SLOVENSKI STANDARD
SIST ISO 91:2018

01-junij-2018

Nadomešča:
SIST ISO 5024:2001
SIST ISO 91-1:2001
SIST ISO 91-2:2001

Naftni in sorodni proizvodi - Volumenski korekcijski faktorji temperature in tlaka (merilne tabele za naftne proizvode) in standardni referenčni pogoji

Petroleum and related products - Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference conditions

Pétrole et produits connexes - Facteurs de correction de volume par rapport à la température et à la pression (tables de mesure du pétrole) et conditions de référence standard

Ta slovenski standard je istoveten z: **ISO 91:2017**

ICS:

75.180.30	Oprema za merjenje prostornine in merjenje	Volumetric equipment and measurements

SIST ISO 91:2018 **en,fr**

INTERNATIONAL STANDARD

ISO 91

First edition
2017-05

Petroleum and related products — Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference conditions

Pétrole et produits connexes — Facteurs de correction de volume par rapport à la température et à la pression (tables de mesure du pétrole) et conditions de référence standard

Reference number
ISO 91:2017(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 2, *Measurement of petroleum and related products*.

This first edition cancels and replaces ISO 91-1:1992, ISO 91-2:1991, ISO 9770:1989, and ISO 5024:1999, which have been technically revised.

Introduction

Custody transfer of crude petroleum and its products are generally transacted in volumetric quantities. Since crude oils and petroleum products have relatively high coefficients of thermal expansion and compressibility, volumes are corrected to standard conditions of temperature and pressure in order to provide a meaningful and consistent basis for measurement. The definition of standard reference conditions is therefore of fundamental importance in measurement, calculation and accounting of petroleum quantities.

Volume correction factors are used to account for the thermal expansion of liquid hydrocarbons and convert observed volumes to volumes at standard temperature and pressure. Tables of volume correction factors were originally developed by collecting empirical data relating to the volumetric change of hydrocarbons over a range of temperatures and pressures. Cooperative international work on volume correction factors dates from 1932. The temperature volume correction factor tables (petroleum measurement tables) referenced in ISO Recommendation (R) 91:1959[1] were developed during the late 1940s and published jointly by the American Society of Testing Materials (ASTM) in 1952 and the Institute of Petroleum (IP) (metric edition) in 1953[9]. These tables corrected to standard temperatures of 15 °C and 60 °F only, and were based on data for crude petroleum and petroleum fractions published in 1916 by the (United States) National Bureau of Standards (NBS) and some later data on natural gasoline reported in 1942. These 1952 tables were referenced in API/Standard 2540-1966[10] (also designated ASTM D1250-56). A few amendments to ISO/R 91 resulted in the publication of a second edition in 1970[2]. ISO/R 91:1970/Amd 1:1975[3] was published in 1975 for tables based on a reference temperature of 20 °C.

In the early 1970s, it was demonstrated that the previously published tables were not satisfactorily applicable to many crude oils of current economic importance. A revised standard was published in 1980 by the American Petroleum Institute as the API Manual of Petroleum Measurement Standards (*MPMS*) Chapter 11.1 (also designated API/Standard 2540, ASTM D1250-80 and IP 200/80) following the development of a new database by API in cooperation with the US NBS. This study included the examination of 463 samples of crude oil and refined products. The crude oil samples represented 67 % of world production in 1974. The 1980 standard also constituted a major conceptual departure from previous versions in the recognition of the use of computers in the petroleum industry. The actual standard represented by API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80 was neither the hardcopy printed tables nor the set of equations used to represent the density data, but was an explicit implementation procedure used to develop computer subroutines. The standardization of an implementation procedure implied the standardization of the set of mathematical expressions, including calculational sequence and round-off procedures, used within the computer code. Adherence to the procedures given in API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80 was an attempt to ensure that all computers and computer codes meeting the stated specifications and restrictions would be able to produce identical results. Hence, the published implementation procedures were the primary standard, the distributed subroutines the secondary standard, and the published tables produced for convenience.

API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80 was referenced in ISO 91-1:1982[4]. Corrections to the 1980 standard were listed in ISO 91-1:1992[5].

Computer implementation procedures developed by the IP for corrections to 20 °C were published in 1988. These implementation procedures were prepared as standard procedures to enable users to produce their own computer programmes either for the generation of 20 °C tables or for use in calculations without the generation of tables. IP Petroleum Measurement Paper No. 3[8] was referenced in ISO 91-2:1991[6], superseding Addendum 1:1975 to ISO/R 91.

Compressibility factors for hydrocarbons in the 0° to 100° API gravity range were developed in 1945 and published in 1960 as API/Standard 1101[12], Appendix B, Table II. This table was superseded by API *MPMS* Chapters 11.2.1[13] and 11.2.1M[14] published in 1984. API *MPMS* Chapter 11.2.1M-1984 was adopted by ISO/TC 28 and published as ISO 9770:1989[13].

Compressibility factors for hydrocarbons in the 0,500 to 0,611 relative density range and 20 °F to 128 °F were published in 1984 as API *MPMS* Chapter 11.2.2[15]. A second edition of API *MPMS* Chapter 11.2.2

was published in 1986 with an expanded relative density range of 0,350 to 0,637. A metric version of this standard (350 kg/m^3 to 637 kg/m^3 range) was also published in 1986 as API *MPMS* Chapter 11.2.2M.

Unlike the 1980 temperature correction factor tables (API *MPMS* Chapter 11.1-1980), the compressibility table values given in API *MPMS* Chapters 11.2.1 and 11.2.2 were the standard, not the implementation procedure for the underlying equations.

In 2004, a revision to API *MPMS* Chapter 11.1 (also designated as an adjunct to ASTM D1250-04 and IP 200/04) was published and established procedures for generalized crude oils, liquid refined products, lubricating oils and individual and special applications, by which volume measurements taken at any temperature and pressure (within the range of the standard) can be corrected to an equivalent volume at 15 °C, 60 °F or 20 °C (or other reference temperature) and standard pressure, by use of a correction factor for temperature and pressure of the liquid (CTPL). API *MPMS* Chapter 11.1-2004/Adjunct to ASTM D1250-04/Adjunct to IP 200/04 superseded API *MPMS* Chapters 11.1-1980, 11.2.1-1984 and 11.2.1M-1984.

In 2007, Addendum 1 to API *MPMS* Chapter 11.1-2004/Adjunct to ASTM D1250-04/Adjunct to IP 200/04 was published in order to include some minor updates to the standard.

Previously, most natural gas liquid (NGL) and liquefied petroleum gas (LPG) temperature correction factors were obtained from a variety of sources.

— ASTM-IP Petroleum Measurement Tables, 1952[9], as referenced in ISO/R 91:1970[4]. This publication is limited to a 60 °F relative density range of 0,500 and higher.

— GPA Standard 2142, published in 1957[16].

— GPA Technical Publication TP-16, published in 1988[17]. It is limited to the following products: HD 5 propane with relative densities of 0,501, 0,505, and 0,510; iso-butane at a relative density of 0,565; normal butane at a relative density of 0,585, and natural gasoline (12 psia to 14 psia Reid vapour pressure) at a relative density of 0,664.

— API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80 Volume XII, Table 33 “*Specific Gravity Reduction to 60 °F For Liquefied Petroleum Gases and Natural Gasoline*”, as referenced in ISO 91-1:1992[5].

— API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80 Volume XII, Table 34 “*Reduction of Volume to 60 °F Against Specific Gravity 60/60 °F For Liquefied Petroleum Gases and Natural Gasoline*”, as referenced in ISO 91-1:1992[5].

— API/ASTM/GPA Technical Publication TP-25, published in 1988[18].

In 2007, these documents were superseded by API *MPMS* Chapter 11.2.4/GPA Technical Publication TP-27.

Petroleum and related products — Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference conditions

1 Scope

This document refers to temperature volume correction factors, which allow users to convert volumes, measured at ambient conditions, to those at reference conditions for transactional purposes. This document also refers to compressibility factors required to correct hydrocarbon volumes measured under pressure to the corresponding volumes at the equilibrium pressure for the measured temperature.

Table 1 shows the defining limits and their associated units of correction factors referenced in this document for crude oil, refined products and lubricating oils. These values are shown in ***bold italics***. Also shown in the table are the limits converted to their equivalent units (and, in the case of the densities, other base temperatures). Table 2 shows defining limits of correction factors for light hydrocarbons (natural gas liquids and liquefied petroleum gases).

Table 1 — Defining limits of correction factors for crude oil, refined products and lubricating oils

	Crude oil	Refined products	Lubricating oils
Density, kg/m³ @ 60 °F	***610,6 to 1 163,5***		***800,9 to 1 163,5***
Relative density @ 60 °F	0,611 2 to 1,164 64		0,801 68 to 1,164 6
API gravity @ 60 °F	100 to –10		45 to –10
Density, kg/m³ @ 15 °C	611,16 to 1 163,79	611,16 to 1 163,86	801,25 to 1 163,85
Density, kg/m³ @ 20 °C	606,12 to 1 161,15	606,12 to 1 160,62	798,11 to 1 160,71
Temperature, °C	***–50,00 to 150***		
Temperature, °F	–58,0 to 302		
Pressure, psig	***0 to 1 500***		
Pressure, kPa (gauge)	0 to 1,034 × 10^4		
Pressure, bar (gauge)	0 to 103,4		
60 °F thermal expansion factor (α60), per °F	***230,3 × 10^{-6} to 930,0 × 10^{-6}***		
α60, Per °C	414,0 × 10^{-6} to 1 674,0 × 10^{-6}		

Table 2 — Defining limits of correction factors for light hydrocarbons (natural gas liquids and liquefied petroleum gases)

Density, kg/m³ @ 60 °F	***350,0 to 688,0***
Density, kg/m³ @ 15 °C	351,7 to 687,8
Density, kg/m³ @ 20 °C	331,7 to 683,6
Temperature °C	***–46,0 to 93,0***
Temperature °F	–50,8 to 199,4
Pressure	***Saturation conditions (bubble point or saturation vapour pressure)*** (see Note 2 to 4.1)

This document also specifies standard reference conditions of pressure and temperature for measurements carried out on crude petroleum and its products, including liquefied petroleum gases (see Annex B).

This document excludes specifying standard reference conditions for natural gas which are given in ISO 13443[15].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Manual of Petroleum Measurement Standards (*MPMS*) Chapter 11.1–2004[1)]/Adjunct to ASTM D1250-04[2)]/Adjunct to IP 200/04, *Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils*/Addendum 1-2007

API *MPMS* Chapter 11.2.2-1986, *Compressibility Factors for Hydrocarbons: 0.350–0.637 Relative Density (60 °F/60 °F) and –50 °F to 140 °F Metering Temperature*/Errata June 1996

API *MPMS* Chapter 11.2.2M-1986, *Compressibility Factors for Hydrocarbons: 350–637 Kilograms per Cubic Metre Density (15 °C) and –46 °C to 60 °C Metering Temperature*

API *MPMS* Chapter 11.2.4-2007/GPA Technical Publication TP-27-2007, *Temperature Correction for the Volume of NGL and LPG, Tables 23E, 24E, 53E, 54E, 59E, and 60E*

API *MPMS* Chapter 11.5[3)] Part 1-2009/Adjunct to ASTM D1250-08/Adjunct to IP 200/08, *Density/Weight/Volume Intraconversion — Part 1: Conversions of API gravity at 60° F*

API *MPMS* Chapter 11.5[3)] Part 2-2009/Adjunct to ASTM D1250-08/Adjunct to IP 200/08, *Density/Weight/Volume Intraconversion — Part 2: Conversions for Relative Density (60/60° F)*

API *MPMS* Chapter 11.5[3)] Part 3-2009/Adjunct to ASTM D1250-08/Adjunct to IP 200/08, *Density/Weight/Volume Intraconversion — Part 3: Conversions for Absolute Density at 15° C*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Sources and usage guidelines for volume correction factors

4.1 Source of volume correction factors

For the purpose of custody transfer in accordance with this document, reference shall be made to API *MPMS* Chapter 11.1-2004/Adjunct to ASTM D1250-04 and IP 200/04, including Addendum 1-2007.

API *MPMS* Chapter 11.1-2004/Adjunct to ASTM D1250-04 and IP 200/04, including Addendum 1-2007, recognizes three distinct commodity groups: crude oil, refined products, and lubricating oils. A special

1) Available from API. Order Product Number H11013.

2) Available from ASTM International. Order Product Number ADJD1250-E-PDF.

3) API *MPMS* Chapter 11.5 Parts 1-3 replaced Volumes XI and XII of API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80 (see Annex C).

application category is also included which provides volume correction based on the input of an experimentally derived coefficient of thermal expansion.

NOTE 1 Additional API volume correction factor standards have subsequently been published or are under development for particular applications. See Annex D.

API *MPMS* Chapter 11.1-2004/Adjunct to ASTM D1250-04 and IP 200/04 provides general procedures for the conversion of input data to generate the corrected values at the user specified base temperature and pressure using the effect of temperature on the liquid (CTL), the compressibility coefficient (F_p), the correction for the effect of pressure on the liquid (CPL), or the correction for temperature and pressure of a liquid (CTPL), in a form that is consistent with the computation procedures used to generate VCF values. Two sets of procedures are given for computing the volume correction factor: one set for data expressed in U.S. customary units (temperature in degrees Fahrenheit, pressure in pounds per square inch gauge), the other for the metric system of units (temperature in degrees Celsius, pressure in kilopascals). In contrast to API *MPMS* Chapter 11.1-1980/ASTM D1250-80/IP 200/80, the metric procedures require the procedure for U.S. customary units be used first to compute density at 60 °F. This value is then further corrected to give the metric output.

For density/weight/volume intraconversion, reference shall be made to API *MPMS* Chapter 11.5 Part 1 to Part 3/Adjunct to ASTM D1250-08 and IP 200/08. These standards provide conversion of measurements from one system of units to another for both in vacuo and in air values.

For NGL and LPG, reference shall be made to API *MPMS* Chapter 11.2.4-2007/GPA Technical Publication TP-27-2007. The implementation procedures describe how to calculate the CTL given an appropriate density factor at basis temperature and an observed temperature, and calculate the appropriate density factor at basis temperature given a relative density at an observed temperature. The implementation procedures are presented in pairs by base temperature. First, the procedures for Tables 23E and 24E of API *MPMS* Chapter 11.2.4-2007/GPA TP-27-2007 at a 60 °F base temperature are given. The procedure for Table 23E makes use of the procedure described in Table 24E, thus Table 24E is presented first. These are followed by procedures for Table 54E and Table 53E at a base temperature of 15 °C, which themselves make use of the procedures in Table 23E and Table 24E; these in turn are followed by the procedures for Table 60E and Table 59E at a base temperature of 20 °C, which also make use of the procedures described in Table 23E and Table 24E.

To correct NGL and LPG volumes metered under pressure to the corresponding volumes under equilibrium pressure for the process temperature at the meter, reference shall be made to API *MPMS* Chapter 11.2.2-1986 (including Errata June 1996) or API *MPMS* Chapter 11.2.2M-1986 or if outside of the density range of these standards, API *MPMS* Chapter 11.2.1-1984 or API *MPMS* Chapter 11.2.1M-1984.

These methods require a knowledge of the equilibrium bubble point pressure (vapour pressure) at the measured conditions. However, the vapour pressure of the process liquid is generally not measured. The vapour pressure can also be calculated from compositional information, but the composition is not always measured for natural gas liquids (NGLs). Therefore, a correlation for the vapour pressure of NGLs based upon normally measured properties is required, and API *MPMS* Chapter 11.2.5-2007/GPA Technical Publication TP-15[19] can be used for this purpose. The procedure given in API *MPMS* Chapter 11.2.5/GPA TP-15 provides a simplified means of estimating equilibrium vapour pressures of various NGLs from a knowledge of the fluid's relative density (60 °F/60 °F) and process temperature. The intended application of this procedure is to provide the values of P_e (equilibrium vapour pressure) required to determine the pressure effect contributions to volume correction factors as specified.

See Annex C for titles of petroleum measurement tables given in the 1980 editions of the API, ASTM, and IP volume correction factor standards, as well as a list of the documents that have superseded these documents.

4.2 Usage guidelines

Due to the nature of the changes in this document, it is recognized that guidance concerning an implementation period might be needed in order to avoid disruptions within the industry and ensure proper application. As a result, it is recommended that this document be utilized on all new applications