INTERNATIONAL STANDARD

ISO 91-1

Second edition
1992-11-15

Petroleum measurement tables —

Part 1:
Tables based on reference temperatures of 15 °C and 60 °F

Tables de mesure du pétrole —

Partie 1: Tables basées sur les températures de référence de 15 °C *et* 60 °F

Reference number
ISO 91-1:1992(E)

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.

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.

International Standard ISO 91-1 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Sub-Committee SC 3, *Static petroleum measurement*.

This second edition cancels and replaces the first edition (ISO 91-1:1982), of which it constitutes a technical revision.

ISO 91 consists of the following parts, under the general title *Petroleum measurement tables*:

— *Part 1: Tables based on reference temperatures of 15 °C and 60 degrees F*

— *Part 2: Tables based on a reference temperature of 20 °C*

Annex A forms an integral part of this part of ISO 91. Annex B is for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Introduction

The tables referred to in ISO/R 91:1970 were developed during the late 1940's and were 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 revised tables referred to in ISO 91-1:1982 were prepared by the American Petroleum Institute following the development of a new data base by the National Bureau of Standards (USA). This study included the examination of 463 samples of crude oil and refined products. The samples represented 67 % of world crude petroleum production and 68 % of the estimated reserves in 1974. The present revision takes account of subsequent publications.

This page intentionally left blank

Petroleum measurement tables —

Part 1:
Tables based on reference temperatures of 15 °C and 60 °F

1 Scope

This part of ISO 91 refers to petroleum measurement tables based on reference temperatures of 15 °C and 60 °F.

The standard reference temperature for petroleum measurement adopted in ISO 5024 [4] is 15 °C, and should be used for international trade. However, it is recognized that its use is not yet universally accepted and references to tables based on 60 °F have therefore been included in this part of ISO 91 and tables based on 20 °C are covered in ISO 91-2[1].

2 Normative references

The tables that form the basis of this part of ISO 91 contain printing errors which are identified in other documents listed below. These subsidiary documents constitute, through reference in the text, an integral part of this part of ISO 91.

API Standard 2540, *Manual of petroleum measurement standards, Chapter 11.1 — Volume correction factors:*

Volumes I to X, 1980;[1)]

Volumes XIII and XIV, 1982.[1)]

API Document, *Editorial amplification of volume X — Background, development, and computer documentation*, American Petroleum Institute, Washington DC, 1980.

API Document, *Errata sheet to tables 23B and 53B*, American Petroleum Institute, Washington DC, 1981.

API Document, *The use of the petroleum measurement tables — API STD. 2540 (CH. 11.1), ASTM D 1250 and IP 200 (1980)*, American Petroleum Institute, Washington DC, 1984 (revised June 1987).

ASTM D 1250, *Petroleum measurement tables:*

Volumes I to X, 1980;[1)]

Volume XI/XII, 1982.[1)]

ASTM-IP-API, *Petroleum measurement tables for light hydrocarbon liquids, density range 0.500 to 0.653 kg/litre at 15 °C*, published for the Institute of Petroleum by John Wiley and Sons, 1986.[2)]

IP Petroleum Measurement Paper No. 2, *Guidelines for users of the petroleum measurement tables (API STD. 2540; IP 200; ANSI/ASTM D 1250)*, the Institute of Petroleum, London, 1984.[3)]

1) All volumes may be purchased from the publishers, the American Petroleum Institute, c/o Publication and Distribution Section, 120 L Street NW, Washington DC 20005, USA, or from the American Society for Testing and Materials, 1912 Race Street, Philadelphia, Pa 19103, USA. The names of local suppliers may be obtained from national standards organizations. The tables are also available on microfiche and the computer sub-routine as magnetic tape or as FORTRAN card decks.

2) This publication may be purchased from John Wiley and Sons Ltd, Distribution Centre, Shripney Road, Bognor Regis, West Sussex PO22 9SA, UK, or from a local bookseller.

3) This publication may be purchased from the Institute of Petroleum, 61 New Cavendish Street, London W1M 8AR, UK.

3 Sources of tables

3.1 For the purpose of custody transfer in accordance with this part of ISO 91, reference shall be made to the API-ASTM-IP *Petroleum measurement tables*, which were developed jointly by

a) the American Petroleum Institute (API) — USA,

b) the American Society for Testing and Materials (ASTM) — USA, and

c) the Institute of Petroleum (IP) — United Kingdom,

and have been adopted by these organizations under the following designations:

API STD. 2540-1980

ANSI/ASTM D 1250-80

IP 200/80

See also 3.6.

3.2 The tables have been published by the American Petroleum Institute under the title *Manual of petroleum measurement standards, chapter 11.1 — Volume correction factors*, and by the American Society for Testing and Materials, which published two of the volumes, Volumes XI/XII, as a combined document. The complete set of tables consists of 14 volumes, and the table numbers and titles are related to the volume numbers given in annex A to this part of ISO 91. Such publications are reprinted from time to time. If corrections are included in such reprints, the API has agreed to advise ISO of them, and an amendment will be issued to this part of ISO 91 referring to the corrections and to the date of the reprint. Users should then ensure that they have the most recent reprint.

No amendments or reprints have been published since the previous edition of this part of ISO 91, but corrections are listed in the following publications and the corrected values shall be used in connection with this part of ISO 91:

a) *Editorial amplification of volume X — Background, development, and computer documentation*;

b) *Errata sheet to tables 23B and 53B;*

c) *The use of the petroleum measurement tables — API STD. 2540 (CH. 11.1), ASTM D 1250 and IP 200 (1980)*;

d) *Guidelines for users of the petroleum measurement tables (API STD. 2540; IP 200; ANSI/ASTM D 1250).*

NOTE 1 Copies of items a), b) and c) are usually supplied with the appropriate volumes of the tables; they are also reproduced within item d), with other corrections.

3.3 Of the tables referred to in annex A, the three series of tables

5A, 5B, 5D, 6A, 6B, 6C, 6D

23A, 23B, 24A, 24B, 24C

53A, 53B, 53D, 54A, 54B, 54C, 54D

are of primary use. They shall be used to convert from hydrometer readings of API gravity or relative density or density and volume measurements, first to obtain API gravity at 60 °F, or relative density 60/60 °F, or density at 15 °C, respectively, and then to find the volume corrected to the corresponding reference temperature. The other tables, which are reproduced in volume XI/XII, permit accurate conversion of measurements from one system of units to another and conversions between apparent mass in air, mass and volume.

3.4 The tables referred to in annex A relate to the following ranges of density and relative density:

tables 5A and 6A: 100° to 0° API

tables 5B and 6B: 85° to 0° API

tables 5D and 6D: 10° to 45° API

tables 23A and 24A: 0.612 to 1.076 (60 °F/60 °F)

tables 23B and 24B: 0.654 to 1.075 (60 °F/60 °F)

tables 53A and 54A: 612 to 1 074 kg/m^3 at 15 °C

tables 53B and 54B: 654 to 1 075 kg/m^3 at 15 °C

tables 53D and 54D: 800 to 1 164 kg/m^3 at 15 °C

3.5 For values below the ranges in 3.4 and down to 500 kg/m^3 (0.500 kg/l) at 15 °C, reference shall be made to ASTM-IP-API *Petroleum measurement tables for light hydrocarbon liquids*, in which the tables are identical with the corresponding tables in the 1953 metric edition of API 2540, ASTM D 1250 and IP 200 and referred to in ISO/R 91:1970. For values in terms of relative density in the equivalent range, reference shall be made to tables 33 and 34 of ASTM D 1250.

The tables relating to values down to the equivalent of 500 kg/m^3 are designated in annex A by reference to footnotes 3 and 4 to that annex.

3.6 Computer sub-routines in ANSI FORTRAN and the required program documentation are available for each of the tables in volumes I to IX. This documentation and information on the background and

development of the tables have been published in volume X entitled "*Background, development, and program documentation*" (see notes 2 and 3).

Computer sub-routines in ANSI FORTRAN are included in volumes XIII and XIV for the tables in these volumes, but without implementation procedures.

The program documentation in volume X includes implementation procedures that are the primary standard. These procedures may be used to develop computer sub-routines in any computer language. Such a sub-routine that exactly follows one of the procedures (including the rounding and truncation operations specified) is a valid application of this part of ISO 91.

No implementation procedures are included in volumes XIII and XIV, but a procedure for table 54D has been included in IP Petroleum Measurement Paper No. 2 as "*Standard for volume correction of lubricating oils*" and is a valid application of this part of ISO 91.

No implementation procedures or computer sub-routines have been published for the tables referred to in 3.5 that provide a completely valid application of this part of ISO 91 (see note 4).

NOTES

2 The computer sub-routines for tables 5, 23 and 53 contain an optional provision to bypass the hydrometer correction so that the values for API gravity, or relative density or density, may be introduced directly.

3 In the printed tables relating to the conversion of hydrometer readings, the coefficient of thermal cubic expansion for glass of $23 \times 10^{-6}\ °C^{-1}$ has been used. This value is marginally below the conventional value quoted in ISO 1768[3], i.e. $25 \times 10^{-6}\ °C^{-1}$. This difference in coefficient is not significant for most temperature differences found in practice. When using metric units, it may be corrected for, before entering tables 53A and 53B with readings made using hydrometers complying with ISO 649-1[2], by subtracting $2 \times 10^{-6} R'(\theta - 15)$ from the hydrometer reading, where R' is the hydrometer reading and θ the observed temperature, if it is agreed between the interested parties that the temperature difference $(\theta - 15)$ is sufficient for the error to be significant.

4 In appendix A to the *Petroleum measurement tables for light hydrocarbon liquids* (see 3.5), calculation procedures have been provided for which sub-routines can be developed that will reproduce most of the tabulated values. The limitations of each procedure are indicated. Sub-routines developed from these procedures may be used by agreement between the parties concerned.

Annex A
(normative)

Titles of tables contained in the API-ASTM-IP petroleum measurement tables

Table No.	Title	Volumes in which table appears	
		Non-metric units	Metric units
1	Interrelation of units of measurement	XI/XII	XI/XII
2	Temperature conversions	XI/XII	XI/XII
3	API gravity at 60 °F to relative density 60/60 °F and to density at 15 °C	XI/XII	XI/XII
4	Gallons (US) at 60 °F to litres at 15 °C and barrels (US) at 60 °F to cubic metres at 15 °C against API gravity at 60 °F	XI/XII	
5A	Generalized crude oils — Correction of observed API gravity to API gravity at 60 °F	I	
5B	Generalized products — Correction of observed API gravity to API gravity at 60 °F	II	
5D	Generalized lubricating oils — Correction of observed API gravity to API gravity at 60 °F	XIII	
6A	Generalized crude oils — Correction of volume to 60 °F against API gravity at 60 °F	I	
6B	Generalized products — Correction of volume to 60 °F against API gravity at 60 °F	II	
6C	VCF[1] for individual and special applications — Volume correction to 60 °F against thermal expansion coefficients at 60 °F	III	
6D	Generalized lubricating oils — Correction of volume to 60 °F against API gravity at 60 °F	XIII	
8	Pounds per gallon (US) at 60 °F and gallons (US) at 60 °F per pound against API gravity at 60 °F	XI/XII	
9	Short tons per 1 000 gal (US) at 60 °F and per barrel (US) at 60 °F against API gravity at 60 °F	XI/XII	
10	Gallons (US) at 60 °F and barrels (US) at 60 °F per short ton against API gravity at 60 °F	XI/XII	
11	Long tons[2] per 1 000 gal (US) at 60 °F and per barrel (US) at 60 °F against API gravity at 60 °F	XI/XII	
12	Gallons (US) at 60 °F and barrels (US) at 60 °F per long ton against API gravity at 60 °F	XI/XII	
13	Metric tons (tonnes) per 1 000 gal (US) at 60 °F and per barrel (US) at 60 °F against API gravity at 60 °F	XI/XII	
14	Cubic metres at 15 °C per short ton and per long ton against API gravity at 60 °F	XI/XII	
21	Relative density 60/60 °F to API gravity at 60 °F and to density at 15 °C	XI/XII	XI/XII[3]
22	Gallons (US) at 60 °F to litres at 15 °C and barrels (US) at 60 °F to cubic metres at 15 °C against relative density 60/60 °F	XI	
23A	Generalized crude oils — Correction of observed relative density to relative density 60/60 °F	IV	

Table No.	Title	Volumes in which table appears	
		Non-metric units	Metric units
23B	Generalized products — Correction of observed relative density to relative density 60/60 °F	V	
24A	Generalized crude oils — Correction of volume to 60 °F against relative density 60/60 °F	IV	
24B	Generalized products — Correction of volume to 60 °F against relative density 60/60 °F	V	
24C	VCF[1] for individual and special applications — Volume correction to 60 °F against thermal expansion coefficients at 60 °F	VI	
26	Pounds per gallon (US) at 60 °F and gallons (US) at 60 °F per pound against relative density 60/60 °F	XI/XII	
27	Short tons per 1 000 gal (US) at 60 °F and per barrel (US) at 60 °F against relative density 60/60 °F	XI/XII	
28	Gallons (US) at 60 °F and barrels (US) at 60 °F per short ton against relative density 60/60 °F	XI/XII	
29	Long tons per 1 000 gal (US) at 60 °F and per barrel (US) at 60 °F against relative density 60/60 °F	XI/XII	
30	Gallons (US) at 60 °F and barrels (US) at 60 °F per long ton (US) against relative density 60/60 °F	XI/XII	
31	Cubic metres at 15 °C per short ton and per long ton against relative density 60/60 °F	XI/XII	
33	Specific gravity reduction to 60 °F for liquefied petroleum gases and natural gasoline	[4]	
34	Reduction of volume to 60 °F against specific gravity 60/60 °F for liquefied petroleum gases	[4]	
51	Density at 15 °C to API gravity at 60 °F and to relative density 60/60 °F		XI/XII[3]
52	Barrels (US) at 60 °F to cubic metres at 15 °C and cubic metres at 15 °C to barrels (US) at 60 °F against density at 15 °C		XI/XII[3]
53A	Generalized crude oils — Correction of observed density to density at 15 °C		VII[3]
53B	Generalized products — Correction of observed density to density at 15 °C		VIII[3]
53D	Generalized lubricating oils — Correction of observed density to density at 15 °C		XIV
54A	Generalized crude oils — Correction of volume to 15 °C against density at 15 °C		VII[3]
54B	Generalized products — Correction of volume to 15 °C against density at 15 °C		VIII[3]
54C	VCF[1] for individual and special applications — Volume correction to 15 °C against thermal expansion coefficients at 15 °C		IX
54D	Generalized lubricating oils — Correction of volume to 15 °C against density at 15 °C		XIV
56	Kilograms per cubic metre at 15 °C and cubic metres at 15 °C per metric ton (tonne) against density at 15 °C		XI/XII[3]
57	Short tons and long tons per cubic metre at 15 °C against density at 15 °C		XI/XII[3]
58	Gallons (US) at 60 °F and barrels (US) at 60 °F per metric ton (tonne) against density at 15 °C		XI/XII[3]

1) VCF: Volume correction factor.

2) 1 long ton (US) = 1 ton (UK) = 2 240 lb

3) To extend the density range of these tables below the values listed in 3.4, see 3.5.

4) Included in ASTM-IP *Petroleum measurement tables*, American Society for Testing and Materials; Philadelphia, 1952. Reprints of tables 33 and 34 available from ASTM.