INTERNATIONAL STANDARD

ISO 8222

Second edition
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Petroleum measurement systems — Calibration — Temperature corrections for use when calibrating volumetric proving tanks

Systèmes de mesure du pétrole — Étalonnage — Corrections de température à utiliser lors de l'étalonnage des jauges étalons

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 8222 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 3, *Static petroleum measurement*.

This second edition cancels and replaces the first edition (ISO 8222:1987), which has been technically revised.

This revision includes an equation for calculation of the density of water in the range 1,0 °C to 40 °C derived from density determinations on water carried out at the CSIRO National Measurement Laboratory, Australia, and published in 1994. It is expressed in terms of the International Temperature Scale of 1990, ITS-90. The equation in ISO 8222:1987 was based on work published in 1971 by PTB, Germany, expressed in terms of the International Practical Temperature Scale of 1968, IPTS-68.

Annex A forms a normative part of this International Standard. Annex B is for information only.

Introduction

When meter proving tanks or other containers are calibrated with a primary measure using water, correction factors are required to make allowance for the effects of temperature during the calibration on the volume of water that is transferred and on the capacities of the primary measure and container.

The corrections take account of differences in the volume of water, and of the capacities of the measure and the tank, arising from the following temperature-related 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 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) Changes in the capacities of the measure and the tank being calibrated caused by any differences between the temperatures of their shells and their standard reference (calibration) temperature(s).

Petroleum measurement systems — Calibration — Temperature corrections for use when calibrating volumetric proving tanks

1 Scope

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

NOTE 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.

Equations are given in annex A for the determination of the density of air-free and air-saturated, pure water in the temperature range 1,0 °C to 40 °C for temperatures expressed in terms of the ITS-90 International Temperature Scale.

A calculation routine is also provided in annex B for the combined water and metal correction factor that is applied when determining the capacity of the tank at reference temperature.

2 Symbols and definitions

For the purposes of this International Standard, the symbols defined in Table 1 apply.

Table 1 — Symbols

Symbol	Quantity	Unit
C_c	Combined correction factor	1
C_{tdw}	Correction factor for expansion of the calibrating liquid (water) over the temperature range t_1 to t_2 where $C_{tdw} = \frac{\rho_1}{\rho_2}$	1
t_{sm}	Standard reference temperature of the measure	°C
t_{st}	Standard reference temperature of the 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
α_{V1}	Cubical expansion coefficient of the shell of the measure	$°C^{-1}$
α_{V2}	Cubical expansion coefficient of the shell of the tank being calibrated	$°C^{-1}$
ρ_1	Density of water at temperature t_1	kg/m^3
ρ_2	Density of water at temperature t_2	kg/m^3

3 Temperatures

3.1 The corrections apply for temperatures in the range 1,0 °C to 40 °C.

For practical reasons, the temperature difference between the temperature of the measure and that of the tank shall not exceed 5,0 °C.

NOTE Larger temperature differences between measure and tank may indicate temperature gradients within the tank that would result in errors in its calibration.

3.2 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.

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

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

3.3 The standard reference temperature (t_s) for petroleum measurement is generally 15 °C [2]. If the measure has been calibrated at 15 °C, the tank calibration will generally be at the same reference temperature. However, the calculation routine covers the circumstance where the reference temperatures of the measure and of the tank being calibrated may differ.

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_{sm} or t_{st} shall be 20 °C and 15,56 °C respectively. If the values of t_1 and t_2 have been recorded in degrees Fahrenheit, they shall be converted to degrees Celsius, to the nearest 0,01 °C.

4 Coefficient of expansion

4.1 Expansion of shells

In the computation of the corrections, the values of the coefficients of cubical expansion for the metals of the shells of the measure (α_{V1}) and the tank being calibrated (α_{V2}) shall be used if they are known. These coefficients shall be reported with the other details of the calibration.

If the value for the particular steel is not known, the following values may be used and reported as part of the calibration:

— mild steel: 33×10^{-6} °C^{-1}

— stainless steel: 51×10^{-6} °C^{-1}

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} °C^{-1} to 54×10^{-6} °C^{-1}. In this International Standard, the value 51×10^{-6} °C^{-1} has been adopted for consistency with ISO 4269[1].

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 being calibrated.

$$C_{tdw} = \frac{\rho_1}{\rho_2}$$

Values of ρ_1 and ρ_2 shall be obtained from the equation given in annex A. Calculate the water correction factor to 6 decimal places.

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: $1 + \alpha_{V1} \times (t_1 - t_{\text{sm}})$;

b) for the tank: $1 + \alpha_{V2} \times (t_2 - t_{\text{st}})$.

5.2 Combined correction factor

The combined correction factor, C_{c}, for both the contraction or expansion of the water and that of the shells of the measure and the tank is given by the equation:

$$C_{\text{c}} = \frac{\rho_1[1 + \alpha_{V1}(t_1 - t_{\text{sm}})]}{\rho_2[1 + \alpha_{V2}(t_2 - t_{\text{st}})]}$$

5.3 Calculation routine

A calculation routine giving the recommended calculation sequence to use is given in annex B.

6 Reporting and use of correction

The combined correction factor, C_{c}, which is dimensionless, shall be rounded to six decimal places before use.

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

a) reference to this International Standard, i.e. ISO 8222;

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

c) value of α_{V1};

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

e) value of α_{V2};

f) standard reference temperature for the measure;

g) standard reference temperature for the tank.

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

Annex A
(normative)

Equations for determining the density of water

A.1 Density of air-free water

The following equation shall be used for determining the density of pure, air-free water, ρ_t in kilograms per cubic metre, at temperature t °C between 1 °C and 40 °C (see NOTE).

$$\rho_t = \rho_0 \left\{1 - \left[A\,(t - t_0) + B\,(t - t_0)^2 + C\,(t - t_0)^3 + D\,(t - t_0)^4 + E\,(t - t_0)^5\right]\right\} \tag{A.1}$$

where

ρ_0 = 999,973 58 kg/m^3 (maximum density of water, at temperature t_0)

t_0 = 3,981 8 °C

A = 7,013 4 $\times$ 10^{-8} °C^{-1}

B = 7,926 504 $\times$ 10^{-6} °C^{-2}

C = $-$ 7,575 677 $\times$ 10^{-8} °C^{-3}

D = 7,314 894 $\times$ 10^{-10} °C^{-4}

E = $-$ 3,596 458 $\times$ 10^{-12} °C^{-5}

The results of the equation shall be rounded to three decimal places.

NOTE Values for the density of water are based on the work of Patterson and Morris[3]. The equation is valid over the temperature range 1 °C to 40 °C as measured on the International Temperature Scale of 1990, ITS-90.

A.2 Correction for air-saturated water

If the water used in the calibration is air-saturated, a correction to the water density calculated by the above equation shall be applied, before rounding, by means of the following equation:

$$\text{Correction} = -(4{,}612 - 0{,}106t) \times 10^{-3}\,\text{kg/m}^3 \tag{A.2}$$

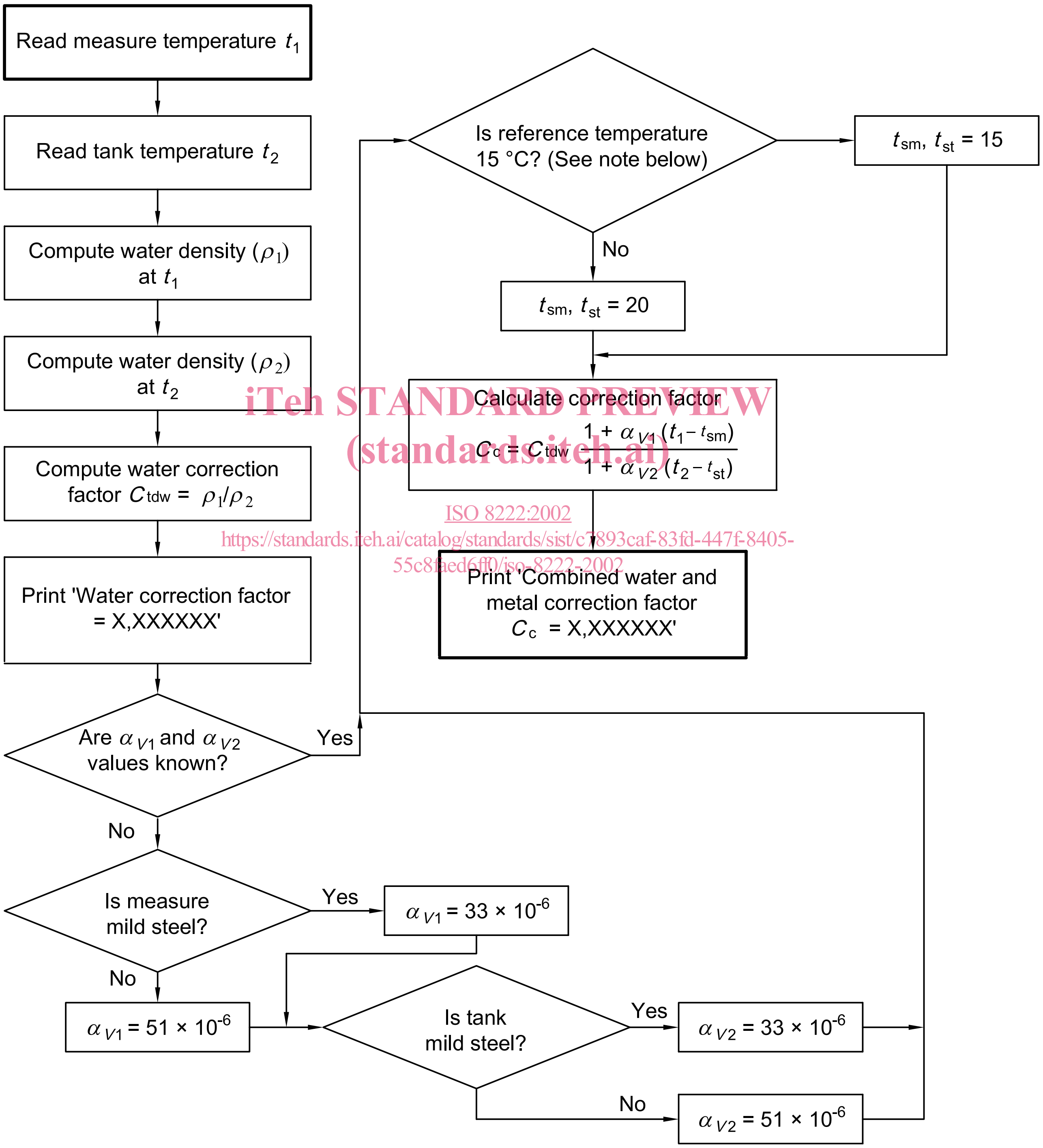
where t is the temperature of the water.

The corrected water density shall be rounded to three decimal places.

NOTE Equation (A.2) was derived by Bignell[4] for water in the temperature range 0 °C to 25 °C. For the purposes of this International Standard, it is applied at water temperatures of up to 40 °C. Any error in tank calibration arising from using the equation in the extended temperature range will be insignificant.

Annex B
(informative)

Calculation routine



NOTE If the reference temperature of the primary measure or that required for the tank calibration is 60 °F, t_{sm} or $t_{st} = 15{,}56$ °C should be substituted in the numerator or denominator respectively of the correction factor equation.