INTERNATIONAL STANDARD 2449

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Milk and liquid milk products — Density hydrometers for use in products with a surface tension of approximately 45 mN/m

Lait et produits laitiers liquides — Aréomètres à masse volumique pour utilisation dans les produits ayant une tension superficielle d'environ 45 mN/m

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2449 was drawn up by Technical Committee ISO/TC 34, *Agricultural food products*, and circulated to the Member Bodies in July 1971.

It has been approved by the Member Bodies of the following countries :

Australia	France	Poland
Austria	Germany	Portugal
Belgium	Hungary	Romania
Brazil	India	South Africa, Rep. of
Bulgaria	Iran	Spain
Chile	Israel	Sweden
Czechoslovakia	Korea, Dem.P.Rep. of	Thailand
Egypt, Arab Rep. of	Netherlands	United Kingdom
Finland	New Zealand	U.S.S.R.

No Member Body expressed disapproval of the document.

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Milk and liquid milk products — Density hydrometers for use in products with a surface tension of approximately 45 mN/m

0 INTRODUCTION

The system of units known as the Système International d'Unités (SI), and adopted by ISO (see ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*), has been used in this International Standard as follows :

1) Instead of the surface tension unit "dyne per centimetre" (dyn/cm) used in ISO/R 387, *Principles of construction and adjustment of hydrometers*, the unit adopted in the present International Standard is the "millinewton per metre" (mN/m), the recommended submultiple of the SI unit of surface tension "newton per metre" (N/m); the newton (N), the SI unit of force, is defined as that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/s^2. (1 mN/m = 1 dyn/cm).

2) The SI unit of density, i.e. mass divided by volume, is the "kilogram per cubic metre" (kg/m^3), a permitted submultiple of this unit being the "gram per cubic centimetre" (g/cm^3). As a convenient synonym for the latter unit, the SI unit system permits the use of the "gram per millilitre" (g/ml), and this method of expressing density, accepted in ISO/R 387, has been adopted in the present International Standard. (1 g/ml ≡ 1 g/cm^3). It should be noted that "density (g/ml)" means "grams (mass) per millilitre" and not "grams (observed weight) per millilitre".

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard gives specifications for glass hydrometers of constant mass, for use in milk and liquid milk products with a surface tension of approximately 45 mN/m, which indicate density (g/ml) at 20 °C (27 °C in tropical countries).

1.2 Two types of hydrometers are specified, a precision type and a wide-range type, which comply in all important respects with ISO/R 387.

1.3 Notes on the verification of the hydrometers are given in annex A, a suitable hydrometer cylinder is described in annex B and a suitable thermometer is described in annex C.

2 SCALE RANGES, SUBDIVISION OF SCALES AND TOLERANCES

2.1 Scale ranges

The scale ranges shall be as follows :

a) 1,025 to 1,035 g/ml for the precision hydrometer, and

b) 1,015 to 1,045 g/ml for the wide-range hydrometer.

NOTE – Additional precision hydrometers of scale range of 1,015 to 1,025, 1,035 to 1,045 or 1,040 to 1,050 g/ml may be required for certain purposes.

2.2 Subdivision of scales

The scale shall be subdivided at each 0,000 2 g/ml for a precision hydrometer, and at each 0,000 5 g/ml for the wide-range hydrometer.

2.3 Tolerances

The density indication shall not be in error at any point on the scale by more than ± 0,000 2 g/ml for a precision hydrometer, or by more than ± 0,000 5 g/ml for a wide-range hydrometer.

3 ADJUSTMENT

3.1 Reading level

The hydrometer shall be adjusted to be read at the top of the liquid meniscus, i.e. where the meniscus appears to meet the stem. (See clause 8 b).)

3.2 Immersion

The hydrometer shall be adjusted to give correct readings when the emergent stem is wetted by the liquid to a level not more than 3 mm above the top of the meniscus.

3.3 Temperature and surface tension

The hydrometer shall be adjusted to indicate density in grams per millilitre at 20 °C when floating in a liquid at 20 °C with a surface tension of 45 mN/m.

NOTES

1 The value 45 mN/m is taken as the average surface tension at 20 °C of a freshly formed surface of cows' milk, i.e. obtained by pouring milk into a vessel until some has overflowed.

2 It is recommended that in tropical countries the hydrometers should be adjusted to indicate density (g/ml) at 27 °C. No significant error will be introduced by assuming that the value 45 mN/m is applicable at this temperature.

3.4 Adjustment level

A precision hydrometer or a wide-range hydrometer shall be regarded as correctly adjusted when its reading at the level of the flat surface of a transparent liquid at 20 °C, with a surface tension of 45 mN/m, exceeds the density of the liquid by 0,000 3 g/ml and 0,000 8 g/ml respectively, values that correspond to the height of each meniscus (see note 1).

NOTES

1 These values were derived from a modification of Langberg's formula for meniscus height (see below), and also from experimental observations, for hydrometers whose scales and dimensions comply with this International Standard.

$$h = \frac{\sigma i}{9{,}81\, d\rho s}\left[\sqrt{\left(1 + \frac{19{,}62\, d^2\rho}{\sigma}\right)} - 1\right]$$

where

h is the meniscus height in terms of grams per millilitre;

σ is the surface tension of the liquid in millinewtons per metre;

i is the scale range in grams per millilitre (for example 0,01 for a precision hydrometer);

d is the external diameter, in millimetres, of the stem;

ρ is the density, in grams per millilitre, of the liquid;

s is the mean scale length in millimetres (for example 64 for a precision hydrometer).

2 It is not essential for the transparent liquid used for adjustment to have a temperature of 20 °C and a surface tension of 45 mN/m, provided that appropriate corrections are applied.

4 MATERIALS AND CONSTRUCTION

4.1 The bulb and stem of the hydrometer shall be made of transparent glass, and shall be as free as possible from strain and visible defects. In particular the external surface shall be smooth and free from irregularities. The base of the bulb may be strengthened by internal thickening of the wall.

4.2 The loading material should preferably be lead shot, securely embedded in a suitable cementing material in the bottom of the bulb. The loading material shall be such that, if the hydrometer is kept in a horizontal position for 1 h at 40 °C, it will float afterwards with its axis within 1,5° of the vertical. When the loading material is mercury, the mercury shall be confined in the bottom of the bulb.

4.3 There shall be no loose material in the hydrometer.

NOTE — Mercury, when used as described in 4.2, is not regarded as "loose material".

4.4 The scale paper should preferably be white, shall be of high quality (see note), and shall have a smooth surface which permits the graduation lines, numbers and inscriptions to be marked finely and clearly on it. All scale markings shall be permanent.

The scale paper in a hydrometer shall show no evidence of charring, and when exposed to a temperature of 80 °C for 24 h shall not become discoloured or distorted.

NOTE — It is recommended that the paper be an esparto paper (65 to 75 % esparto is suitable) and that the scale strips be cut with their length in the machine direction of the paper.

4.5 The scale paper shall be securely fastened in place. The scale paper shall have a scale mark, a few millimetres above the top graduation line, consisting of a short horizontal line with a "V" at each end, thus : >——< . A fine reference line of uniform thickness shall be cleanly etched on the hydrometer stem, at a position coincident with the horizontal portion of the scale mark, so that the ends of the etched line project into the "V" at each end of the scale mark.

A hydrometer shall be deemed not to comply with this International Standard if there is any displacement of the scale paper, i.e. if the scale mark and the reference line do not coincide exactly.

5 FORM

5.1 The outer surface of the hydrometer shall be symmetrical about its axis; there shall be a smooth transition between the bulb and the stem and no other abrupt changes in cross-section.

5.2 The tapered design shown in figure 1 is preferred, but any similar design that does not permit air bubbles to be trapped is acceptable.

5.3 The hydrometer shall float so that its axis does not deviate by more than 1,5° from the vertical position.

6 SCALES

6.1 Figure 2 shows the sequence and numbering of graduation lines which shall be followed, and illustrates acceptable scales.

6.2 General

6.2.1 The scale shall be straight and without twist.

6.2.2 There shall be no irregularities in the spacing of the graduation lines.

6.2.3 The graduation lines shall be at right angles to the axis of the hydrometer.

6.2.4 The graduation lines shall be of uniform thickness not exceeding 0,2 mm.

6.2.5 On the unnumbered side of the scales, the ends of all graduation lines shall lie vertically above one another, except in the case of lines that extend completely round the circumference of the stem.

6.2.6 The scale should preferably extend beyond its nominal limits at both ends by at least two graduation lines.

6.2.7 The numbers shall be placed immediately above the graduation lines to which they refer, and slightly to the side of the adjacent short graduation lines.

6.2.8 The numbers representing the nominal limits of the scales shall be written in full, and the remaining numbers indicated by the second and third decimal digits only.

6.2.9 All numbers should preferably be black.

6.3 Scales for a precision hydrometer

The long graduation lines shall all be the same length, shall be distinctly longer than all other lines, shall be numbered and should preferably be black. They may extend completely round the circumference of the stem.

The short graduation lines shall all be the same length, which shall not be less than 2 mm, i.e. they shall extend not less than approximately one-quarter of the way round the circumference of the stem. These lines may be black but should preferably be red to distinguish them from the long lines.

6.4 Scales for a wide-range hydrometer

6.4.1 *Single scale*

The longest graduation lines shall all be the same length, shall be distinctly longer than all other lines, shall be numbered and should preferably be black. They may extend completely round the circumference of the stem.

The medium-length graduation lines shall all be the same length but distinctly longer than the shortest graduation lines. These lines also should preferably be black.

The shortest graduation lines shall all be the same length and shall extend not less than one-fifth of the way round the circumference of the stem, i.e. their length shall not be less than approximately 3 mm. These lines may be black but should preferably be red.

6.4.2 *Double scale*

The recommendations of 6.4.1 apply, but the longest lines should preferably extend completely round the circumference of the stem.

The scale shall be arranged so that density readings can be made on two opposite sectors of the stem (see figure 2).

NOTE – It is impracticable to provide a double scale for a precision hydrometer because of the narrowness of the stem of this type of hydrometer.

7 PRINCIPAL DIMENSIONS

The hydrometers shall conform to the dimensions given in table 1 and illustrated in figure 1.

TABLE 1 – **Principal dimensions of the hydrometers**

Dimension	Precision hydrometer	Wide-range hydrometer
	mm	mm
Distance between top numbered graduation line and bottom of bulb, maximum	220	220
Distance between top numbered graduation line and top of stem, approximately	20	30
Length of uniform stem, maximum	100	130
Distance between top and bottom numbered graduation lines (scale length)	60 to 68	72 to 80
Length of uniform stem below bottom graduation line, minimum	5	5
External diameter of stem, approximately	3,1	4,6
External diameter of bulb	24 to 26	24 to 26
	ml	ml
Volume below bottom numbered graduation line	43 to 56	37 to 50

8 INSCRIPTIONS

The following information shall be marked on the paper bearing the scale. Except for the red band b) all inscriptions shall be black.

a) The inscription "g/ml, 20 °C" (or 27 °C for hydrometers adjusted at that temperature).

b) As an indication that the hydrometer is adjusted to be read at the top of the liquid meniscus the top 3 mm of the scale paper shall be coloured red. As a further indication the inscription "Read at top of meniscus", or an abbreviation for this, for example "Rd menisc. top" or "Menisc. top" may be added.

c) An identification of the purpose of the hydrometer.

NOTE – This may be the word "Milk" and the number of the appropriate national standard or some other indication that the hydrometer is in accordance with this International Standard.

d) An individual identification number for the hydrometer.

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

ANNEX A

NOTES ON VERIFICATION OF THE HYDROMETERS

A.1 INTRODUCTION

In order to place confidence in the results obtained from the reading of a hydrometer, it is necessary to verify the scale after manufacture and if possible at intervals later, either to ensure that the scale errors are within the specified tolerance or, when working to closer limits, to ascertain the values of the corrections to apply for scale error.

These notes are only intended to offer guidance on verification and do not attempt to cover all possible methods in full detail.

A.2 METHODS

Various methods may be used to verify a hydrometer, including the use of :

a) a hydrostatic balance, whereby the hydrometer is weighed while suspended in a liquid of known density and also in air. The scale errors of the hydrometer are calculated from the results of the weighings;

b) a pyknometer, a hydrostatic balance fitted with a sinker (for example Mohr-Westphal balance) or other apparatus by means of which the density of liquids can be directly or indirectly determined to the fourth decimal place. The results of these determinations are compared with those obtained by using the hydrometer being verified.

NOTE – If this method is used, it is essential that the surface tension of the liquids is accurately known. If their surface tension differs from 45 mN/m, a correction, whose calculation requires the surface tension factor of the hydrometer being verified, must be applied to the observed hydrometer readings.

The liquids used in Method c) (see table 2) may be used in Method b) but, if this is done, it cannot be assumed that their surface tension is 45 mN/m;

c) a reference hydrometer, of the same type as the hydrometer to be verified, whose scale errors have been determined by either Method a) or Method b) above, preferably by an official standardizing laboratory. The reference hydrometer is floated in suitable liquids together with the hydrometer being verified, and the readings of the two hydrometers directly and simultaneously compared. The scale errors of the reference hydrometers shall be re-determined at least every 2 years.

Method a) is more suitable for the standardization of a reference hydrometer by an official standardizing laboratory. It is not a method which the ordinary user of hydrometers would find convenient, as it is unwieldy compared with the alternatives and requires specialized apparatus.

Method b) could be adopted by the ordinary user of hydrometers but it has several disadvantages. For example, it is time-consuming, the pyknometer method requires buoyancy corrections, and it is essential that the liquids used have a known surface tension and that they are at the same temperature when the comparative determinations of density are made.

Method c) is simple and relatively rapid. The actual temperature of the liquids used is unimportant (it can be the ambient temperature). The actual value of the surface tension of the liquids used is not important, but it should remain constant. For these reasons, Method c) is recommended and is therefore described in detail :

The liquids used may be milk samples (it may be advantageous to use milks which have gone through the process of homogenization) but should preferably be transparent liquids of suitable density and with a stable surface tension between 40 and 50 mN/m. Suitable liquids can be prepared by dissolving anhydrous sodium carbonate in a 10 % (*V*/*V*) solution of ethanol, 94 to 97 % (*V*/*V*), in distilled water or water of at least equivalent purity, as indicated in table 2 :

TABLE 2 – **Correlation between concentration of sodium carbonate solution and density**

Concentration of sodium carbonate (anhydrous)	**Approximate hydrometer reading at level liquid surface at 20 °C**
g/l	g/ml
31,0	1,016
33,1	1,018
35,3	1,020
37,4	1,022
39,6	1,024
41,7	1,026
43,9	1,028
46,1	1,030
48,2	1,032
50,4	1,034
52,5	1,036
54,7	1,038
56,8	1,040
59,0	1,042
61,2	1,044

It is not feasible to check all points on a hydrometer scale. It is suggested that verification at three evenly spaced points, for example at about 1,026, 1,030 and 1,034 g/ml on a precision hydrometer and at about 1,020, 1,030 and 1,040 g/ml on a wide-range hydrometer, should be sufficient to ensure confidence in interpolating scale corrections for the remainder of the scale.

The reference hydrometer shall be one made to the same specification as the one being verified, for example a reference precision hydrometer shall be used to check another precision hydrometer. This ensures that any deviation of the surface tension of the liquids from the adjustment value of 45 mN/m will affect the reading of both hydrometers equally.

The liquid in which the hydrometers are to be floated shall be contained in a rectangular glass jar or other suitable vessel large enough for the two hydrometers to float side by side, and with the front wall flat, transparent and free from visible defects. The liquid shall be well stirred before inserting the hydrometers, which shall be at about the same temperature as the liquid (approximately 20 °C), so as to ensure a uniform density. The actual temperature of the liquid and the hydrometers is not important, however, as both instruments will be affected to the same extent by any deviation from the adjustment temperature of 20 °C. Care shall be taken not to wet the hydrometer stems more than 3 mm above the top of the liquid meniscus.

The readings of the hydrometers shall be taken as nearly as possible at the same moment and as soon as possible after the hydrometers have become steady, but not more than 1 min after immersion. If a transparent liquid is used, the readings shall be taken at the level of the flat liquid surface. If milk is used, the readings shall be taken at the top of the meniscus. The correction for scale error of the hydrometer being verified is obtained by subtracting its reading from the corrected reading of the reference hydrometer as shown in the following example for a precision hydrometer.

	g/ml
Reading of reference hydrometer	1,030 4
Correction for scale error of reference hydrometer (from certificate)	− 0,000 2
Corrected reading of reference hydrometer	1,030 2...a)
Reading of hydrometer being verified	1,030 0...b)
Correction for scale error of hydrometer being verified [a) minus b)]	+ 0,000 2

ANNEX B

HYDROMETER CYLINDER

A cylindrical vessel of suitable rigid material such as metal (not thicker than 0,7 mm), glass or plastics, having the following minimum dimensions, is suitable for use with either a precision hydrometer or the wide-range hydrometer :

— minimum internal diameter 35 mm;

— minimum internal depth 225 mm;

These dimensions are the smallest which ensure that any point on the scale of the hydrometers can be read and that the hydrometers can float freely. These dimensions, which give a capacity of 216 ml, also ensure an overflow of milk with a sample as small as 180 ml.

A cylinder having an internal diameter larger than the minimum above may be used when the volume of the milk sample is large enough. For example, the internal diameter could be 36,6 or 40,2 mm if a 200 or 250 ml sample respectively were available.

The top edge of the cylinder shall be circular (without a spout) and in one plane. If the cylinder is made of metal there should preferably be a reinforcing band 1 mm thick outside the rim, extending 8 mm down from the top. In use, the axis of the cylinder shall be vertical and the top edge horizontal.

ANNEX C

THERMOMETER

A thermometer having the following characteristics is suitable for determining the temperature of the milk in the hydrometer cylinder :

— overall length 255 ± 10 mm;

— scale length 100 ± 5 mm;

— distance between lowest graduation line and bottom of bulb 110 ± 5 mm;

— scale range + 10 to + 45 °C;

— graduation interval 0,5 °C;

— maximum scale error ± 0,25 °C.

The depth of immersion at which the thermometer should be used shall be inscribed on the instrument.

Dimensions in millimetres

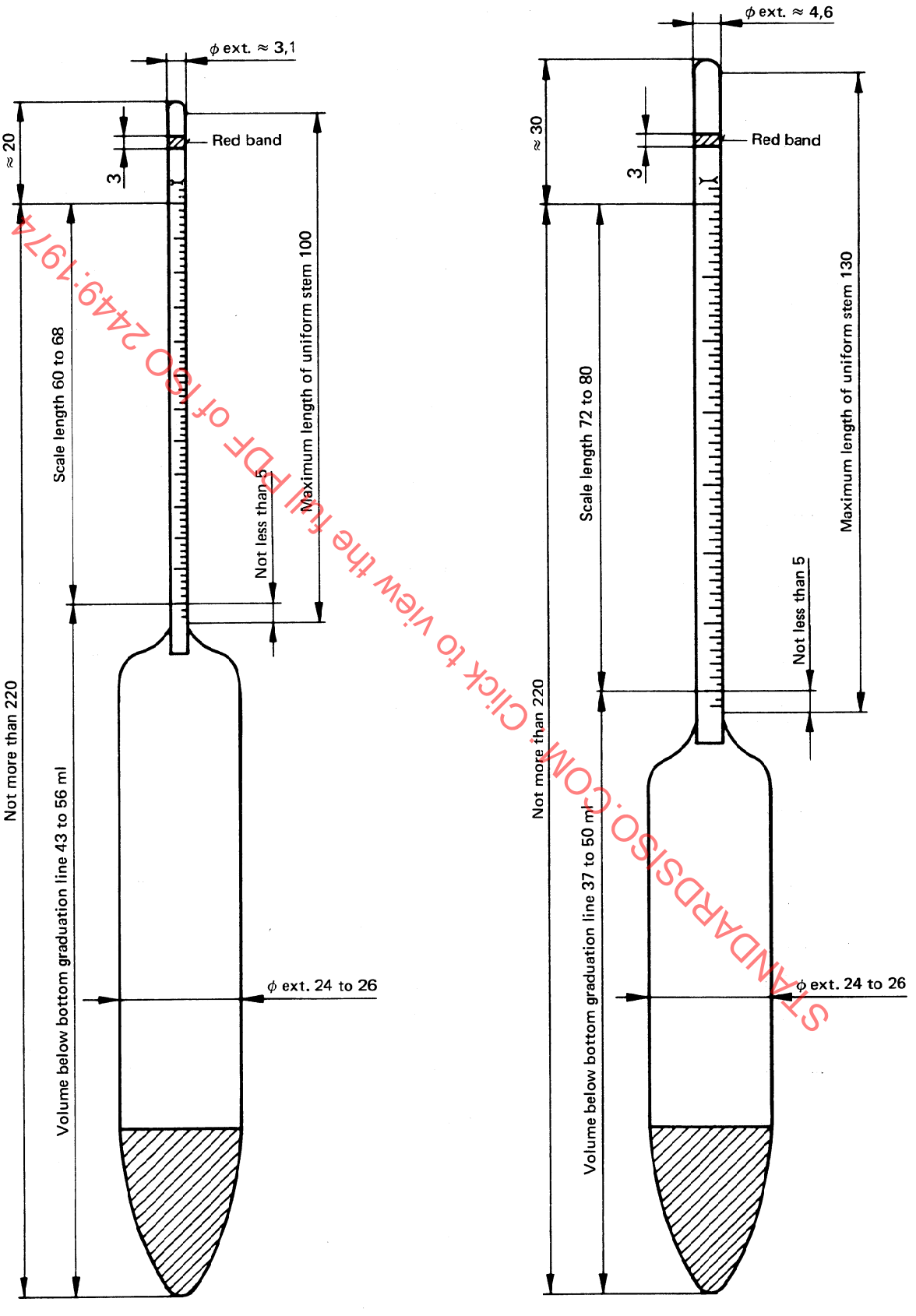

FIGURE 1 — **Density hydrometers for use in milk and liquid milk products**