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Petroleum measurement tables

Tables de mesure du pétrole

ORGANISATION INTERNATIONALE
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Foreword

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- **International Guides (OIML G)**, which are also informative in nature and which are intended to give guidelines for the application of certain requirements to legal metrology; and
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OIML Draft Recommendations, Documents and Guides are developed by Project Groups linked to Technical Committees or Subcommittees which comprise representatives from the Member States. Certain international and regional institutions also participate on a consultation basis. Cooperative agreements have been established between the OIML and certain institutions, such as ISO and the IEC, with the objective of avoiding contradictory requirements. Consequently, manufacturers and users of measuring instruments, test laboratories, etc. may simultaneously apply OIML publications and those of other institutions.

International Recommendations, Documents, Guides and Basic Publications are published in English (E) and translated into French (F) and are subject to periodic revision.

Additionally, the OIML publishes or participates in the publication of **Vocabularies (OIML V)** and periodically commissions legal metrology experts to write **Expert Reports (OIML E)**. Expert Reports are intended to provide information and advice, and are written solely from the viewpoint of their author, without the involvement of a Technical Committee or Subcommittee, nor that of the CIML. Thus, they do not necessarily represent the views of the OIML.

This publication – reference OIML D 35, Edition 2020 (E) – was developed by Project Group 7 of OIML TC 8 *Measurement of quantities of fluids*. It was approved for final publication by the International Committee of Legal Metrology in 2020 and will be submitted to the International Conference on Legal Metrology in 2021 for formal sanction. It supersedes OIML R 63 dated 1994.

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Introduction

In 1982 and in 1991 respectively, the International Organization for Standardization (ISO) published the two parts of its revised Standard 91 “Petroleum measurement tables”, Part 1: “Tables based on reference temperatures of 15 °C and 60 °F” and Part 2: “Tables based on a reference temperature of 20 °C”. This Standard, developed by ISO/TC 28, replaces the tables referred to in the previous edition of ISO 91, developed during the late 1940’s and based on data for crude petroleum and petroleum fractions published in 1916. Some later data on natural gasolines reported in 1942 were also used.

The tables referred to in ISO 91-1:1982 were developed jointly by the American Petroleum Institute (API) in USA, the American Society for Testing and Materials (ASTM) in USA and the Institute of Petroleum (IP) which was merged into the Energy Institute (EI) in the United Kingdom. In 1992, the 1982 edition was amended and published as ISO 91-1:1992. The tables in ISO 91-1 were prepared by the API following the development of a data base by the National Institute of Standards and Technology (NIST) in USA.

In 2017, a new version of ISO 91 [1] was published which superseded ISO 91-1 and ISO 91-2. This version provided updated links to the five Chapters of the Manual of Petroleum Measurement Standards (MPMS) [2] of API which consists of 23 Chapters in total. In ISO 91:2017, some tables for gases also referenced the Technical Publications (TPs) of Gas Processors Association (GPA) of USA.

A simplified version of Table C.1 of ISO 91 is reproduced in this OIML Document with kind permission from ISO.

Petroleum measurement tables

1 Scope

This International Document covers petroleum measurement tables used by administrative services (such as customs) for the official determination of quantities of petroleum and its products, under reference conditions, using measurements of volume or mass, temperature, density, etc.

2 Reference temperature

The reference temperature at which volumes are expressed is 15 °C. However, other reference temperatures (for example, 20 °C or 60 °F) may be used if required by national regulations.

The list given in Annex A as numbers 53A, 53B, 53D, 53E, 54A, 54B, 54C, 54D, 54E, 56, 57 and 58 are based on the reference temperature of 15 °C.

3 Recommended petroleum tables

OIML Member States are requested to use the petroleum measurement table A.1 in Annex A.

4 Information concerning availability of tables

All tables of MPMS [2] referenced in the Annex may be purchased from the publishers, the **American Petroleum Institute** (<http://www.api.org/>), c/o Publication and Distribution Section, 1220 L Street, NW, Washington, DC 20005-4070, USA, or from the **American Society for Testing and Materials** (<https://www.astm.org/>), 100 Barr Harbor Drive, West Conshohocken, PA 19103, USA.

5 Bibliography

- [1] ISO 91:2017: *Petroleum and related products - Temperature and pressure volume correction factors (petroleum measurement tables) and standard reference conditions.*
- [2] Manual of Petroleum Measurement Standards (MPMS): American Petroleum Institute - American Society for Testing and Materials - Energy Institute. Following chapters are referred in Table A.1.
 - Chapter 11.1 - *Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils*: 2004/ Adjunct to ASTM D1250-04 and IP 200/04
 - Chapter 11.2.1 - *Compressibility Factors for Hydrocarbons: 0-90 Degrees API Gravity Range*: 1984 (superseded by Chapter 11.1.8.25)
 - Chapter 11.2.1M - *Compressibility Factors for Hydrocarbons: 638-1074 Kilograms per Cubic Metre Range*: 1984 (superseded by Chapter 11.1.8.26)
 - Chapter 11.2.2 - *Compressibility Factors for Hydrocarbons: 0.350–0.637 Relative Density (60 °F/60 °F) and –50 °F to 140 °F Metering Temperature*: 1986
 - Chapter 11.2.2M - *Compressibility Factors for Hydrocarbons: 350–637 Kilograms per Cubic Meter Density (15 °C) and –46 °C to 60 °C Metering Temperature*: 1986
 - Chapter 11.2.4 - *Temperature Correction for the Volume of NGL and LPG*: 2007/ GPA TP-27-2007
 - Chapter 11.5.1 Part 1 - *Conversions of API Gravity at 60 °F*: 2009/ Adjunct to ASTM D1250-08 and IP 200/08
 - Chapter 11.5.2 Part 2 - *Conversions for Relative Density (60/60 °F)*: 2009/ Adjunct to ASTM D1250-08 and IP 200/08
 - Chapter 11.5.3 Part 3 - *Conversions for Absolute Density at 15 °C*: 2009/ Adjunct to ASTM D1250-08 and IP 200/08

Annex A

Table A.1: Titles of petroleum measurement tables (Extract from ISO 91:2017)

| PMT number | Title of petroleum measurement table (PMT) of volume correction factors | Chapters of MPMS [2] by which PMT is currently covered |
|------------|--|--|
| 1 | Interrelation of units of measurement | 11.5.1 to 11.5.3 |
| 2 | Temperature conversions | 11.5.1 to 11.5.3 |
| 3 | API gravity at 60 °F to relative density 60/60 °F and to density at 15 °C | 11.5.1 |
| 4 | U.S. Gallons and barrels at 60 °F to litres at 15 °C against API gravity at 60 °F | 11.5.1 |
| 5A | Correction of observed API gravity to API gravity at 60 °F for generalised crude oils | 11.1.8.1 |
| 5B | Corrections of observed API gravity to API gravity at 60 °F for generalised products | 11.1.8.2 |
| 5D | Correction of observed API gravity to API gravity at 60 °F for generalised lubricating oils | 11.1.8.3 |
| 6A | Correction of volume to 60 °F against API gravity at 60 °F for generalised crude oils | 11.1.8.4 |
| 6B | Correction of volume to 60 °F against API gravity at 60 °F for generalised products | 11.1.8.4 |
| 6C | Volume correction to 60 °F against thermal expansion coefficients at 60 °F for individual and special applications | 11.1.8.23 |
| 6D | Correction of volume to 60 °F against API gravity at 60 °F for generalised lubricating oils | 11.1.8.5 |
| 8 | Pounds per U.S. gallon at 60 °F and U.S. gallons at 60 °F per pound against API gravity at 60 °F | 11.5.1 |
| 9 | Short tons per 1000 U.S. gallons at 60 °F and per barrel at 60 °F against API gravity at 60 °F | 11.5.1 |
| 10 | U.S. gallons at 60 °F and barrels at 60 °F per short ton against API gravity at 60 °F | 11.5.1 |
| 11 | Long tons per 1000 U.S. gallons at 60 °F and per barrel at 60 °F against API gravity at 60 °F | 11.5.1 |
| 12 | U.S. gallons at 60 °F and barrels at 60 °F per long ton against API gravity at 60 °F | 11.5.1 |
| 13 | Metric tons (tonnes) per 1000 U.S. gallons at 60 °F and per barrel at 60 °F against API gravity at 60 °F | 11.5.1 |
| 14 | Cubic metres at 15 °C per short ton and per long ton against API gravity at 60 °F | 11.5.1 |
| 21 | Relative density 60/60 °F to API gravity at 60 °F and to density at 15 °C | 11.5.2 |
| 22 | U.S. gallons at 60 °F to litres at 15 °C and barrels at 60 °F to cubic metres at 15 °C | 11.5.2 |
| 23A | Correction of observed relative density to relative density 60/60 °F for generalised crude oils | 11.1.8.6 |
| 23B | Correction of observed relative density to relative density 60/60 °F for generalised products | 11.1.8.7 |
| 23D | Correction of observed specific gravity to specific gravity 60/60 °F for generalised lubricating oils | 11.1.8.8 |
| 23E | Correction of observed relative density to relative density 60/60 °F for NGL and LPG | 11.2.4 |
| 24A | Correction of volume to 60 °F against relative density 60/60 °F for generalised crude oils | 11.1.8.9 |

| PMT number | Title of petroleum measurement table (PMT) of volume correction factors | Chapters of MPMS [2] by which PMT is currently covered |
|------------|--|--|
| 24B | Correction of volume to 60 °F against relative density 60/60 °F for generalised products | 11.1.8.9 |
| 24C | Volume correction to 60 °F against thermal expansion coefficients at 60 °F for individual and special applications | 11.1.8.23 |
| 24D | Correction of volume to 60 °F against specific gravity 60/60 °F for generalised lubricating oils | 11.1.8.10 |
| 24E | Correction of volume to 60 °F against relative density 60/60 °F for NGL and LPG | 11.2.4 |
| 26 | Pounds per gallon at 60 °F and U.S. gallons at 60 °F per pound against relative density 60/60 °F | 11.5.2 |
| 27 | Short tons per 1000 U.S. gallons at 60 °F and per barrel at 60 °F against relative density 60/60 °F | 11.5.2 |
| 28 | U.S. gallons at 60 °F and barrels at 60 °F per short tons against relative density 60/60 °F | 11.5.2 |
| 29 | Long tons per 1000 U.S. gallons at 60 °F and per barrel at 60 °F against relative density 60/60 °F | 11.5.2 |
| 30 | U.S. gallons at 60 °F and barrels at 60 °F per long ton against relative density 60/60 °F | 11.5.2 |
| 31 | Cubic metres at 15 °C per short ton and per long ton against relative density 60/60 °F | 11.5.2 |
| 33 | Specific gravity reduction to 60 °F for liquefied petroleum gases and natural gasoline | 11.2.4 |
| 34 | Reduction of volume to 60 °F against specific gravity 60/60 °F for liquefied petroleum gases | 11.2.4 |
| 51 | Density at 15 °C to relative density 60/60 °F and to API gravity at 60 °F | 11.5.3 |
| 52 | Barrels at 60 °F to cubic metres at 15 °C and cubic metres at 15 °C to barrels at 60 °F | 11.5.2 and 11.5.3 |
| 53A | Correction of observed density to density at 15 °C for generalised crude oils | 11.1.8.11 |
| 53B | Correction of observed density to density at 15 °C for generalised products | 11.1.8.12 |
| 53D | Correction of observed density to density at 15 °C for generalised lubricating oils | 11.1.8.13 |
| 53E | Correction of observed density to density at 15 °C for NGL and LPG | 11.2.4 |
| 54A | Correction of volume to 15 °C against density at 15 °C for generalised crude oils | 11.1.8.14 |
| 54B | Correction of volume to 15 °C against density at 15 °C for generalised products | 11.1.8.15 |
| 54C | Volume correction to 15 °C against thermal expansion coefficients at 15 °C for individual and special applications | 11.1.8.24 |
| 54D | Correction of volume to 15 °C against density at 15 °C for generalised lubricating oils | 11.1.8.16 |
| 54E | Correction of volume to 15 °C against density at 15 °C for NGL and LPG | 11.2.4 |
| 56 | Kilograms per cubic metre at 15 °C and cubic metres at 15 °C per metric ton (tonnes) against density at 15 °C | 11.5.3 |
| 57 | Short tons and long tons per 1000 litres at 15 °C against density at 15 °C | 11.5.3 |
| 58 | U.S. Gallons and barrels per metric ton (tonne) against density at 15 °C | 11.5.3 |
| 59A | Correction of observed density to density at 20 °C for generalised crude oils | 11.1.8.17 |

| PMT number | Title of petroleum measurement table (PMT) of volume correction factors | Chapters of MPMS [2] by which PMT is currently covered |
|---------------------------------------|---|--|
| 59B | Correction of observed density to density at 20 °C for generalised products | 11.1.8.18 |
| 59D | Correction of observed density to density at 20 °C for lubricating oils | 11.1.8.19 |
| 59E | Correction of observed density to density at 20 °C for NGL and LPG | 11.2.4 |
| 60A | Correction of volume to 20 °C against density at 20 °C for generalised crude oils | 11.1.8.20 |
| 60B | Correction of volume to 20 °C against density at 20 °C for generalised products | 11.1.8.21 |
| 60C | Volume Correction Factors for Individual and Special Applications Volume Correction to 20 °C Against Thermal Expansion Coefficients. | 11.1.8.24 |
| 60D | Correction of volume to 20 °C against density at 20 °C for lubricating oils | 11.1.8.22 |
| 60E | Correction of volume to 20 °C against density at 20 °C for NGL and LPG | 11.2.4 |
| (1984) Chapter 11.2.1 Table | Compressibility Factors for Hydrocarbons: 0-90 Degrees API Gravity Range | 11.2.1 (11.1.8.25) |
| (1984) Chapter 11.2.1M Table | Compressibility Factors for Hydrocarbons: 638-1074 Kilograms per Cubic Metre Range | 11.2.1M (11.1.8.26) |
| (1986) Chapter 11.2.2 Table | Compressibility Factors for Hydrocarbons: 0.350–0.637 Relative Density (60 °F/60 °F) and –50 °F to 140 °F Metering Temperature | 11.2.2 |
| (1986) Chapter 11.2.2M Table | Compressibility Factors for Hydrocarbons: 350–637 Kilograms per Cubic Meter Density (15 °C) and –46 °C to 60 °C Metering Temperature | 11.2.2M |