company.



Graduation Pattern I **Graduation Pattern II** **Graduation Pattern III**

LENGTH AND POSITION OF GRADUATION LINES
Fig. 2

5.1.13 Sequence of graduation lines

5.1.13.1 On articles in which the volume equivalent of the smallest scale division is 1 ml (or a decimal multiple or submultiple thereof):

a) every tenth graduation line is a long line;
b) there is a medium line midway between two consecutive long lines;
c) there are four short lines between consecutive medium and long lines.

5.1.13.2 On articles in which the volume equivalent of the smallest scale division is 2 ml (or a decimal multiple or submultiple thereof):

a) every fifth graduation line is a long line;
b) there are four short lines between two consecutive long lines.

5.1.13.3 On articles in which the volume equivalent of the smallest scale division is 5 ml (or a decimal multiple or submultiple thereof):

a) every tenth graduation line is a long line;
b) there are four medium lines equally spaced between two consecutive long lines;
c) there is one short line between two consecutive medium lines or between consecutive medium and long lines.

5.1.14 Figuring of graduation lines

The requirements given in 5.1.14.1, 5.1.14.2 and 5.1.14.3 shall be applied for articles for which figuring of graduation lines are not specified.

5.1.14.1 On articles having one, two or three graduation lines, the numbers representing nominal capacity need not be adjacent to the lines to which they relate.

5.1.14.2 On articles having one principal graduation line and a small number of subsidiary lines, the number representing the principal capacity need not be adjacent to the principle line, provided that the subsidiary graduation lines are suitably identified.

5.1.14.3 On articles having scale

a) the scale shall be so figured as to enable the value corresponding to each graduation line to be readily identified;

b) the scale should normally have only one set of figures;

c) at least every tenth line shall be figured;

d) figures shall be confined to long graduation lines and should be placed immediately above the line and slightly to the right of the adjacent shorter graduation lines;

e) where it is necessary in special cases to use a number relating to a medium or short graduation line, the number should be placed slightly to the right of the end of the line in such a way that an extension of the line would bisect it.

5.1.15 Visibility of graduation lines, figures and inscriptions

5.1.15.1 All figures and inscriptions shall be of such size and form as to be clearly legible under normal conditions of use.

5.1.15.2 All graduation lines, figures and inscriptions shall be clearly visible and permanent.

5.1.15.3 The durability of graduation lines and inscriptions shall be tested by the methods described in ISO 4794.

5.1.16 Laboratory glass wares which for them, special requirements are given in this Standard shall conform the general requirements of this Standard as applicable.

5.2 Requirements for Laboratory Bottles

5.2.1 Material

Laboratory bottles shall be made of any material which is required. If glass bottles are required, they shall be constructed of clear colorless or amber glass of suitable chemical and thermal properties.

Internal stress and visible defects in the glass (such as bubbles near the surface) shall be reduced to a level sufficient to minimize the possibility of fracture due to thermal or mechanical shock. The bottle shall be blown so as to achieve a good distribution of glass in the mould without sudden change in wall thickness.

5.2.2 The shoulder of the bottle shall have a suitable radius in order to provide a smooth transition between the side and the conical upper portion of the bottle.

5.2.3 The upper portion of the screw necked bottle is better to be of conical shape with an included angle of $90^{\circ}{}^{0}_{-5^{\circ}}$. The transition radius to the neck shall be as small as possible compatible with good manufacturing practice.

5.2.4 Preferred nominal capacities are 50, 100, 250, 500, 1000, 2000, 5000 and 10000 mL. 5000 and 10000 mL bottles shall be equipped with stoppers and handles.

5.2.5 The neck of the bottle shall be stoutly constructed and, in the case of ground conical necks, finished with a strengthening lip formed to facilitate pouring without liquid running down the outside of the bottle. A clip-on anti-drip ring of plastics material fitting into a slightly recessed channel on the outside of the neck is a permitted alternative form of construction.

5.2.6 Bottles shall preferably be provided with stoppers, closures which shall be of glass or a suitable inert plastics material.

5.2.7 If required, laboratory bottles shall be equipped with stoppers, handles, stopcocks, aspirators, caps with or without screwed neck, tubes for tubing and etc.

5.2.8 General requirements of bottles shall comply with Sub-clause 5.1 as appropriate.

5.3 Requirements for Burettes

5.3.1 General requirements for burettes

5.3.1.1 Volumetric accuracy

There shall be two classes of accuracy:

- Class A for the higher grade.
- Class B for the lower grade.

In neither class shall the limit of volumetric error exceed the smallest scale division.

5.3.1.2 Capacities and related scales

Nominal capacities of burettes and the related small scale divisions are given in Table 2.

Errors in delivered volume shall not exceed the limits given in ISO 384.

Test shall be carried out in accordance with ISO 4787.

TABLE 2 - CAPACITIES, SUB-DIVISIONS [1)]

NOMINAL CAPACITY ml	SMALLEST SCALE DIVISION ml
1	0.01
2	0.01
5	0.02
10	0.02
10	0.05
25	0.05
25	0.1
50	0.1
100	0.2

1) If burettes are required with nominal capacities and/or sub-divisions other than those listed in this table, and the limitation of errors is not specified, then the actual limitation of errors shall not have any non-conformity with this Standard (e.g. see 5.1.2).

5.3.1.3 Material

Shall comply with 5.1.3.

5.3.1.4 Top of burette

The top of each burette, if not provided with a filling device, shall be smoothly finished with a strengthening flange or bead, and shall be at right angles to the axis of the burettes. Burettes with sub-divisions of 0.05 ml or less, if not fitted with a filling stopcock, should preferably be finished with a cylindrical cup at the top. Larger diameter burettes may be fitted with a funnel top for special purposes.

The length of tube of uniform bore between the zero graduation line and the cup shall be at least 20 mm.

5.3.1.5 Stopcocks

Shall comply with 5.1.10.

5.3.1.6 Delivery jet

Shall comply with 5.1.8.

5.3.1.7 Stopcock leakage

A stopcock of conventional design made entirely of glass or intended for use with grease shall be tested for leakage with the burette clamped in a vertical position, the stopcock free from grease, the barrel and key wetted with water, and the burette filled initially to the zero line with water. The rate of leakage, with the key in either of the fully shut-off positions, shall not exceed one scale sub-division in the case of Class A burettes or two scale sub-divisions in the case of Class B burettes, in 20 min.

Other all-glass stopcocks shall be subjected to similar tests with their component parts free from grease and wetted with water.

In addition to this test, a double-bore stopcock shall not show a rate of leakage greater than that given above when tested similarly, with the burette empty, the key of the stopcock in the normal delivery position and the filling tube connected to a suitable graduated tube filled with water to a level of 250 mm above the zero line of the burette.

If the stopcock is of such material that it is intended for use without grease, it shall be tested in a similar manner. The rate of leakage shall not exceed one half of one scale sub-division in the case of Class A burettes, or one scale sub-division in the case of B burettes, in 50 min.

For all leakage tests, in order to ensure a sufficiently accurate determination, precautions shall be taken against large temperature changes (and evaporation) during the period of test.

5.3.1.8 Graduation lines

In addition to requirements given in 5.1.11 the thickness of lines shall not exceed 0.3 mm., length of graduation lines shall be as below:

- graduation pattern I as specified in 5.1.12.2.2 applies to Class A burettes;
- graduation pattern III as specified in 5.1.12.2.4 applies to Class B burettes;
- graduation pattern II as specified in 5.1.12.2.3, may also apply to Class B burettes (not preferred).

5.3.1.9 Sequence of graduation lines shall comply with 5.1.13.

5.3.1.10 Figuring of graduation lines

All burettes shall be figured downwards from zero at the top, at the intervals shown in Table 3.

TABLE 3 - FIGURING OF GRADUATION LINES

SMALLEST SCALE DIVISION	m1	0.01	0.02	0.05	0.1	0.2
FIGURED AT EVERY	m1	0.1	0.2	0.5	1	2

Figures shall be placed immediately above the long lines to which they refer and slightly to the right of the end of the adjacent shorter lines. In the case of graduation pattern III, the figures may be placed slightly to the right of the end of the line to which they refer, in such a way that an extension of the line would bisect them.

5.3.1.11 Position of graduation lines for different graduation patterns shall be as illustrated in Fig. 2.

5.3.1.12 Visibility of graduation lines, figures and inscriptions shall conform with 5.1.15.

5.3.1.13 Setting of the meniscus

Setting of the meniscus shall be carried out as below:

The meniscus shall be set so that the plane of the center of the graduation line is horizontally tangential to the lowest point of the meniscus. The eye shall be raised towards the plane and shall observe the front and back portions of the line apparently meeting the lowest point simultaneously.

5.3.1.14 Inscriptions

The following inscriptions shall be marked on each burette:

- **a)** the symbol "cm³" or the symbol "ml" or mL to indicate the unit in terms of which the burette is graduated;
- **b)** the inscription "20°C" to indicate the reference temperature[1)];
- **c)** the letters "Ex" to indicate that the burette has been adjusted to deliver its indicated capacity;
- **d)** the inscription "A" or inscription "B" to indicate the class of accuracy for which the burette has been adjusted;
- **e)** the maker's and/or Vendor's name or mark;
- **f)** any other inscriptions if required in data-sheet.

5.3.2 Delivery times for burettes shall be as specified in Table 4.

Note:

For measuring of capacity corresponding to any graduation line, no period being required for drainage of liquid adhering to the wall before making the final setting.

TABLE 4 - DELIVERY TIMES OF BURETTES

NOMINAL CAPACITY	SMALLEST SCALE DIVISION	DELIVERY TIME			
		CLASS A		CLASS B	
ml	ml	min. s	max. s	min. s	max. s
1	0.01	35	45	20	45
2	0.01	50	70	25	70
5	0.02	75	95	40	95
10	0.02	75	95	40	95
10	0.05	75	95	45	75
25	0.05	70	100	35	100
25	0.1	45	75	25	75
50	0.1	60	100	30	100
100	0.2	60	100	30	100

1) Where, exceptionally, the reference temperature is 27°C, this value shall be substituted for 20°C.

5.4 Requirements for Volumetric Pipettes

5.4.1 General requirements

Volumetric pipettes shall be made of borosilicate glass and shall be calibrated to deliver the intended capacity at 20°C and shall consist in general of a suction tube and a delivery tube separated by a bulb, and all three parts shall be permanently attached together. Any cross-section of the pipette taken in a plane perpendicular to the longitudinal axis shall be circular. The shape shall permit complete emptying and thorough cleaning. Maximum outflow time for pipettes shall be 60 second.

The length of the suction tube shall be 150 to 190 mm and the minimum wall thickness of both suction and delivery tubes shall be 0.90 mm. Pipettes must comply with the essential dimensions given in Table 5.

Delivery tips shall be made with a gradual taper of 1.5 to 3 cm. The end of the tip shall be perpendicular to the longitudinal axis of the tip. The outside edge of the tip may be beveled slightly and the end and the bevel shall be ground or fire-polished. Sudden constriction at the orifice would impair smooth flow characteristics of the delivery stream and is not acceptable. Workmanship, marking and graduation lines of pipettes shall comply with pertenant requirements of Sub-clause 5.1.

TABLE 5 - REQUIREMENTS FOR VOLUMETRIC PIPETTES

NOMINAL CAPACITY, ml	CAPACITY TOLERANCE, ml		LENGTH OF DELIVERY TUBE mm		INSIDE DIAMETER AT CAPACITY MARK mm		MAX. DISTANCE BETWEEN BULB AND GRADUATION MARK mm	MINIMUM OUTFLOW TIME S[A]		COLOR-CODING BAND
	Class A	Class B	min.	max.	min.	max.		Class A	Class B	
1	±0.006	±0.012	100	140	2	4	60	10	3	Blue
2	±0.006	±0.012	120	150	2	4	60	10	3	Orange
5	±0.01	±0.02	130	170	2	4	60	10	8	White
10	±0.02	±0.04	150	190	2	4	70	15	8	Red
25	±0.03	±0.06	230	260	3.5	5.5	70	25	15	Blue
50	±0.05	±0.10	230	260	4	6	70	25	15	Red
100	±0.08	±0.16	230	260	5	7	80	30	20	Yellow

5.5 Requirements for Micropipettes

Micropipettes shall be supplied in accordance with ASTM E 193-64 (Re-approved in 1988). The types given in Figs. 1, 2 and 3 of the above-mentioned standard are not preferred types but shall be supplied if ordered.

The numerical values of capacity of micropipettes should preferably be selected from the series of 1, 2, 2.5, 5 and 10 or decimal multiple or sub-decimal multiple, thereof and in accordance to ASTM E 193-64. Except otherwise specified, all characteristics as well as the dimensions and tolerances, given in the same standard shall be applicable.

5.6 Requirements for Graduated Measuring Cylinders

These cylinders shall be required only in one class of accuracy, and as requested they may be provided either with a pouring spout or with a ground neck and a suitably fitting stopper.

If required cylinders shall be supplied with key used to loosen top of cylinder.

5.6.1 Series of capacities, divisions and tolerances shall be as given in Table 6.

TABLE 6 - SERIES OF CAPACITIES, DIVISIONS AND TOLERANCES

NOMINAL CAPACITY	SMALLEST SCALE DIVISION	MAXIMUM PERMITTED ERROR [1)]	MAXIMUM CAPACITY CORRESPONDING TO LOWEST GRADUATION LINE
ml	ml	±ml	ml
10	0.2	±0.2	1
25	0.5	±0.5	2.5
50	1	±1	5
100	1	±1	10
250	2	±2	20
500	5	±5	50
1000	10	±10	100
2000	20	±20	200

1) These errors represent the maximum permissible error at any point and also the maximum permissible difference between the errors at any two points.

5.6.2 Material of graduated measuring cylinders shall comply with 5.1.3.

5.6.3 Robustness of graduated measuring cylinders shall comform with 5.1.4.3.

5.6.4 Stability of graduated measuring cylinders shall comply with 5.1.7.

5.6.5 The base shall be of glass, or a suitable plastics material, and may be either circular or of other suitable form provided the cylinder satisfies the requirements of 5.6.4.

5.6.6 Rim and spout

5.6.6.1 The rim of the cylinder shall be fire - polished and shall lie in a plane at right angles to the axis of the cylinder.

5.6.6.2 The spout of a spouted cylinder shall be so formed as to enable the contents of the cylinder to be poured out in a narrow stream without spilling or running down the outside of the cylinder.

5.6.7 Stoppers of graduated measuring cylinders shall comform with 5.1.9.

5.6.8 Dimensions

The cylinders shall comply with the dimensional requirements shown in Table 7.

TABLE 7 - DIMENSIONS

CAPACITY	INTERNAL HEIGHT TO HIGHEST GRADUATION LINE min.	OVERALL HEIGHT [1)] max.	DISTANCE FROM HIGHEST GRADUATION LINE TO TOP OF CYLINDER OR BASE OF NECK min.
ml	mm	mm	mm
10	65	140	20
25	85	170	25
50	110	200	30
100	145	260	35
250	200	335	40
500	250	390	45
1000	310	470	50
2000	380	570	50

1) In the case of a stoppered cylinder, the "overall height" shall be considered to be height to the base of the neck.

5.6.9 Graduation lines

5.6.9.1 Graduation lines shall be clean, permanent uniform lines of thickness not exceeding;

0.3 mm for cylinders of nominal capacity	5	and	10 ml;
0.4 mm for cylinders of nominal capacity	25, 50, 100	and	250 ml;
0.5 mm for cylinders of nominal capacity	500, 1000	and	2000 ml.

5.6.9.2 All graduation lines shall lie in planes at right angles to the longitudinal axis of the cylinder.

5.6.9.3 Graduation lines may be omitted from the bottom portion of the cylinder, but the ungraduated capacity shall not exceed the maximum value specified in Table 6.

5.6.10 Spacing of graduation lines

There shall be no evident irregularity in the spacing of the graduation lines.

5.6.11 Graduation lines shall comply with 5.1.12.2.4.

5.6.12 Sequance of graduation lines

On cylinders of capacities 5 ml, 50 ml, 100 ml and 1000 ml the sequance of graduation lines "when reading the scale from the top" shall conform with 5.1.13.1.

On cylinders of capacities 10 ml, 250 ml and 2000 ml the sequance of graduation lines "when reading the scale from the top" shall comply with 5.1.13.2.

On cylinders of capacities 25 ml and 500 ml the sequance of graduation lines "when reading the scale from the top" shall be as specified in 5.1.13.3.

5.6.13 Position of graduation lines

The graduation lines shall form a vertical scale on the cylinder. On a spouted cylinder the spout shall be to the left when the cylinder is positioned with the scale facing the viewer.

5.6.14 Figuring of graduation lines

Graduation lines shall be figured in accordance with the following principles.

5.6.14.1 On a cylinder of 250 ml capacity, alternate long lines shall be figured from 20 to 240 with an additional Fig. 250; alternatively, alternate long lines shall be figured from 30 to 250 ml. On cylinders of 10 ml and 2000 ml capacity, alternate long lines shall be figured.

5.6.14.2 On all cylinders except those of 10 ml, 250 ml and 2000 ml capacity, every long line shall be figured.

5.6.14.3 The scheme of figuring shall be such that the figure representing the nominal capacity refers to the highest graduation line.

5.6.14.4 Figures shall be placed immediately above the long lines to which they refer and slightly to the right of the adjacent shorter lines. The figures shall alternatively be placed slightly to the right of the end of the line to which they refer in such a way that an extension of the line would bisect them.

5.6.15 Inscriptions

Inscriptions shall be as specified in the 5.3.1.14 with the exceptions as following:

- instead of symbol "Ex" symbol "In" shall be marked, symbol "In" indicates that the cylinder has been adjusted to contain its indicated capacity;

- items "d" and "f" shall be omitted;

- cylinder with a standard interchangeable stopper, the size number of the joint shall be marked on both the cylinder and the stopper;

- cylinders with non-interchangeable stoppers, an identification number should be marked on both the cylinder and the stopper.

5.6.16 Visibility of graduation lines, fingures and inscriptions shall be as specified in 5.1.15.

5.7 Requirements for Flasks

5.7.1 Boiling flasks

5.7.1.1 Series of capacities

The series of nominal capacities of conical flasks is as follows:

25, 50, 100, 250, 500, 1000, 2000, 3000, 5000, 10000 ml [1)].

5.7.1.2 Material

5.7.1.2.1 General

Flasks shall be made from borosilicate glass of suitable chemical and thermal properties, shall be as free as possible from visible defects and shall be reasonably free from internal strain.

5.7.1.2.2 Hydrolytic resistance

When the glass is tested in accordance with ISO/R 719, the amount of alkali extracted, expressed as Na_2O, shall not be greater than 25 μg per gram of glass.

5.7.1.2.3 Thermal shock resistance

The glass shall have a maximum coefficient of linear thermal expansion of 5.5×10^{-6}/°C over the temperature range 20 to 300°C.

5.7.1.3 Shape and dimensions

Boiling flasks may be required in conical shape and round shape. Round shapes may be ordered in flat bottom or in round bottom.

5.7.1.3.1 Neck

The neck of the flask shall be substantially circular in cross-section and the mouth of the neck shall not be belled to any considerable distance from the top. The top of the neck shall be suitably strengthened. The length of the neck should be 1 to 1.25 times the external diameter of the neck.

5.7.1.3.2 Dimensions of base

The radius at the junction between the base and the side of conical shape flasks should be between 15 and 20% of the maximum external diameter, and diameter of the base of a round shape-flat bottom flasks should be approximately 50% of the maximum external diameter.

1) 10000 ml flasks may, only be used for round shape.

5.7.1.3.3 Stability

The flat bottom round or conical flasks shall stand vertically without rocking or spinning when placed on a level surface.

5.7.1.4 Inscriptions

The following inscriptions shall be permanently and legibly marked on all conical flasks:

a) the nominal capacity of the flask, for example "100 ml" (or "100");
b) the maker's or Vendor's name or mark;
c) the size of the conical ground joint for round flasks.

Each flask shall also bear an area with a surface suitable for marking with pencil.

5.7.1.5 Details of dimensions preferably should comply with ISO 1773 and conical ground joints of round flasks "if required" should preferably be selected in accordance with ISO 4797.

5.7.2 Volumetric flasks

5.7.2.1 Series of capacities

The series of capacities of volumetric flasks are as follows:

50, 100, 200, 250, 500 and 1000 ml.

All these flasks may be finished with a plain neck or be provided with a stopper.

5.7.2.2 Accuracy

The capacity of the flask shall not differ from the nominal capacity by more than the maximum permitted errors shown in Table 8.

TABLE 8 - MAXIMUM PERMITTED ERRORS ON CAPACITY

NOMINAL CAPACITY	MAXIMUM PERMITTED ERRORS	
	Class A	Class B
50	±0.06	±0.12
100	±0.10	±0.20
200	±0.15	±0.30
250	±0.15	±0.30
500	±0.25	±0.50
1000	±0.40	±0.80

5.7.2.3 Construction

Material of volumetric flasks shall comply with 5.1.3. The wall thickness, shape, neck, stopper (if required), dimensions and graduation line shall comply with ISO 1042.

5.7.3 Distillation flasks

5.7.3.1 Series of capacities shall be 500 and 1000 ml.

5.7.3.2 Material

Distillation flasks shall be made of heat-resistant-glass.

5.7.3.3 Shape and dimensions

Flasks may be required in round shape with 500 and 1000 ml capacities and in conical shape with 500 ml only. The details of dimensions shall comply with ASTM E 123-78 (re-approved in 1984). Condensers "if required" shall be a Liebig or West straight type with a jacket not less than 400 mm with details given in the above-mentioned standard. Traps may be required with 5, 10 or 25 ml capacities as mentioned in detail in ASTM E 123.

5.8 Requirements for Joints

5.8.1 Interchangeable conical ground joints

5.8.1.1 Taper

The taper of the joints shall be such as to give one increment on diameter for ten increments on axial length, with a tolerance of ±0.006 on the diameter increment, i.e. a taper of (1.00 ±0.006)/10.

5.8.1.2 Large end diameters

The following series of large end diameters may be required:

14.5, 18.8, 24, 29.2 mm.

5.8.1.3 Dimensions and tolerances

Length of ground zone is given in Table 9. If the required length is not specified, K6 series shall be supplied.

TABLE 9 - LENGTH OF GROUND ZONE

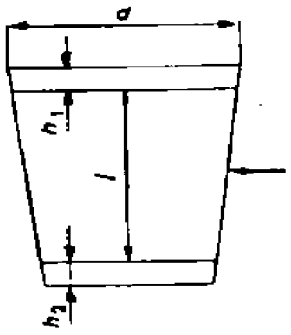
LARGE END DIAMETER	LENGTH OF GROUND ZONE [1)]			
	K2 SERIES	K4 SERIES	K6 SERIES	K8 SERIES
14.5		15	23	30
18.8	9	17	26	35
24	10	20	29	39
29.2	11	22	32	43

1) The length of the ground zone l, see Fig. 3 in millimeters, is calculated using the formula:

$$l = k\sqrt{d}$$

Where:

k is a constant; (k = 6 is preferred)
d is the large end diameter, in millimeters.



$$\text{Taper} = \frac{1}{10}$$

(Increase of diameter/length)

Fig. 3

Other dimensions according to Fig. 3 is given in Table 10.

TABLE 10 - DIMENSIONS AND TOLERANCES

NOMINAL DIAMETER OF JOINT	d	K2 SERIES NON-PREFERRED 1 2 2			K4 SERIES NON-PREFERRED 1 2 2			K6 SERIES PREFERRED 2 2			K8 SERIES NON-PREFERRED 2 2		
		l	h_1	h_2	l	h_1	h_2	1^1	h_1	h_2	1^1	h_1	h_2
14.5	14.6 ±0.010				14	2	2	22	2	2	29	2.5	2
18.8	18.9 ±0.015	8	2.5	2	16	2	2	25	2	2	34	2.5	2
24	24.1 ±0.015	9	2.5	2	19	2	2	28	2	2	38	2.5	2
29.5	29.3 ±0.015	10	2.5	2	21	2	2	31	2	2	40	2.5	3.5

1) Tolerance on l = ±0.015.

2) Tolerance on h_1 and h_2 = ±0.010.

Note:

If required nominal diameter of joint is different from the values given in Table 10. The relevant preferred dimensions and tolerances shall be chosen from K6 series.

5.8.1.4 Surface finish

The center-line-average height of the ground surface shall be less than 0.5 μm.

Note:

The "center-line-average height" of the ground surface is the average value R_a of the roughness as defined in ISO/R 468.

5.8.1.5 Designation

Joints shall be designated as below:

$$\mathbf{d/\tau \text{ or } \frac{d}{\tau}}$$

Where:

d is the large end diameter of the joint.
τ is the length of ground zone.

5.8.2 Interchangeable spherical ground joints

5.8.2.1 Dimensions and tolerances

Dimensions and tolerances of spherical ground joints (in respect to Fig. 4) shall be in accordance with Table 11.

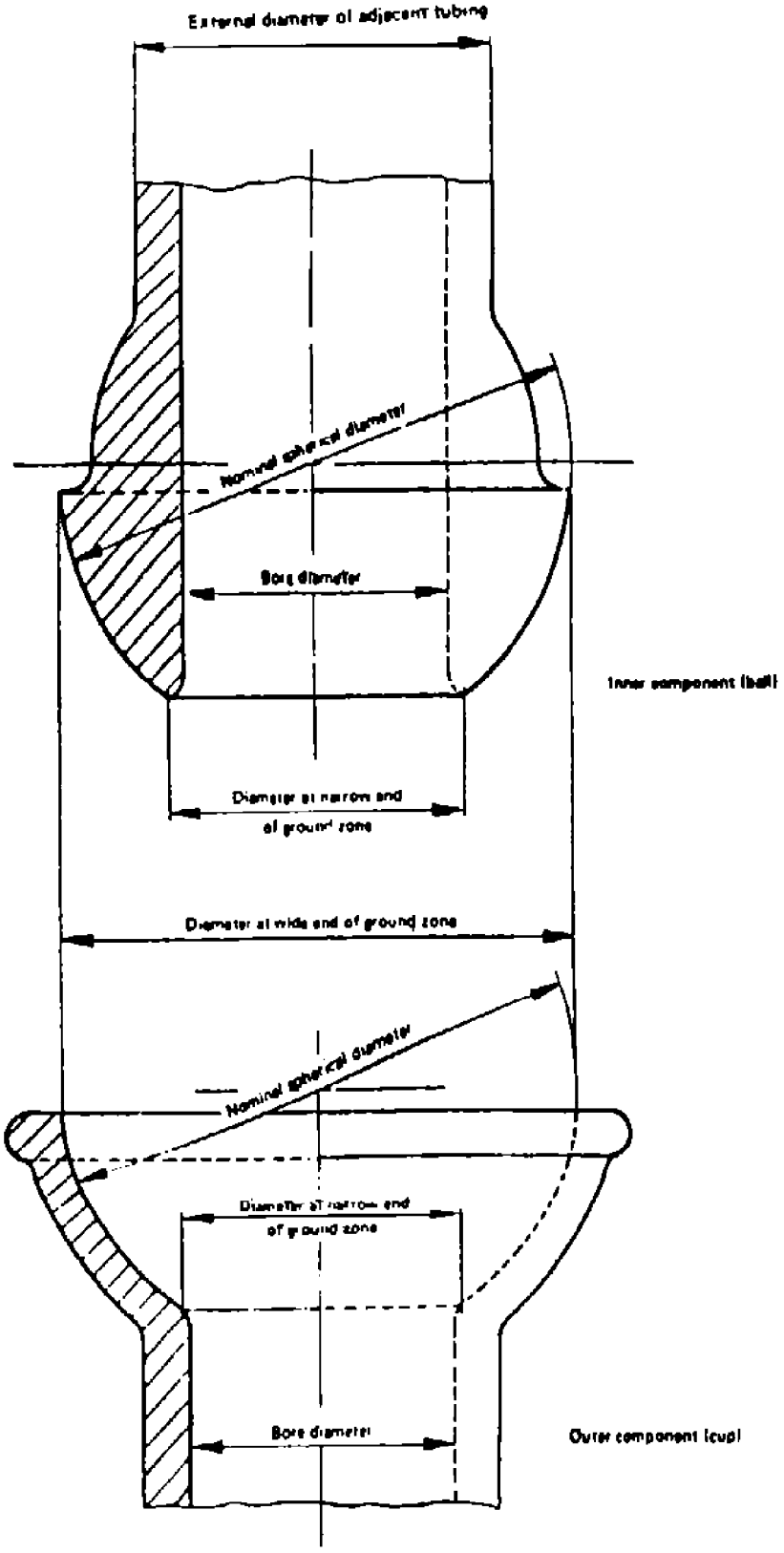
TABLE 11 - DIMENSIONS AND TOLERANCES OF SPHERICAL GROUND JOINTS

Dimensions in millimeters

1	2	3	4	5	6	7
SIZE DESIGNATION	SPHERICAL DIAMETER			MINIMUM DIAMETER AT WIDE END OF GROUND ZONE	MAXIMUM DIAMETER AT NARROW END OF GROUND ZONE	MAXIMUM EXTERNAL DIAMETER OF ADJACENT TUBING
	NOMINAL DIMENSION	TOLERANCE ON INNER COMPONENT	TOLERANCE ON OUTER COMPONENT			
S 7	7.144	0 -0.025	+0.025 0	6.9	2.0	4.5
S 13	12.700	0 -0.025	+0.025 0	12.5	7.0	9
S 19	19.050	0 -0.025	+0.025 0	18.7	12.5	14
S 29	28.575	0 0.025	+0.025 0	28.0	19.0	22
S 35	34.925	0 0.025	+0.025 0	34.3	27.5	30
S 41	41.275	0 -0.025	+0.025 0	40.5	30.0	34
S 51	50.800	0 -0.025	+0.025 0	50.0	36.0	43
S 64	63.500	0 -0.035	+0.035 0	62.5	47.0	53
S 76	76.200	0 -0.040	+0.040 0	75.0	58.0	64
S 102	101.600	0 -0.050	+0.050 0	100.0	84.0	85

Testing of inner and outer components (ball and cup) of spherical ground joints shall be carried out according to ISO 641.

5.8.3 If the dimensions of required ground joints are different with this Standard, other requirements shall conform with this Standard as far as applicable.



DIMENSIONS OF SPHERICAL JOINTS
Fig. 4

5.9 Requirements for Glass Tubing

5.9.1 Material

5.9.1.1 Tubing shall be made from borosilicate glass complying with the requirements of ISO 3585. It shall be as free as possible from striae and other defects that may interfere with vision or service, and shall be reasonably free from internal strain.

Materials other than borosilicate glass is permitted if not less qualification than the borosilicate glass.

5.9.1.2 Hydrolytic resistance

When the glass is tested in accordance with ISO/R 719, the amount of alkali extracted from the glass shall not be greater than 31 μg of Na_2Og^{-1} [31 microgram of sodium oxide (Na_2O) per gram of glass].

5.9.1.3 Thermal coefficient of expansion

The glass shall have a thermal coefficient of expansion of $(3.3 \pm 0.1) \times 10^{-6}$ K^{-1} over a temperature range of 20 to 300°C.

5.9.2 Dimensions and tolerances

5.9.2.1 Diameter and wall thickness

Borosilicate glass tubing shall comply at all points with the dimensions and tolerances given in Table 12.

5.9.2.2 Length

Tubing shall be supplied preferably in lengths of 1.5 m.

5.9.2.3 Straightness

All tubing shall be straight within the limits on bow given in Table 13.

5.9.2.4 Ovality

At any cross-section of the tubing, the maximum and minimum external diameters shall not differ by more than 2% of the nominal diameter.

5.9.2.5 Siding

The difference between the minimum and maximum wall thicknesses at any cross - section shall not exceed the following values:

- light wall tubing: 25% of nominal wall thickness;
- medium and heavy wall tubing: 15% of nominal wall thickness.

5.9.2.6 Conicity

The conicity of the tubing shall not exceed the tolerances on external diameter.

TABLE 12 - EXTERNAL DIAMETER AND WALL THICKNESS

Dimensions in millimeters

EXTERNAL DIAMETER	WALL THICKNESS
6.0 ±0.4	1.5 ±0.2
7.0 ±0.4	1.5 ±0.2
8.0 ±0.4	1.5 ±0.2
9.0 ±0.4	1.5 ±0.2
10.0 ±0.4	1.5 ±0.2
11.0 ±0.4	1.5 ±0.2
12.0 ±0.4	1.5 ±0.2
13.0 ±0.4	1.5 ±0.2
14.0 ±0.4	1.5 ±0.2
15.0 ±0.4	1.8 ±0.2
16.0 ±0.4	1.8 ±0.2
17.0 ±0.4	1.8 ±0.2
18.0 ±0.4	1.8 ±0.2
19.0 ±0.4	1.8 ±0.2
20.0 ±0.5	1.8 ±0.2
22.0 ±0.5	1.8 ±0.2
24.0 ±0.5	1.8 ±0.2

TABLE 13 - LIMITS ON BOW

Values in millimeters

EXTERNAL DIAMETER	LIMITS ON BOW
Up to 6	0.9%
7 to 10	0.7%
Above 10	0.5%

5.10 Requirements for Laboratory Glass Condensers

5.10.1 Material

Material of laboratory glass condensers shall comply with 5.1.3 and construction shall be sufficiently robust to withstand normal use.

The extremities may be plain or fitted with conical or spherical interchangeable ground glass joint. In the case of plain extremities, the wide end of plain-end condensers shall be fire-polished, and the stem shall be either ground or fire-polished and if fitted with joints, the joints shall comply with 5.8.

The drip tip at the lower end of the condenser shall be cut off at an angle of not less than 30° to the plane of right angles to the longitudinal axis of the condenser.

5.10.2 Classification, types and dimensions of laboratory glass condensers

Five types of condenser, of three classes, according to design and the relative position of the cooling medium, are specified, with the nominal jacket lengths shown:

- Water jacketed condensers:

a) Liebig-West condenser: 400, 630 and 1000 mm;

(Dimensions of these condensers for above-mentioned jacket sizes shall conform with Sub-clause 8.1 of ISO 4799 or ASTM E 123).

b) Allihn condenser: 160, 250, 400 and 630 mm;

(Dimensions of these condensers, for above-mentioned jacket sizes shall comply with Sub-clause 8.2 of ISO 4799).

c) Coiled distillate condenser: 160, 250, and 630 mm;

(Dimensions of these condensers, for above-mentioned jacket sizes shall comply with Sub-clause 8.3 of ISO 4799).

- Coolant-tube condensers:

d) Graham condenser: 160, 250 and 400 mm;

(Dimensions of these condensers, for above-mentioned jacket sizes shall comply with Sub-clause 8.4 of ISO 4799).

- Double-action condensers:

e) Jacketed coil condenser: 160, 250 and 400 mm.

(Dimensions of these condensers, for above mentioned jacket sizes shall comply with Sub-clause 8.5 of ISO 4799).

5.10.3 Inscriptions

The following inscriptions shall be permanently marked on all condensers:

- the nominal (jacket) length;
- the maker's or vendor's name or mark;
- the size of any ground joints.

5.11 Requirements for Separating and Dropping Funnels

5.11.1 Material and construction

5.11.1.1 Material shall be as specified in 5.1.3.

5.11.1.2 Dropping funnels if required shall be supplied with a ground joint fitted below the stopcock, complying with the requirements of 5.8.

Dropping funnels with a ground joint below the stopcock if required shall be provided with a pressure-equalizing tube placed at the back of the funnel when it is in the position of normal use with the handle of the stopcock on the right.

5.11.1.3 The scale of graduated dropping funnels is placed centrally on the cylindrical part of the funnel when it is in the position of normal use with the handle of the stopcock on the right graduation and figuring, shall conform with 5.1.11 to 5.1.15 inclusive.

5.11.2 Types of funnels

5.11.2.1 Separating funnels

- Separating funnel (conical), nominal capacity 100, 250, 500 and 1000 ml;

Dimensions of concial separating funnels for different capacities shall comply with Sub-clause 7.1 of ISO 4800.

- Separating funnel (pear-shaped), nominal capacity 50, 100, 250, 500, 1000 and 2000 ml;

Dimensions of pear-shaped separating funnel for different capacities shall conform with Sub-clause 7.2 of ISO 4800.

- Separating funnel (Gilson type), nominal capacity 50, 100, 250, 500, 1000 and 2000 ml;

Dimensions of Gilson type separating funnels in respect to different nominal capacity shall comply with Sub-clause 7.3 of ISO 4800.

5.11.2.2 Dropping funnels

- Dropping funnel (cylindrical), nominal capacity 50, 100, 250, 500 and 1000 ml;

Dimensions of cylindrical dropping funnels in respect to different nominal capacity shall conform with Sub-clause 7.4 of ISO 4800.

- Dropping funnel, graduated (cylindrical), nominal capacity 50, 100, 250, 500 and 1000 ml;

Dimensions of graduated cylindrical dropping funnels for different nominal capacities shall comply with Sub-clause 7.5 of ISO 4800.

5.11.3 Inscriptions

The following inscriptions shall be permanently marked on all separating funnels and dropping funnels:

- the nominal capacity, except for graduated dropping funnels;
- the symbol cm^3 or the symbol ml or mL;
- the maker's or vendor's name or mark.

5.12 Requirements for Laboratory Beakers

5.12.1 Material and construction

5.12.1.1 Beakers shall be made of borosilicate glass of suitable chemical and thermal properties, preferably of borosilicate glass 3.3 in accordance with ISO 3585.

5.12.1.2 The glass shall be free from visible defects and from internal stress which would impair the performance of the beaker.

5.12.1.3 Hydrolytic resistance of beakers shall be such that when tested in accordance with the procedure and using the classification laid down in ISO 719, the glass from which the beaker is made shall comply with the requirements of class HGB 1.

5.12.1.4 Thermal shock resistance of beakers shall be in such a way that the glass used shall have a coefficient of linear thermal expansion of $5.6 \times 10^{-6}\ °C^{-1}$ over the temperature range from 20°C to 300°C.

5.12.1.5 The design of the base shall enable the beaker to have stability complying with 5.1.7.

5.12.1.6 Side

The side of the beaker shall be slightly flared near the brim in a smooth and regular curve. The diameter of the brim shall be of the order of 5 to 15% greater than the diameter of the body. The edge of the brim shall be finished in a plane parallel with that of the base.

5.12.1.7 Spout

The spout shall be shaped so that, when the beaker is filled with water, the water may be poured in a regular stream clear of the side of the beaker. When the beaker is placed on a horizontal surface and filling is continued beyond its overflow capacity, the water shall first overflow from the spout and not from any other part of the brim.

5.12.1.8 Scale

Beakers may be provided with a scale, which should approximately indicate the volume contained in the beaker.

5.12.2 Types, capacities and dimensions

5.12.2.1 Types and required capacities for each types are given below:

a) Low-form beaker with spout:

25, 50, 100, 250, 400, 600, 800, 1000, 2000, 3000 and 5000 ml.

b) Tall-form beaker with spout:

50, 100, 150, 250, 400, 600, 800, 1000, 2000, 3000 ml.

5.12.2.2 Preferred dimensions for each capacity are specified in ISO 3819.

5.12.3 Inscriptions

The following inscriptions shall be permanently and legibly marked on all beakers:

a) the nominal capacity of the beaker, for example "100 ml" (or 100), and the scale if marked on the beaker;
b) the maker's or vendor's name or mark;
c) the type of glass, if not identifiable otherwise.

In addition, each beaker shall bear an area with a surface suitable for marking with pencil.

5.13 Requirements for Liquid in Glass Thermometers

5.13.1 General requirements

5.13.1.1 Glass

The thermometer shall be made of suitable thermometric glass selected and processed so that the finished thermometer shows the following characteristics:

a) Stress in the glass of the bulb, capillary stem and where appropriate, the protective sheath shall be reduced to a level sufficient to minimize the possibility of fracture due to thermal or mechanical shock.

b) The bulb glass shall be stabilized by suitable heat treatment to ensure that the accuracy requirements of 10.1 and 10.3 can be met.

c) The legibility of the reading shall not be impaired by devitrification or clouding.

d) The image of the meniscus shall be distorted as little as possible by defects or impurities in the glass.

5.13.1.2 Shape

5.13.1.2.1 The thermometers shall be straight and their external cross-section approximately circular.

5.13.1.2.2 The top of the thermometer may have a plain finish or a glass ring or button. The outer diameter of the ring or button shall not exceed that of the stem.

5.13.1.2.3 For enclosed-scale thermometers, the strip bearing the scale shall be of a material suitable for the temperature to be measured and compatible with the method of fixing the strip. It shall be placed tightly against the capillary tube inside the sheath and shall be firmly and securely fastened at the top of the thermometer. A suitable method of fixing is by fusing a glass tube or rod to the sheath and to the upper end of the strip bearing the scale, while the lower end of the strip shall be freely held in a suitable saddle. Alternatively it shall be fixed inside the sheath in any other suitable manner that also allows for differential expansion.

5.13.1.2.4 The inside of the capillary tube shall be smooth. The cross-sectional area of the bore shall not show variations from the average greater than 10%. The size of the bore shall be such that when the temperature is rising at a specified uniform rate, any jumping of the meniscus does not exceed a specified proportion of the graduation interval.

5.13.1.2.5 No expansion or contraction chamber or other enlargement of the bore shall be so located as to produce any variation (greater than that permitted in 5.13.1.2.4) in the cross-section of the capillary tube in the scale ranges, and unless otherwise specified (see 5.13.1.2.6 and 5.13.1.2.7) there shall be at least 5 mm of unchanged capillary tube between any enlargement of the bore and any adjacent scale line. In the case of partial immersion thermometers no variation (greater than that permitted in 5.13.1.2.4) in the cross-section of the capillary tube is allowed between the immersion line and the first scale line above it.

5.13.1.2.6 To minimize the effect of being accidentally overheated, and to provide for the exceptional case of a thermometer whose temperature range is below ambient being stored at ambient temperature, an expansion volume shall be provided at the top of the capillary tube.

This volume should preferably consist of an expansion chamber with at least 10 mm of unchanged capillary tube between the highest scale line and the commencement of the widening of the capillary tube. Such a chamber shall be pear-shaped with the hemisphere at the top. The approximate capacity of the expansion chamber shall be specified in terms of either the equivalent length of capillary tube or the corresponding temperature interval. In the case of gas filling, the expansion volume may consist of at least 30 mm of unchanged capillary tube above the highest scale line.

5.13.1.2.7 Contraction chamber

To prevent the liquid withdrawing into the bulb during storage or to allow the inclusion of an auxiliary scale, a suitable contraction chamber may be provided.

5.13.2 Specification of dimensions

The following dimensions of the thermometers as well as the condition of immersion will be specified in requisition, which may be chosen from ASTM E 1-88 (05.03):

a) total length;
b) bulb length;
c) scale position;
d) scale length;
e) depth of immersion;
f) diameter of stem or sheath;
g) external diameter of bulb.

In the case of absence of such information, the supplier shall inform the Company of the above-mentioned dimensions before delivery.

5.13.3 Liquid filling

The general requirements for the liquid filling shall include the following:

5.13.3.1 There shall be no freezing or partial freezing of the liquid filling throughout the temperature range under the pressures prevailing in the thermometer.

5.13.3.2 The liquid shall be free from any contamination likely to interfere with the proper functioning of the thermometer.

5.13.3.3 The liquid shall be Mercury or alcohol as required. For liquids which wet glass, additional requirements are as follows:

a) The physical properties of the liquid shall be such as to ensure that the drainage time when the thermometer is cooled, is within specified limits.

b) If the liquid is artificially colored, a light-fast dye which does not stain the glass shall be used.

5.13.4 Gas filling

When gas filling is employed above the liquid filling, a dry gas shall be used at a pressure which raises the boiling point of the liquid sufficiently. In the case of mercury filling the gas shall be inert.

5.13.5 Accuracy

5.13.5.1 Instrument error

The maximum permissible instrument error shall be specified and should not be more than one scale division when the thermometer is in a vertical position and at the prevailing atmospheric pressure under the conditions of immersion and average emergent liquid column temperature specified for use.

Note:

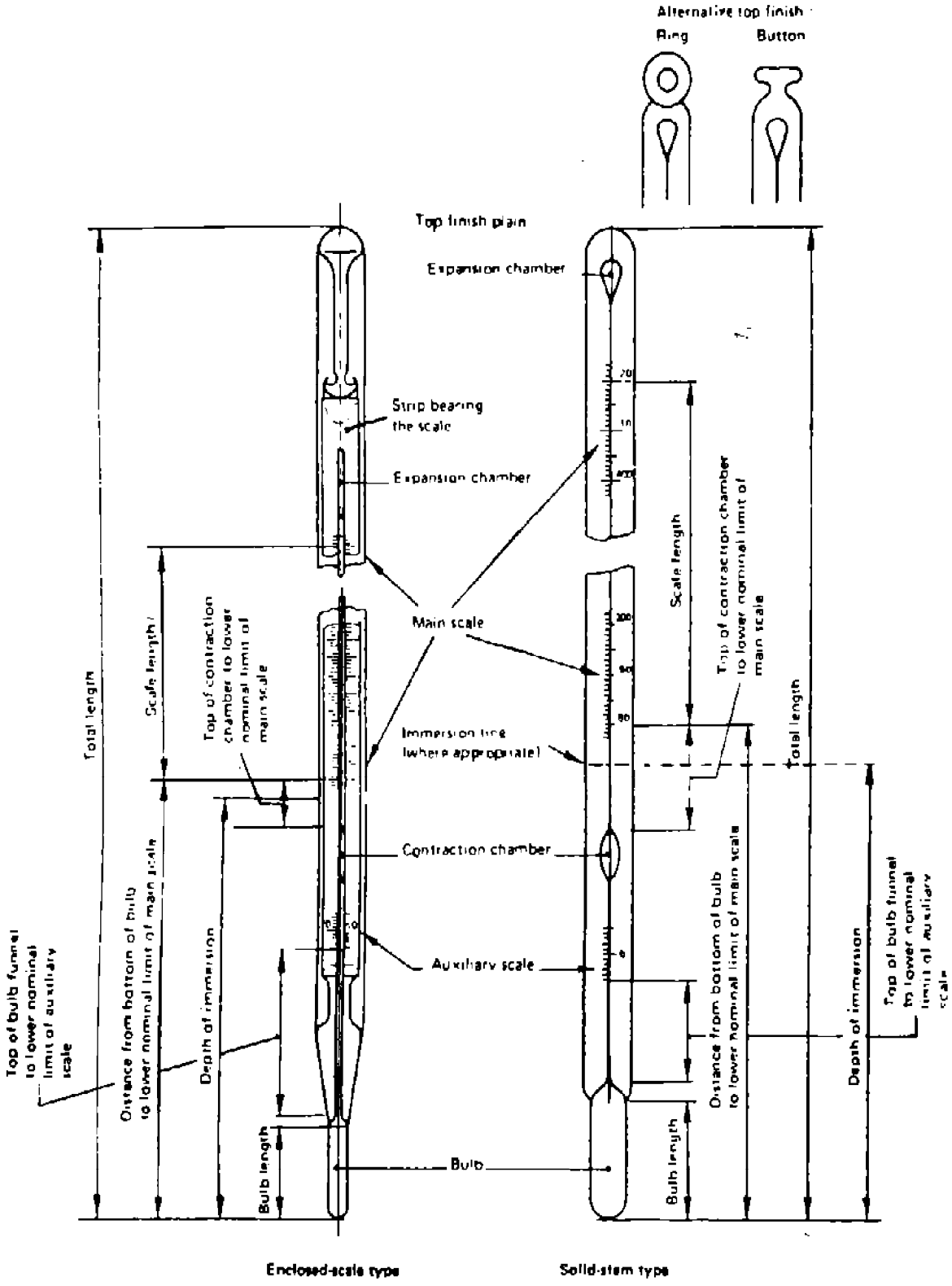
For thermometers having scale divisions of 0.01, 0.02 or 0.05°C or indicating temperatures above 300°C or below -38°C a larger error is permitted. In this case the Company shall be informed before delivery.

5.13.5.2 Change in zero indication

After being subjected, under precisely defined conditions of test (see Annex A, Clause A.2 of ISO 386), to a temperature corresponding to the highest scale reading, the change in the indication corresponding to a temperature of 0°C or other reference point, measured according to the conditions of test, shall not be greater than that specified or declared by supplier.

5.13.6 Marking

The scheme of graduation, figuring and inscriptions shall comply with ISO 386.



GENERAL DESIGN AND TERMINOLOGY FOR LIQUID-IN-GLASS THERMOMETERS
Fig. 5

5.14 Requirements for Hydrometers

5.14.1 Specific gravitymeter (pyknometer)

Two types of pyknometers, namely tublar type and flask type pyknometers may be required.

5.14.1.1 Special requirements for tublar pyknometers

5.14.1.1.1 Dimensional requirements

Required nominal capacity of tublar pyknometers shall comply with Table 14.

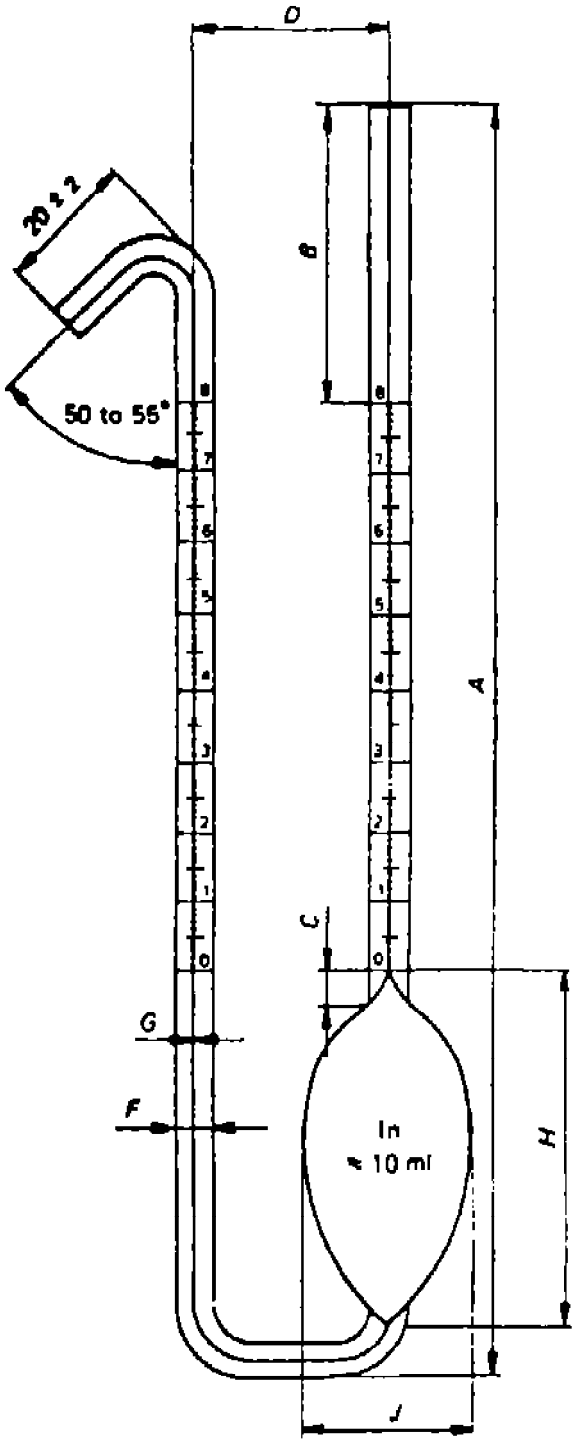
TABLE 14 - DIMENSIONAL REQUIREMENTS FOR PYKNOMETER TUBES

CHARACTERISTICS		LIPKIN TYPE (See Fig. 6)				SPRENGEL TYPE (See Fig. 7)		
NOMINAL CAPACITY, ml		**1**	**2**	**5**	**10**	**5**	**10**	**25**
Difference between actual capacity and nominal capacity, max., ml maximum mass (including cap for Type 2, if fitted),	g	±0.2 30	±0.3 30	±0.5 30	±1 30	±0.5 25	±1 30	±2 40
Overall Height, A,	mm	175 ±5				90	105	120
Height above scale, B, min.,	mm	40				—	—	—
Height from bulb to scale, C, min.,	mm	5				—	—	—
Distance between centers of vertical limbs, D,	mm	28 ±2				10	13	16
Length of side arms, E,	mm	—				40	45	50
External diameter of tubing, F,	mm	6				6	6	6
Internal diameter of tubing, G,	mm	1 ±0.1				1.5	1.5	1.5
Length from bottom of bulb to zero graduation line, H,	mm	40				—	—	—
Length of bulb, H,	mm		—			60	75	90
External diameter of bulb, J,	mm	11	14	20	25	12	17	22

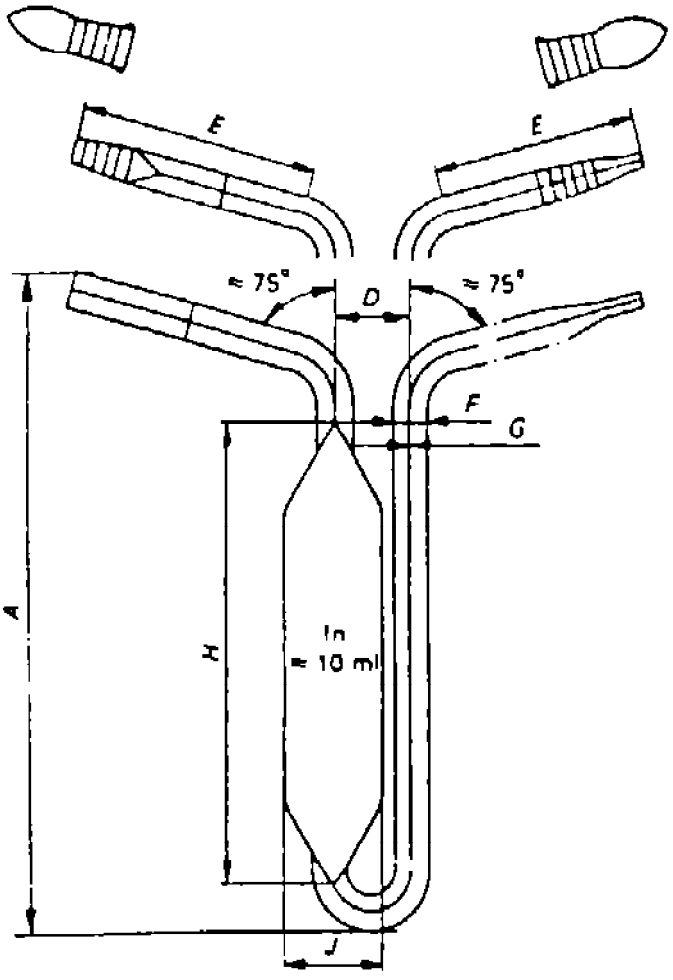
5.14.1.1.2 Material

Pyknometers should preferably be made from borosilicate glass of Class 1 hydrolytic resistance in accordance with ISO 4789, and shall be as free as possible from visible defects and reasonably free from internal strain. Stoppers of taps shall be made from glass having similar thermal properties to that used for the pyknometers to which they are fitted. Pyknometers made from soda-lime glass may require more frequent calibration than those made from borosilicate glass.

TUBLAR PYKNOMETERS



TYPE 1 (LIPKIN)
Fig. 6



TYPE 2 (SPRENGEL)
Fig. 7

5.14.1.1.3 Shape

Shapes and forms of different parts of tublar type pyknometers are given in Figs. 6 and 7.

All tapered portions of pyknometers shall be smoothly formed so as to avoid sharp shoulders which could entrap air bubbles.

The two ends of the tublar pyknometers shall be finished square with the axis of the tubes and smoothly fire-polished without constriction.

Sprengle (Fig. 7) pyknometers may, if required, be fitted with ground - on caps at the ends of the side arms.

The joints of pyknometers shall conform with 5.8.

5.14.1.1.4 Graduation lines

Graduation lines shall be clean, permanent, uniform lines of thickness not exceeding 0.3 mm.

All graduation lines shall lie in planes at right angles to the axis of the tube on which they are situated.

5.14.1.1.4.1 Lipkin type (Fig. 6) pyknometers shall comply the requirements given below:

a) Position of scale

Each vertical arm of the pyknometer shall have a graduated scale of length 8 cm divided into millimeters. The two scales shall be on the same level when the pyknometer is in a vertical position. Dimensions limiting the position of the scale are given in Table 14.

b) Length of graduation lines

The long lines representing each centimeter shall either extend completely round the circumference of the tube or leave a gap not exceeding 10% of the circumference.

The length of the medium lines midway between the long lines shall be at least one-quarter of the circumference of the tube.

There shall be four short lines between consecutive long and medium lines, each of length at least one-eighth of the circumference of the tube.

The short and medium lines shall appear centrally down the front of the two tubes when the pyknometer is viewed in a vertical position with the bent arm to the left.

c) Figuring of graduation lines

The two scales shall be numbered with figures representing centimeters from 0 at the lowest long line to 8 at the top.

The figures shall be placed immediately above the long lines to which they refer and slightly to the side of the shorter lines, as indicated in Fig. 6.

5.14.1.1.4.2 The sprengel type pyknometers shall have a single graduation line completely encircling the arm which is not provided with a jet. This line shall be placed not less than 5 mm from the point where the tube begins to bend and not less than 20 mm from the open end of the tube.

5.14.1.1.5 Inscriptions

The following inscriptions shall be permanently marked on all pyknometers:

a) the symbol ≈ to indicate that the capacity is approximate and not accurately adjusted, followed by a number to indicate the nominal capacity;

b) the symbol "cm³"or the symbol "ml" or "mL" to indicate the unit of volume;

c) as an alternative to inscriptions (a and b), or in addition to them, a figure showing determined capacity to the nearest 0.001 ml together with the temperature at which this determined capacity applies, for example "49.813 ml at 20°C".

d) the type of glass used or its coefficient of cubical expansion;

e) the maker's or vendor's name or mark;

5.14.1.2 Special requirements for flask type pyknometers

5.14.1.2.1 Dimensional requirements

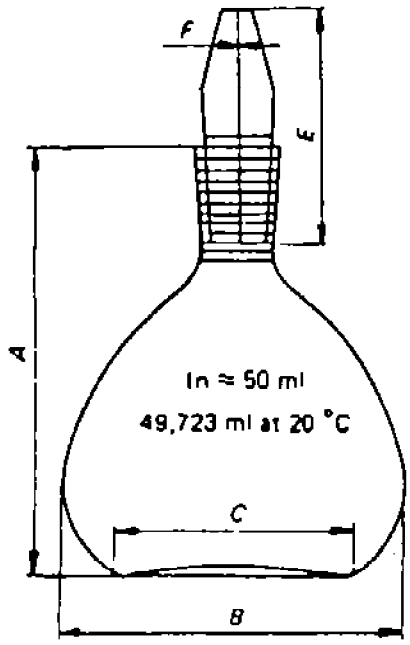
Required nominal capacity of flask pyknometers shall comply with Table 15.

TABLE 15 - DIMENSIONAL REQUIREMENTS FOR PYKNOMETER FLASKS

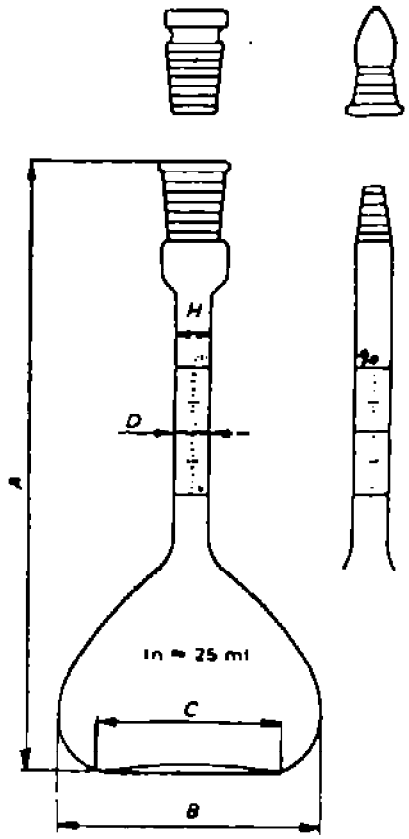
CHARACTERISTICS		GAY-LUSSAC TYPE (see Fig. 8)			REISCHAUER TYPE (see Fig. 9)		HUBBARD TYPE (see Fig. 10)
Nominal capacity, ml		**10**	**25**	**50**	**25**	**50**	**25**
Difference between actual capacity and nominal capacity, max., ml maximum mass including stopper, g		±1 25	±2 30	±3 35	±2 25	±3 30	±2 40
Height to top of neck, A,	mm	40	55	65	95	105	43
Diameter of body, B,	mm	27	40	50	40	50	40
Diameter of base, C,	mm	18	27	35	27	35	28
External diameter of neck, D,	mm	—	—	—	6	6	—
Height of stopper, E,	mm	25	33	33	—	—	22
Bore of stopper, F,	mm	1 ±0.3	1 ±0.3	1 ±0.3	—	—	1.6 ±0.3
Depth of concavity in stopper, G,	mm	—	—	—	—	—	5 ±1
Internal diameter of neck, H,	mm	—	—	—	2.2 to 3.8	2.2 to 3.8	—
Top end diameter of neck grinding,	mm	7 ±1	10 ±1	10 ±1	—	—	—
Minimum length of engagement of stopper in neck[1)]	mm	11	13	13	—	—	—
Neck socket grinding		—	—	—	10/13	10/13	24/10
Neck cone grinding [Alternative design, see Fig. 11a)]		—	—	—	5/9	5/9	—

1) Interchangeable grinding is not suitable for the neck and stopper of Gay-Lussac type.

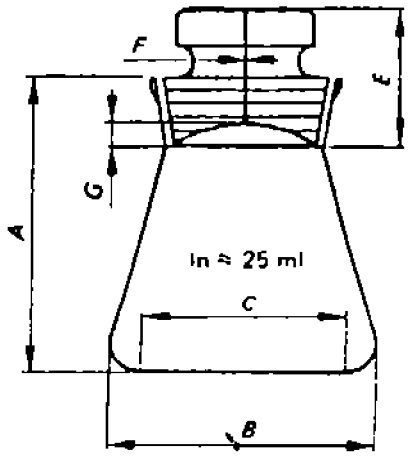
PYKNOMETER FLASKS



GAY-LUSSAC TYPE
Fig. 8



REISCHAUER TYPE
Fig. 9



HUBBARD TYPE
Fig. 10

5.14.1.2.2 Material

Material of flask type pyknometers shall comply with 5.14.1.1.2.

5.14.1.2.3 Shape

Shapes and form of different parts of flask type pyknometers are given in Figs. 8, 9, and 10 and the followings are required:

a) Stability of flask type pyknometers shall comply with Clause 5.1.7.

b) Pyknometers of Gay-Lussac and Reischauer types should preferably have a body shape similar to that shown in Figs. 8 and 9, in which the plane of maximum diameter is at approximately one-quarter of the distance from the base to the bottom of the neck.

c) Pyknometers of Hubbard, type shall have a body shape as shown in Fig. 10, in which the upper end of the conical portion merges smoothly with the neck without a sharp shoulder. The radius of curvature between the lower end of the conical portion and the base shall not be less than 5 mm.

d) The top of the flask type pyknometers shall be so that there is no channel in which liquid can lodge between the stopper and the neck of the bottle.

5.14.1.2.4 Graduation lines

Graduation lines shall be clean, permanent, uniform lines of thickness not exceeding 0.3 mm.

All graduation lines shall lie in planes at right angles to the axis of the tube on which they are situated.

The neck of Reischauer types shall have a graduated scale of length 2 cm divided into millimeters. There shall be at least 5 mm of the tube of uniform bore above and below the graduated scale before the tube starts to expand.

The length and sequence of graduation lines shall comply with the requirements of the first three paragraphs of 5.14.1.1.4.1-b. The placing of the lines shall be as indicated in Fig. 9.

5.14.1.2.5 Inscriptions shall be as given in 5.14.1.1.5.

5.14.2 Requirements for density hydrometers for general purposes

5.14.2.1 Material and workmanship

The bulb and stem shall be made of transparent glass as free as possible from stress and visible defects and shall have a coefficient of cubical thermal expansion $(25 \pm 2) \times 10^{-6}\ °C^{-1}$.

5.14.2.2 Graduation lines

5.14.2.2.1 Graduation lines shall be of uniform thickness not exceeding one-fifth of the distance between the centers of adjacent scale lines or 0.2 mm, whichever is less.

The short, medium and long graduation lines shall extend, respectively to at least one-fifth, one-third and one-half of the circumference of the stem.

Graduation lines shall comply with all applicable requirements given in 5.1.11.

5.14.2.2.2 Sequence of graduation lines shall be as below:

a) hydrometers scales whose smallest interval is 1 kg/m³ or 0.001 g/ml shall comply with 5.1.13.1;

b) hydrometers scales whose smallest interval is 2 kg/m³ or 0.002 g/ml or 0.0002 g/ml shall comply with 5.1.13.2.

c) hydrometers scales whose smallest interval is 5 kg/m³ or 0.005 g/ml shall comply with 5.1.13.3.

5.14.2.2.3 Figuring of graduation lines shall comply with 5.1.14 plus the followings:

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

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

5.14.2.3 Series and dimensions

The series of density-meters which may be required is given in the column 1 of Table 16.

The dimensions of the density-meters shall conform with the requirements given in Table 16 plus the following:

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

- the stem shall extend unchanged in diameter at least 15 mm above the uppermost graduation line on the scale;

- no hydrometer shall have a stem of diameter smaller than 4.0 mm.

TABLE 16 - PRINCIPAL REQUIREMENTS FOR SERIES OF HYDROMETERS

SERIES	MAX. TOTAL LENGTH	NOMINAL RANGE OF EACH HYDRO-METER		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	MAXIMUM PERMITTED ERROR AT ANY POINT ON THE SCALE	
							min.	max.	min.	max.			
	mm	kg/m³	g/ml	kg/m³	g/ml	mm	mm	mm	ml	ml	GRADUATION LINES	kg/m³	g/ml
L20	335	20	0.020	100 × 0.2	100 × 0.0002	105	36	40	108	132	5 to 10	±0.2	±0.0002
L50	335	50	0.050	100 × 0.5	100 × 0.0005	125	23	27	50	65	2 to 5	±0.5	±0.0005
M50	270	50	0.050	50 × 1	50 × 0.001	70	20	24	30	45	2 to 5	±1.0	±0.001
M100	250	100	0.100	50 × 2	50 × 0.002	85	18	20	18	26	2 to 5	±2.0	±0.002
S50	190	50	0.050	25 × 2	25 × 0.002	50	18	20	18	26	2 or 3	±2.0	±0.002
SPECIAL SUB-SERIES													
L50SP	335	50	0.050	100 × 0.5	100 × 0.0005	125	23	27	50	65	2 to 5	±0.3	±0.0002
M50SP	270	50	0.050	50 × 1	50 × 0.001	70	20	24	30	45	2 to 5	±6.0	±0.0006
S50SP	190	50	0.050	50 × 1	50 × 0.001	50	18	20	18	26	2 or 3	±1.0	±0.0010

5.14.3 Requirements for alcoholmeters

Alcoholmeters shall comply with pertinent requirements given in Sub-clause 5.1 of this Standard plus the requirements given in ISO 4801.

6. TESTS AND CALIBRATIONS

Tests and if required calibrations shall be made at the manufacturer's work.

The supplier/manufacturer shall maintain appropriate inspection and test records to substantiate conformance with specified requirements.

Calibration certificate shall be included:

Test and calibration records shall be legible and relevant to product involved. Supplier/manufacturer shall submit to purchaser the test and calibration records (in ..... copies) on completion of tests.

7. DOCUMENTS

7.1 At Quotation Stage

Documents to be submitted by manufacturer/supplier shall give the following as complete:

- Report of experience,
- drawings and documents which define the technical data of required commodity(ies),
- list of tests and calibrations which may be made on his work,
- complaint and compensation policies,
- declaration of any certificate from any impartial laboratory "if any".

7.2 At Ordering Stage

- a copy of test and calibration certificate;
- quality assurance certificate.

Note:

All documents shall be in English language.

8. CONFLICTING REQUIREMENTS

In case of conflict between documents relating to the inquiry or Purchase Order following priority of documents shall apply:

First priority:	Purchaser order (including attachments) and variations thereon.
Second priority:	Data-requisition sheet and drawings.
Third priority:	This Standard specification.

9. PACKING

9.1 Laboratory glasswares shall be packaged in away to avoid damage in transit.

9.2 Packages shall display the quantity of commodities and trade mark (identification mark) of manufacturer.

9.3 Packages shall have the Company name and full address of Company.

9.4 Packages shall have the word "BRITTLE" and the sign in all side surfaces as well as the sign which points to the top of the package.

10. INSURANCE

The insurance shall be carried out exactly as Company Purchaser Order.

11. SHIPMENT

11.1 It is desired that the hole commodity and related accessories are shipped at one batch.

11.2 The greatest care must be taken to ensure that shipping and associated documents with exact description for customs release are accompanied with the shipment.

APPENDICES

APPENDIX A
DATA SHEET FOR LABORATORY GLASSWARES

NAME OF COMMODITY: .....

CAPACITY: .....

TYPE OF COMMODITY: .....

CLASS OF ACCURACY: 0 .....

GLASS TYPE: ..... (IF OTHER THAN THAT SPECIFIED IN THIS STANDARD)

THE GLASS NEEDS TO BE ALKALI RESISTANT:

NO b YES b

IF THE REPLY IS YES THE CLASS OF ALKALI RESISTANT: CLASS A_1 b, CLASS A_2 b, CLASS A_3 b

(SEE PAGE 4)

STOPCOCK "IF ANY" INTENDED TO BE USED:

WITH GREASE b WITHOUT GREASE b

IF ANY JOINT INTENDED TO BE USED IT SHALL BE:

CONICAL JOINT b
SERY OF JOINT K2b K4 b, K6b AND K8 b
OR SPHERICAL JOINT b

ANY OTHER REQUIREMENTS

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.....
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