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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Petroleum measurement systems — Calibration — Temperature corrections for use with volumetric reference measuring systems

Systèmes de mesure du pétrole — Étalonnage — Corrections de température pour utilisation avec les systèmes volumétriques de mesure de référence

Reference number
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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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8222 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Petroleum measurement systems — Calibration — Temperature corrections for use with volumetric reference measuring systems

0 Introduction

This International Standard is intended to be applied when calibrating meter proving tanks or other containers with primary measures using water. The corrections given in this International Standard correct for the effects of differences in temperature between the tank and the primary measure and between these temperatures and the reference temperature.

The corrections are given in the form of factors which, when multiplied by the volume delivered or received by the measure, give the volume of the tank at the reference temperature. This is suitable for use in the field on programmable hand calculators. An algorithm is given in annex B.

Values for the density of water at temperatures between 0 and 40 °C based on the work of Wagenbreth and Blank (1968) [1] have been adopted internationally. At the request of the ISO Committee charged with the preparation of this International Standard, other published data [2] for the density of water were reviewed and a table of densities for water for the range 0 to 100 °C was provided. The Wagenbreth equation for the 1968 data has been used in this International Standard. Comparison with the later data shows that its range may be extended from 40 to 45 °C in the calculation of the correction factor, provided that the final factor is rounded to 5 decimal places before use.

Although a similar correction routine is given in ISO 4269 [3], it only covers a temperature range of 0 to 40,9 °C, and it is intended for use with larger containers and to correct for greater differences in temperature.

1 Scope and field of application

This International Standard specifies multiplication factors for the correction of the volume of water transferred from a primary measure (measure) to a tank for differences in volume arising from temperature differences during the determination of the capacity of the tank at a reference temperature.

NOTE 1 — This International Standard does not set out a calibration procedure nor consider the uncertainties in temperature measurement, for which reference should be made to other standards.

The corrections take account of differences in the volume of water, and of the measure and the tank arising from the following temperature effects:

a) the change in volume of the calibrating liquid (water) caused by any change in its temperature from the time it is measured in the measure to the time when the total volume has been transferred to or drawn from the tank being calibrated;

NOTE 2 — Although this International Standard is applicable to volumes transferred to, or drawn from, a tank, it has been written in terms of the volume transferred to the tank.

b) the changes in the volumes of the measure and the tank being calibrated when the temperatures are different from the calibration temperature of the measure.

The corrections apply for temperatures in the range 0,05 to 45 °C, but the difference between the temperature of the measure and of the tank shall not be more than 5,0 °C, unless otherwise specified in the calibration procedure (see note 3).

The corrections are specified in the form of an algorithm or calculation routine, which will always generate the same values from the same input data. Although tables may be generated from the calculation routine, it is mainly intended for use with a computer.

NOTE 3 — The calculation procedure is accurate for any difference between the temperature of the measure and of the tank within the

range 0,05 to 45 °C, but the limit of 5,0 °C is specified to avoid other errors that could arise if the difference were greater, e.g. temperature gradients within the tank being calibrated.

2 Symbols and definitions

The symbols used in this International Standard are defined in the table.

3 Temperatures

3.1 Because of the difficulty of accurately measuring the temperatures of the shell of the measure and the shell of the tank being calibrated, the following assumptions shall be made.

3.1.1 The measure is at the same temperature as the liquid it contains when the volume of the particular increment (pour) is measured.

3.1.2 The tank being calibrated is at the same temperature as the liquid it contains when the total volume of liquid has been transferred.

3.2 The standard reference temperature (t_s) for petroleum measurement is generally 15 °C (ISO 5024)[4]. If the measure has been calibrated at 15 °C, the tank calibration will be at the same reference temperature (see the note).

NOTE — If this International Standard is applied for one of the other reference temperatures used in some countries, i.e. 20 °C or 60 °F, the values entered for t_s should be 20 and 15,56 respectively. If the values of t_1 and t_2 (see 4.2) have been recorded in degrees Fahrenheit, they should be converted to degrees Celsius, to the nearest 0,1 °C.

4 Coefficient of expansion

4.1 Expansion of shells

The coefficients of cubical expansion assumed for the shells of the measure α_{V_1} and the tank α_{V_2} being calibrated in the computation of the corrections shall be as follows:

mild steel : $33 \times 10^{-6}\ °C^{-1}$

stainless steel : $51 \times 10^{-6}\ °C^{-1}$;

however, if the value for the particular steel is known, it may be used and its value shall be reported as part of the calibration.

If other steels or metals with other coefficients of expansion are used, then corresponding coefficients shall be obtained and applied. These coefficients shall be reported with the other details of the calibration.

NOTE — Values for the coefficient of cubical expansion of stainless steel depend upon its composition. Values have been reported over the range 43×10^{-6} to $54 \times 10^{-6}\ °C^{-1}$ and $51 \times 10^{-6}\ °C^{-1}$ has been adopted for consistency with ISO 4269. The errors arising from any deviation from the true value for the material used is unlikely to be significant in practice.

4.2 Expansion of water

The expansion of the water, C_{tdw}, expressed as the 'water correction factor' is the ratio of the densities of water at temperature t_1 in the measure and at the temperature t_2 in the tank to be calibrated.

$$C_{tdw} = \frac{\text{density at } t_1}{\text{density at } t_2} = \frac{\varrho_1}{\varrho_2}$$

Values of ϱ_1 and ϱ_2 shall be obtained from the polynomial based on the table mentioned in the introduction and set out in annex A.

Table — Symbols used

Symbol	Quantity	Unit
α_{V_1}	Cubic expansion coefficient of the shell of the measure	$°C^{-1}$
α_{V_2}	Cubic expansion coefficient of the shell of the tank being calibrated	$°C^{-1}$
t_s	Standard reference temperature for the measure and tank being calibrated	°C
t_1	Temperature of the water in the measure and of its shell	°C
t_2	Temperature of the water in the tank being calibrated at the completion of the calibration and of the shell of the tank	°C
ϱ_1	Density of water at temperature t_1	kg/m^3
ϱ_2	Density of water at temperature t_2	kg/m^3
C_{tdw}	Correction factor for expansion of the calibrating liquid (water) over the temperature range t_1 to t_2 when $C_{tdw} = \frac{\varrho_1}{\varrho_2}$	

5 Basis of the computation of the corrections

5.1 Determination of the change in the volume of the measure or the tank

Express the corrections as multiplication factors:

a) for the measure: $1 + \alpha_{V_1}(t_1 - t_s)$

b) for the tank : $1 + \alpha_{V_2}(t_2 - t_s)$

5.2 Combined equation

The combined equation for the correction for both the contraction or expansion of the water and that of the shells of the measure and the tank is:

$$\text{Correction factor} = \frac{\varrho_1[1 + \alpha_{V_1}(t_1 - t_s)]}{\varrho_2[1 + \alpha_{V_2}(t_2 - t_s)]}$$

5.3 Algorithm or computer routine

An algorithm indicating the recommended calculation steps is given in annex B for measures and tanks made of mild steel or stainless steel (see 4.1 for reference to other materials).

6 Reporting and use of correction

The correction factor, which is dimensionless, shall be rounded to five decimal places before use.

Report the value of the connection factor together with the following information:

a) reference to this International Standard;

b) material of construction of the shell of the measure;

c) value of α_{V_1};

d) material of construction of the shell of the tank;

e) value of α_{V_2}.

The correction shall be used in the form of a multiplication factor to be applied to the volume of the measure to give the volume of water transferred to or from the tank at the reference temperature.

7 Bibliography

[1] WAGENBRETH, H. and BLANK, H. *The density of water in the International System of units and in the International Practical Temperature Scale of 1968.* Mitteilungen der Physikalish-Technischen Bundesanstalt. (PTB-Mitt.), pp. 412-415, June 1971.

[2] *Physikalisch-Teschnische Bundesanstalt, Jahresbericht 1980,* Braunschweig, February 1981.

[3] ISO 4269, *Petroleum and liquid petroleum products — Tank calibration — Liquid methods.* [1]

[4] ISO 5024, *Petroleum liquids and gases — Measurement — Standard reference conditions.*

[5] ISO 3838, *Crude petroleum and liquid or solid petroleum products — Determination of density or relative density — Capillary-stoppered pyknometer and graduated bicapillary pyknometer methods.*

1) At present at the stage of draft.

Annex A

Equation for determining the density of water

(This annex forms an integral part of the Standard.)

For the purpose of this International Standard, the following polynomial equation shall be used for determining the density of water, ϱ, in kilograms per cubic metre, at temperature t °C between 0,05 and 45 °C (see the notes).

$$\varrho = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5$$

where

$a_0 =$ 999,839 563 9
$a_1 =$ + 0,067 982 999 89
$a_2 =$ − 0,009 106 025 564
$a_3 =$ + 0,000 100 527 299 9
$a_4 =$ − 0,000 001 126 713 526
$a_5 =$ + 0,000 000 006 591 795 606

NOTES

1 This equation gives accurate values to 6 decimal places for the density of water at temperatures between 0,05 and 40 °C, but it cannot be extrapolated accurately beyond this temperature range. However, the extrapolation is sufficiently accurate for the purpose of this International Standard because the calculation in 5.2 is based on the ratio of densities at temperatures within 5 °C and the correction factor is rounded to 5 decimal places before use.

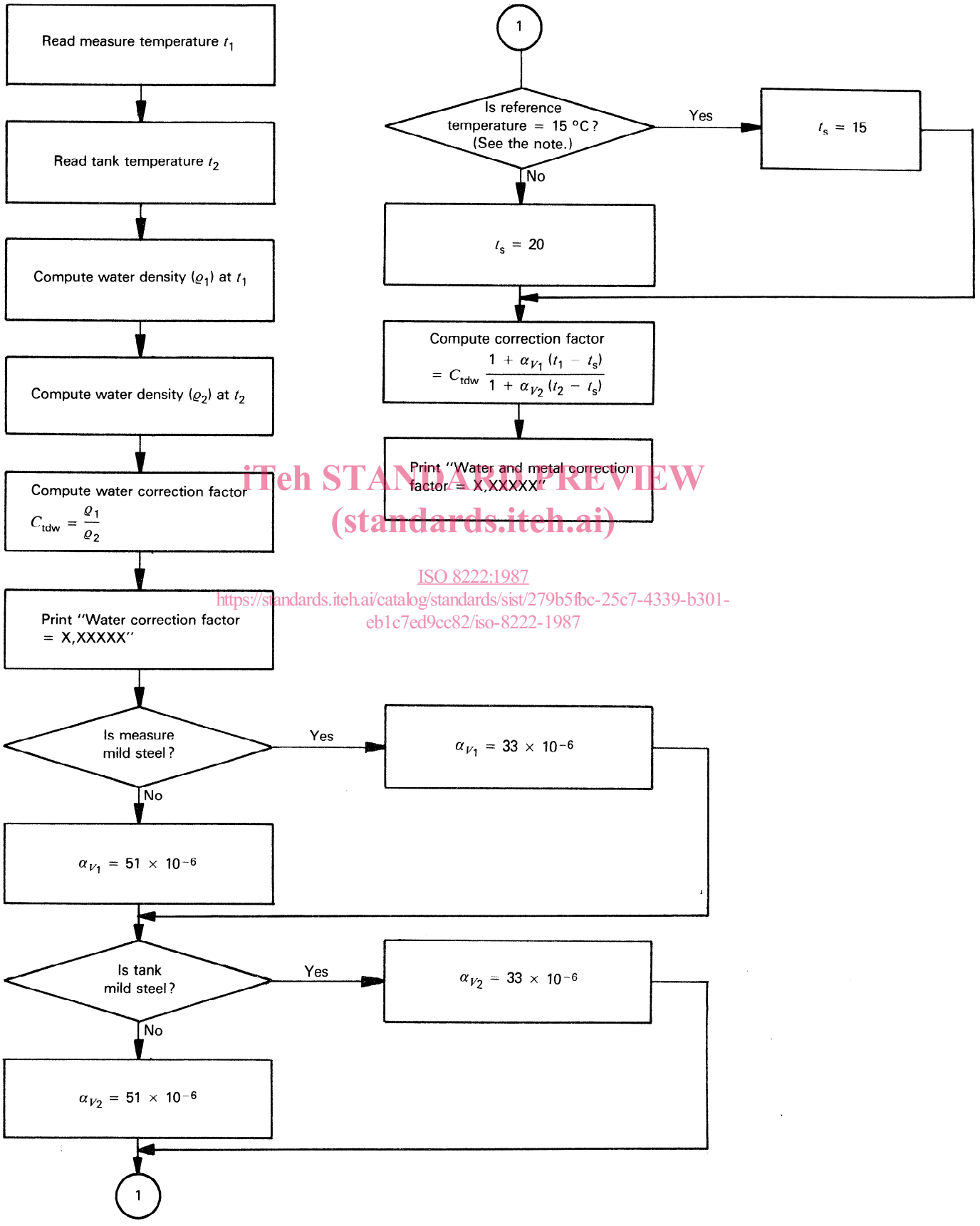
2 The expression of the expansion of water relates to demineralized water, but the calculation in 5.2 is based on the ratio of densities and will tend to eliminate any errors arising from the use of impure water.

3 A table of values for the density of water at temperatures between 0 and 40 °C has been published in ISO 3838. [5]

Annex B

Algorithm showing calculation routine

(This annex does not form an integral part of the Standard.)



NOTE — If the reference temperature of 60 °F is required, t_s = 15,56 should be substituted for one of the values for t_s before using this routine.

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