IS 2164 (1961): Method for calculation of bulk quantities of petroleum and liquid petroleum products [PCD 1: Methods of Measurement and Test for Petroleum, Petroleum Products and Lubricants]

BLANK PAGE

IS : 2164 - 1961
(Reaffirmed 2002)

Indian Standard

METHOD FOR CALCULATION OF BULK QUANTITIES OF PETROLEUM AND LIQUID PETROLEUM PRODUCTS

(Fourth Reprint OCTOBER 1997)

UDC 665.5 : 531.732

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 7 *November* 1962

Indian Standard
METHOD FOR CALCULATION OF BULK QUANTITIES OF PETROLEUM AND LIQUID PETROLEUM PRODUCTS

Petroleum Measurements Sectional Committee, CDC 32

Chairman	*Representing*
Dr H. K. Joshi	Esso Standard Refining Co of India Ltd, Bombay
Members	
Shri T. B. Bhonsle	Central Public Works Department
Executive Engineer (*Alternate*)	
Shri E. M. Bhumgara	Caltex (India) Ltd, Bombay; *and* Caltex Oil Refining (India) Ltd, Visakhapatnam
Shri V. H. Khakhar (*Alternate*)	Caltex (India) Ltd, Bombay
Shri N. S. Rao (*Alternate*)	Caltex Oil Refining (India) Ltd, Visakhapatnam
Shri K. V. Bole	Ministry of Finance (Revenue Division)
Director	CSIR (Indian Institute of Petroleum, Dehra Dun)
Shri K. B. Ganesan	Directorate General of Civil Aviation (Ministry of Transport & Communications)
Shri S. G. Ghoshalkar	Railway Board (Ministry of Railways)
Shri S. B. J. Rajaiah (*Alternate*)	
Shri J. M. Guha	Department of Mines & Fuel (Ministry of Mines & Fuel)
Shri A. S. Krishnaswamy	Indian Oil Co Ltd, Bombay
Shri V. D. Bapat (*Alternate*)	
Shri S. D. Mehta	Indian Refineries Ltd, New Delhi
Shri S. S. Pandit (*Alternate*)	
Shri N. A. Mendes	Indo-Burma Petroleum Co, Bombay
Shri R. M. Chari (*Alternate*)	
Shri S. N. Nakhate	Esso Standard Eastern, Inc, Bombay
Shri A. N. Nandy	Ministry of Defence (R & D)
Shri D. M. Banerjee (*Alternate*)	
Shri K. Srinivasa Rao	Standing Metric Committee, Ministry of Commerce & Industry
Shri T. R. Rao	Burmah-Shell Oil Storage & Distributing Co of India Ltd, Bombay
Shri A. S. Vaidya (*Alternate*)	
Shri K. K. Roy	Western India Oil Distributing Co Ltd, Bombay
Shri M. C. Desai (*Alternate*)	

(*Continued on page* 2)

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

(*Continued from page* 1)

Members	*Representing*
Dr B. S. Subrahmanyam	Assam Oil Co Ltd, Digboi
Shri H. D. Suri	Ministry of Finance (Revenue Division)
Shri Manohar Lal (*Alternate*)	
Maj Swaran Singh	Directorate of Supply & Transport, Quartermaster General's Branch, Army Headquarters
Capt A. K. Pandya (*Alternate*)	
Dr Sadgopal, Deputy Director (Chem)	Director, BIS (*Ex-officio Member*)

Secretary

Shri D. Das Gupta

Assistant Director (Chem), BIS

Gauging of Tanks and Calculation of Bulk Quantities of Oils in Tanks (Other Than Pressure Vessels) Subcommittee, CDC 32 : 3

Convener	
Shri T. R. Rao	Burmah-Shell Oil Storage & Distributing Co of India Ltd, Bombay
Members	
Shri A. S. Vaidya (*Alternate* to Shri T. R. Rao)	
Shri A. S. Krishnaswamy	Indian Oil Co Ltd, Bombay
Shri V. D. Bapat (*Alternate*)	
Shri S. N. Nakhate	Esso Standard Eastern, Inc, Bombay
Dr B. S. Subrahmanyam	Assam Oil Co Ltd, Digboi
Shri H. D. Suri	Ministry of Finance (Revenue Division)
Shri Manohar Lal (*Alternate*)	

Indian Standard
METHOD FOR CALCULATION OF BULK QUANTITIES OF PETROLEUM AND LIQUID PETROLEUM PRODUCTS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 June 1961, after the draft finalized by the Petroleum Measurements Sectional Committee had been approved by the Chemical Division Council.

0.2 The Indian Standards on tank calibration, gauging, sampling, temperature measurement and determination of density have laid down procedures which, when followed, allow the volume, temperature and density of a bulk quantity of oil to be determined with considerable precision. The care with which these physical measurements have been made will be largely nullified if the subsequent calculations are carried out inaccurately or incorrectly. The quantity calculated will be substantially correct if:

a) The accepted* volume is substantially correct. This implies that:

   1) the container has been accurately calibrated and its Calibration Table correctly computed by recognized methods. For vertical and horizontal tanks, the recommendations laid down in the following standards shall apply:

      IS : 2007-1961 METHOD FOR CALIBRATION OF VERTICAL OIL STORAGE TANKS

      IS : 2008-1961 METHOD FOR COMPUTATION OF CAPACITY TABLES FOR VERTICAL OIL STORAGE TANKS

      IS : 2009-1961 METHOD FOR CALIBRATION OF HORIZONTAL AND TILTED OIL STORAGE TANKS

      IS : 2166-1963 METHOD FOR COMPUTATION OF CAPACITY TABLES FOR HORIZONTAL AND TILTED OIL STORAGE TANKS

   2) the oil depth has been correctly measured and recorded by the methods laid down in IS : 1518-1960 Method for Gauging of Petroleum and Liquid Petroleum Products;

b) The container has been correctly sampled in accordance with IS : 1447-1966 Methods of Sampling of Petroleum and Its Products;

---

* 'Accepted' means the 'figure taken into further calculation'.

c) The accepted oil temperature is substantially correct and has been obtained in accordance with the recommendations laid down in IS : 1519 (Part I)-1961 Method for Temperature Measurement of Petroleum and Its Products, Part I; and

d) All densities have been determined in accordance with the method for determination of density laid down in P : 16 of IS : 1448 (Part I)-1960 Methods of Test for Petroleum and Its Products, Part I.

0.3 The methods of calculation given in this standard have, therefore, been drawn up to give the maximum possible accuracy in the final calculated quantities compatible with the precision of the physical measurements.

0.3.1 For large quantities, namely, supplies made by tanker, pipeline, transfer from a shore tank into a ship, barges, etc, it is essential that the methods specified in this standard shall be used for accurate assessment. However, for small quantities, namely, supplies made in barrels, tank lorries and rail tank wagons of which a very large number of despatches are made daily, a short method has been given in Appendix A. This simpler method would save time in calculation and would be sufficiently accurate for purposes of billing.

0.4 Wherever a reference to any Indian Standard appears in this standard, it shall be taken as a reference to the latest version of the standard.

0.5 In reporting the result of a calculation made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960 Rules for Rounding Off Numerical Values (*Revised*).

---

1. SCOPE

1.1 This standard prescribes method of calculations, normal and special, of bulk quantities of petroleum and liquid petroleum products.

1.1.1 The *normal method* shall apply to all liquid petroleum products in bulk except those listed in **1.1.2**.

1.1.2 The *special method* of calculations, which is a modification of the normal method of calculations, will usually be necessary if the product concerned is:

a) a liquid under high pressure (propane, butane, etc);

b) a volatile liquid in vapour-tight storage;

c) a liquid contained in a pipeline;

d) a liquid stored in a tank subject to bottom movement; or

e) a liquid stored in a floating roof tank.

2. TERMINOLOGY

2.1 For the purpose of this standard, the following definitions shall apply:

Accepted Temperature — Is the temperature reading which is taken into further calculation, the temperature being measured as prescribed in IS : 1519 (Part I)-1961 Method for Temperature Measurement of Petroleum and Its Products, Part I. However, if the initial and final temperatures of the oil before and after the movement of oil are different, the *accepted temperature* shall be the weighted average of these two temperatures, the weights being based on the estimated volumes of oil before and after its movement.

Algebraic Sum — Of a number of quantities is their sum, having due regard to the signs of these quantities. For example, if any containers A, B and C are receiving oil and, at the same time, the container C is making a transfer. And if the containers A, B and C have received a quantity X, Y and Z, respectively, of oil and at the same time container C has delivered a quantity X_1, then the net change in the quantity of oil in the containers is $X + Y + Z - X_1$.

Gross Measured Volume — Is the total volume of material in a container for a given dip or gauge and at the observed temperature at the time of gauging.

Net Measured Volume — Is the gross measured volume at the accepted temperature after deducting any free water and sediment which may be present.

Net Quantity Received or Delivered — Is the difference between the net volume or net weight of clean oil, before and after the oil movement for each container under consideration.

Net Volume of Clean Oil at the Accepted Temperature — Is the net measured volume of oil at the accepted temperature, less the quantity of any water and sediment in suspension in the oil.

Net Volume of Clean Oil at Standard Reference Temperature — Is the net measured volume of oil, reduced to standard reference temperature of 15°C by means of the appropriate ASTM/IP Volume Reduction Table, less the quantity of any water and sediment in suspension in the oil.

Standard Reference Temperature — 15°C.

Weight of Net Clean Oil — Is the weight in air of the net volume of clean oil at standard reference temperature.

SECTION I METHODS FOR NORMAL CALCULATIONS

3. GENERAL

3.1 The final quantity of oil may be required in terms of weight in air, volume at standard reference temperature, or for some purposes, volume at the accepted temperature. All these requirements involve a knowledge of the volume of oil in a container.

3.2 When several containers are involved, the quantity of oil in each container shall be separately calculated and the final quantity shall be recorded by adding the separate quantities so obtained by following the procedures laid down in this standard. For the purpose of measurement, a pipeline is considered as a separate container and all appropriate pipelines shall, therefore, be taken into consideration. Pipelines do not lend themselves to simple methods of measurements and are most conveniently dealt with either completely empty or completely full, although with full pipelines some correction for difference in temperature before and after an oil movement, may be necessary. Pipelines are dealt with separately in Section II.

4. INTERPRETATION OF REPORTED MEASUREMENTS

4.1 Measurements Reported — Gauging reports shall give all relevant details of tank number or numbers, the position and number of dip hatches, product, date and time, etc. The gauger's note shall, in addition, contain the following information:

a) *Dip or Ullage (With Height of Reference Point Above the Datum Point)* — The dip or ullage shall be taken as prescribed in IS : 1518-1960 Method for Gauging of Petroleum and Liquid Petroleum Products, from the dip hatch specified on the tank calibration table, except as described in **10.2**.

b) *Temperature* — It shall be middle or the average of upper, middle and lower temperatures as prescribed in IS : 1519 (Part I)-1961 Method for Temperature Measurement of Petroleum and Its Products, Part I. In exceptional cases, namely, heated oils, temperature of samples drawn from other levels and from more than one dip hatch may be reported.

c) *Water Dips* — Water dips shall be taken as prescribed in IS : 1518-1960 Method for Gauging of Petroleum and Liquid

Petroleum Products, from the dip hatch specified in the tank calibration table but where incomplete water bottoms are encountered, dips will be reported from more than one dip hatch if the tank is so fitted.

d) *Sludge* — If sludge is present at the bottom of the tank the gauger may report this by an ullage measurement or by a measurement in accordance with appropriate Indian Standard when published.

4.2 In addition to the above, the following information will be required:

a) Density of the contents of each container, and

b) Percentage of water or sediment in suspension in the product.

4.3 Preliminary Calculations — Before the final calculations of oil quantities can be commenced, it may be necessary to adjust the reported measurements in order to obtain correct ('true') figures, namely, the determination of true dip or ullage.

4.3.1 *Determination of True Dip or Ullage* — The true dip or ullage is that taken from the dip hatch specified on the tank calibration table and will be the dip or ullage normally reported. Exceptions to this are:

a) when tank bottom movement is suspected. The method of calculating oil volume in these circumstances is treated separately in **10.2**.

b) where the dip or ullage reported from the dip hatch specified on the tank calibration table shows that the oil level is below the level of the first entry in the tank calibration table the volume of oil shall be determined as specified in **10.1**.

4.3.2 *Determination of Average Dip* — The average dip, where required, shall be determined by the following procedure:

a) If the tank is fitted with a central dip hatch and a number of peripheral dip hatches, first compute the arithmetic means of the dips at the central dip hatch and at each peripheral dip hatch taken in pairs. The average dip for the tank is then the sum of these arithmetic means divided by the number of arithmetic means so computed.

b) If the tank is fitted with a central dip hatch, n peripheral dip hatches and n intermediate hatches situated midway between the centre and the periphery of the tank, the average dip is $\frac{1}{3n}$ ($n \times$ central dip + the sum of all the non-central dips).

c) If the tank is fitted with the peripheral dip hatches only, the average dip of the tank is the arithmetic mean of the dips at all dip hatches.

d) In all other cases make the best possible estimate of the average dip of the tank from the dips at all dip hatches, making due allowance for the relative positions of the dip hatches.

4.3.3 *Determination of True Water Dip* — The true water dip is that taken from the dip hatch specified on tank calibration table, and will be the water dip normally reported. Exceptions to this are:

a) when tank bottom movement is suspected. The method of calculating water volumes in these circumstances is treated separately in **10.2**, and

b) where the water dip reported shows that the water level is below the level of the first entry in the tank calibration table, the volume of water shall be determined as specified in **10.1**.

4.3.4 *Determination of the True Quantity of Sludge or Sediment at the Bottom of a Tank* — When the level of sludge or sediment at the bottom of a tank has been determined by ullage measured at the dip hatch specified on the tank calibration table, the level so reported will normally be the level at which the tank calibration table will be entered to obtain the true quantity of sludge or sediment at the bottom of the tank.

If, however, the level so reported is below the level of the first entry in the tank calibration table, then the levels of sludge or sediment shall be measured from all the dip hatches fitted to the tank and an average of these levels obtained by the procedure specified in **4.3.2**. The volume of sludge or sediment represented by this average shall be determined as specified in **10.1**.

4.3.5 *Determination of Accepted Temperature* — The accepted temperature of the oil in a tank shall be the middle temperature of the oil in the tank or average of the upper, middle and lower temperatures, as the case may be.

4.3.6 *Determination of Accepted Density* — The accepted density of the oil in a tank shall be the density determined on a composite sample prepared in accordance with IS : 1447-1966 Methods of Sampling of Petroleum and Its Products.

4.3.7 *Determination of True Percentage of Water and Sediment in Suspension* — Where percentages of water and sediment in suspension have been reported on more than one sample, the true percentage of water and sediment in suspension shall be determined by calculating the average percentage, due allowance being given to the approximate quantity of oil represented by each sample on which the percentage has been determined.

5. CALCULATION OF VOLUME AT THE ACCEPTED TEMPERATURE

5.1 Gross Measured Volume Before Movement

5.1.1 Obtain from the calibration table for the tank the volume corresponding to the true dip (*see* **4.3.1**) interpolating or using the proportional parts table where this is available, if necessary.

5.1.2 Where ullages are given and the calibration table for the tank has been compiled on an oil depth basis, first convert the ullage to equivalent dip by deducting the ullage from the known distance between the ullage reference point and the dipping datum point.

5.1.3 Where ullages are given and if the tank calibration table is compiled on the ullage basis, proceed as in **5.1.1**.

5.2 Volume of Water, Sludge and Sediment

5.2.1 Obtain from the calibration table for the tank, the volume of free water and sediment corresponding to the true water dip before the oil movement, interpolating or using the proportional parts table where this is available, if necessary.

5.2.2 Where water and/or sediment measurements are given as ullages and the tank calibration table has been compiled on an oil depth basis, convert the ullages to equivalent dips as in **5.1.2** before entering the tank calibration table.

5.2.3 Where the tank calibration table is entered against ullage, convert the true water dip to equivalent ullage by procedure implied in **5.1.2**.

5.2.4 Where water and/or sediment are given as ullages and the tank calibration table has been compiled on an ullage basis, proceed as in **5.1.1**.

5.3 Net Measured Volume Before Movement — To obtain the net measured volume of oil in a tank before movement, deduct from the gross measured volume before movement as measured in **5.1**, the volume of free water, sludge and sediment before movement as in **5.2**.

5.4 Net Volume of Clean Oil at Accepted Temperature Before Movement

5.4.1 To obtain the net volume of clean oil at accepted temperature in a tank before movement, deduct from the net measured volume before movement obtained as in **5.3** the true water and sediment in suspension present in the oil.

5.4.2 Where contracts make an allowance for suspended water and sediment, deduct from the net measured volume before movement the difference between the true and the allowable quantity of suspended water and sediment.

5.5 Gross Measured Volume After Movement — Use procedure similar to that prescribed in **5.1**.

5.6 Volume of Water, Sludge and Sediment After Movement — Use procedure similar to that described in **5.2**.

5.7 Net Measured Volume After Movement — Use procedure similar to that described in **5.3**.

5.8 Net Volume of Clean Oil at the Accepted Temperature After Movement — Use procedure similar to that described in **5.4**.

5.9 Net Volume of Clean Oil at Accepted Temperature, Received or Delivered — To obtain the net volume of clean oil at accepted temperature, received or delivered as a result of an oil movement, proceed as follows:

a) Calculate the net volume of clean oil at accepted temperature before and after movement as described in **5.1** to **5.8** in respect of each oil container concerned in the oil movement.

b) For each oil container concerned in the oil movement, determine the difference between the volume in the container before the oil movement and the volume in the container after the oil movement.

c) When more than one container is involved in the oil movement, determine for all containers the algebraic sum of the quantities determined as in (b).

6. CALCULATION OF VOLUME AT STANDARD REFERENCE TEMPERATURE

6.1 Net Volume of Clean Oil at Standard Reference Temperature, Received or Delivered

6.1.1 Deduct from the volume obtained as in **5.9**, the true water and sediment in suspension in the oil (*see* **4.3.7**).

6.1.2 Calculate the net volume of oil at 15°C in a tank by multiplying the net measured volume of oil at accepted temperature obtained as in **6.1.1**, by the volume correction factor which corresponds to the accepted temperature and accepted density at 15°C (*see* **4.3.5** *and* **4.3.6**). Obtain this factor from ASTM/IP Table No. 54.

6.1.3 Where contracts make an allowance for suspended water and sediment, deduct from the volume obtained as in **6.1.1**, the difference between the true and allowable quantity of suspended water and sediment.

6.2 Net Volume of Clean Oil at Standard Reference Temperature After Movement — Use procedure similar to that described in **6.1**.

6.3 Net Volume of Clean Oil at Standard Reference Temperature, Received or Delivered — To obtain the net volume of clean oil at standard reference temperature received or delivered as a result of an oil movement, proceed as follows:

a) Calculate the net volumes of clean oil at standard reference temperature before and after movement for each container concerned in the oil movement.

b) For each oil container concerned in the oil movement, determine the difference between the volume in the container before the oil movement and the volume in the container after the oil movement.

c) When more than one container is involved in the oil movement, determine for all containers the algebraic sum of the quantities determined as in (b).

7. CALCULATION OF VOLUME AT ACCEPTED TEMPERATURE (CASES OF TEMPERATURE DIFFERING BEFORE AND AFTER MOVEMENT)

7.1 Calculate as follows:

a) Calculate the net volume of clean oil at standard reference temperature before movement as in **6**. From this, calculate the net volume of the clean oil at the accepted temperature by the appropriate factor corresponding to that temperature as obtained from ASTM/IP Table No. 54.

b) Calculate the net volume of clean oil after movement at accepted temperature as in (a).

c) Determine the difference in quantities as obtained under (a) and (b). This will give the net quantity of clean oil received or delivered at the accepted temperature.

7.2 To obtain the net total volume of the oil received or delivered from all the containers, take algebraic sum of the net oil received or delivered as the case may be for each container by the procedures as explained in **7.1**.

8. CALCULATION OF WEIGHT

8.1 Oils Containing no Suspended Water and Sediment

8.1.1 *Weight of Clean Oil Before or After Movement* — To obtain the weight of clean oil in a tank before or after movement, multiply the net volume of clean oil at standard reference temperature by the appropriate factor giving weight per unit volume (*see* ASTM/IP Petroleum Measurement Tables).

8.2 Oil Containing Suspended Water and Sediment — Calculate the volume of wet oil at standard temperature, then multiply this volume by the factor giving weight per unit volume (*see* ASTM/IP Petroleum Measurement Tables) corresponding to the wet oil density at standard reference temperature. Calculate the true volume at standard reference temperature of suspended water and sediment in the tank. Assuming the suspended water and sediment to have a density at 15°C of 1·000 kg/l, calculate, using the appropriate ASTM/IP weight per unit volume factor, the weight of suspended water and sediment represented by the above determined volume at standard reference temperature. Deduct this weight of suspended water and sediment from the weight of wet oil.

8.3 Weight of Clean Oil Received or Delivered — To obtain the weight of clean oil received or delivered as a result of an oil movement, proceed as follows:

a) Calculate the weight of clean oil before the oil movement and after the oil movement for each container concerned in the oil movement. Then by difference between these two weights of clean oil, obtain the quantity of oil received or delivered for each container involved in oil movement.

b) Determine the algebraic sum of the quantities as obtained in (a), for all the containers concerned.

9. EXAMPLES OF NORMAL CALCULATIONS

9.1 The following are some of the examples.

9.1.1 *Delivered Volume at the Observed Temperature Where Before Delivery and After Delivery Temperatures are Same* — The following data and calculations illustrate the recommended procedure for determining the volume of gasoline at observed temperature delivered from a storage tank:

	Before Loading	After Loading
a) *Gauging Data*	*Before Loading*	*After Loading*
True gross dip	9·206 m	3·112 m
True water dip	0·070 m	0·070 m
True average temperature	26°C	26°C
b) *Laboratory Data*		
Average density at tank temperature	0·707 1 kg/l at 26°C	0·707 1 kg/l at 26°C
Density at 15°C (ASTM/IP Table No. 53)	0·716 3 kg/l	0·716 3 kg/l

c) *Calculations*

	Litres at 26°C	
Gross measured volume (from tank calibration table)	13 809 000	4 668 000
Volume of free water (from tank calibration table)	105 000	105 000
Net measured volume	13 704 000	4 563 000

There is no deduction for suspended water and sediment and the above net measured volumes, therefore, represent the net volumes of clean oil at observed temperature.

The delivered volume of gasoline at observed temperature is, therefore:

13 704 000 − 4 563 000 = 9 141 000 litres.

9.2 Delivered Volume at Standard Temperature — The following calculations illustrate the recommended procedure for determining the volume of gasoline at 15°C delivered during the movement quoted in **9.1.**

a) *Gauging Data*

As given in **9.1.1** (a)

b) *Laboratory Data*

As given in **9.1.1** (b)

c) *Calculations*

	Before Loading	*After Loading*
Net measured volume at accepted temperature [from **9.1.1** (c)], litres at 26°C	13 704 000	4 563 000
Factor to reduce volume to 15°C (ASTM/IP Table No. 54)	0·986 9	0·986 9
Net volume of clean oil, litres at 15°C	13 524 478	4 503 225

The net delivered volume at 15°C is, therefore:

13 524 478 − 4 503 225 = 9 021 253 litres.

9.3 Delivered Volume at Accepted Temperature Where 'Before Delivery' Temperature Differs from 'After Delivery' Temperature — The following calculations illustrate the recommended procedure for determining volume of gasoline at accepted temperature when the 'before delivery' and 'after delivery' temperatures are different:

	Before Loading	After Loading
a) *Gauging Data*	*Before Loading*	*After Loading*
True gross dip	9·206 m	3·112 m
True water dip	0·070 m	0·070 m
True average temperature	26°C	23°C
b) *Laboratory Data*		
Average density at 26°C	0·707 9 kg/l	—
Average density at 23°C	—	0·710 8 kg/l
Density at 15°C (ASTM/IP Table No. 53)	0·716 3 kg/l	0·717 5 kg/l
c) *Calculation of Net Volume of Clean Oil Delivered*	*Litres at* 15°C	
Gross measured volume (from tank calibration table)	13 809 000	4 668 000
Volume of free water (from tank calibration table)	105 000	105 000
Net measured volume	13 704 000	4 563 000
Factor to reduce volume to 15°C (ASTM / IP Table No. 54)	0·986 9	0·990 5
Net volume of clean oil at 15°C	13 524 478	4 519 652

The net volume of clean oil delivered at 15°C is, therefore:

$$13\ 524\ 478 - 4\ 519\ 652 = 9\ 004\ 826 \text{ litres.}$$

When the before and after delivery temperatures differ, the accepted temperature shall be the weighted average of these two temperatures, the weightage being based on the estimated volumes of oil before and after its movement.

d) *Calculation of Accepted Temperature*

Net measured volume before delivery at 26°C = 13 704 000 litres

Net measured volume after delivery at 23°C = 4 563 000 litres

Therefore, accepted temperature will be

$$\frac{13\ 704\ 000 \times 26 + 4\ 563\ 000 \times 23}{18\ 267\ 000} = 25{\cdot}5°\text{C}$$ (by rounding off to nearest 0·5°C)

$$\text{and, oil delivered at } 25{\cdot}5°\text{C} = \frac{9\ 004\ 826}{0{\cdot}987\ 5} = 9\ 118\ 811 \text{ litres.}$$

(Factor 0·987 5 obtained from ASTM/IP Table No. 54)

9.4 Weight Received — The following data and calculations illustrate the recommended procedure for calculating the weight of oil received into an oil storage tank. In this example, it is assumed that the oil was received in accordance with a contract the terms of which allowed 0·20 percent water and sediment in suspension to be considered as ' clean oil '.

	Before Receipt	After Receipt
a) *Gauging Data*	*Before Receipt*	*After Receipt*
True gross dip	1·377 m	11·709 m
True water dip	0·066 m	0·922 m
True average temperature	25·5°C	29·5°C
b) *Laboratory Data*		
Average density at tank temperature	0·866 5 kg/l at 25·5°C	0·860 0 kg/l at 29·5°C
Average density at 15°C (from ASTM/IP Table No. 53)	0·873 3 kg/l	0·869 4 kg/l
Suspended water and sediment	0·9 percent by volume	1·3 percent by volume
c) *Calculations*	*At* 25·5°C	*At* 29·5°C
Gross measured volume (from tank calibration table)	1 435 938 litres	12 574 466 litres
Volume of free water (from tank calibration table)	70 982 litres	990 126 litres

Calculations — contd	*At* 25·5°C	*At* 29·5°C
Net measured volume	1 364 956 litres	11 584 340 litres
Factor to reduce volume to 15°C (ASTM / IP Table No. 54)	0·992 0	0·988 8
Net volume of wet oil at 15°C	1 354 036 litres	11 454 595 litres
Factor for converting to kilograms (ASTM/ IP Table No. 56)	0·872 2	0·868 3
Weight of wet oil	1 180 990 kg	9 946 025 kg

The weight of wet oil received is, therefore:

9 946 025 – 1 180 990 = 8 765 035 kg.

9.4.1 *Suspended Water and Sediment* — From the percentage of suspended water and sediment given in **9.4** (b) the corresponding net volume of clean oil and suspended water and sediment at 15°C are:

	Before Receipt	*After Receipt*
Volume of clean oil at 15°C	1 341 850 litres	11 305 685 litres
Volume of suspended water and sediment at 15°C	12 186 litres	148 910 litres

The net volume of clean oil at 15°C received is therefore:

11 305 685 – 1 341 850 = 9 963 835 litres.

Since the contract allows 0·2 percent water and sediment in suspension to be considered as 'clean oil', the net volume at 15°C of 'clean oil' received will be

$$\frac{9\,963\,835 \times 100}{99{\cdot}8} = 9\,983\,803 \text{ litres at } 15^\circ\text{C}$$

and the volume of suspended water and sediment which can be included as 'clean oil' is 9 983 803 – 9 963 835 or 19 968 litres at 15°C.

The volume at 15°C of suspended water and sediment in the tank after the oil movement shall be reduced by this amount and is now 148 910 – 19 968 = 128 942 litres at 15°C.

The increase (under the terms of contract) in suspended water and sediment in the tank as a result of oil movement is, therefore:

128 942 – 12 186 = 116 756 litres at 15°C.

Assuming the density at 15°C of the suspended water and sediment to be 1·000 kg/l the factor for converting this to kilograms (ASTM/IP Table No. 56) is 0·998 9 and the weight of suspended water and sediment which has been added to that in the tank before the oil movement is:

$$116\ 756 \times 0{\cdot}998\ 9 = 116\ 628 \text{ kg}$$

The weight of 'clean' oil received under the terms of the contract is, therefore:

$$8\ 765\ 035 - 116\ 628 = 8\ 648\ 407 \text{ kg} = 8\ 648{\cdot}407 \text{ tonnes.}$$

SECTION II METHOD FOR SPECIAL CALCULATIONS

10. GENERAL

10.0 The special calculations and modifications to the normal calculations specified in Section I, necessary when dealing with products under certain given conditions, are given in this section.

10.1 Liquids in Tanks with Uncalibrated Irregular Bottoms — If the oil or water dip in a tank is below the first entry in the calibration table, dips shall be taken at all the dip hatches, and an average dip calculated as described in **4.3.2.** The quantity represented by this average dip is then calculated using the litres per centimetre at the first entry in the tank calibration table.

10.2 Tank Bottom Movement

10.2.1 The overall height of the dip hatch above the bottom datum point in a tank may change owing to tank bottom movement. This change will not normally affect the calculation of any quantity of oil in a tank or quantity of oil moved, if the datum point is fully covered by the oil or water before and after movement.

10.2.2 Where an incomplete water bottom or no water bottom exists or the oil level is below the datum point, as shown by dips taken at all the dip hatches on the tank, both gross dips and water dips, if any, shall be averaged before entering the tank calibration table. The method of averaging these dips is the same as that given in **4.3.2.** The quantities represented by these dips are read from the calibration table and taken for further calculations.

10.3 Liquid in Pipelines — For the purpose of calculating the quantity of oil contained in them, pipelines shall be regarded as separate containers. The total capacity of the pipeline shall be calculated by a sound mathematical method, or by means of tables giving the capacity per unit length. In calculating the total quantity of an oil movement, the difference in the quantities contained in the pipelines before and after the movement is added to or subtracted from quantities received into or delivered from the tanks, as the case may be. For stock quantity purposes, the quantities contained in the pipelines are added to the relevant stock in the tank or tanks.

10.4 Liquid in Floating Roof Tanks

10.4.1 When the roof is freely floating, a quantity equivalent to the roof displacement should be deducted from the measured quantity corresponding to the gauge taken.

The following formula may be used to calculate the quantity equivalent to the roof displacement:

$$Q = \frac{W}{P}$$

where

Q = volume in litres equivalent to the roof displacement,

W = weight of floating roof in kilograms, and

P = kilograms per litre of product at standard reference temperature.

10.4.2 When the roof is not in a freely floating position the proportionate fractional displacement due to the floating roof is to be deducted from the measured volume. This displacement will be obtained from the supplementary tables provided with the tank calibration tables. Since this cannot be calculated accurately, it is suggested to keep the roof always in a floating position.

10.4.3 Where the oil level is low and does not touch the roof, no deduction is to be made for the roof weight, as the roof rests on its supports.

10.4.4 The following example illustrates the recommended procedure for calculating the quantity:

Data

True gross dip	8·106 m
True water dip	0·082 m
Temperature of oil in tank	26°C
Density of oil in tank	0·715 0 kg/l at 24°C
Weight of floating roof	85 214 kg

Calculations

Gross measured volume corresponding to the dip	8 916 600 litres

Volume of free water	90 200 litres
Density of oil at 15°C (ASTM/IP Table No. 53)	0·722 5 kg/l
Factor to reduce volume to 15°C (ASTM/IP Table No. 54)	0·987 1
Net measured volume at 26°C (before accounting for roof displacement)	8 826 400 litres
Net measured volume at 15°C (before accounting for roof displacement)	8 826 400 × 0·987 1 = 8 712 539 litres
Factor giving kilograms per litre for density at 15°C (ASTM/IP Table No. 56)	0·721 4
Volume of oil equivalent to roof displacement	85 214 ÷ 0·721 4 = 118 123 litres at 15°C
Therefore, net volume of oil is	8 712 539 − 118 123 = 8 594 416 litres at 15°C

To calculate the net volume of oil at accepted temperature of 26°C, divide the net volume of oil at 15°C by the factor 0·987 1 obtained from ASTM/IP Table No. 54. That is, net volume of oil is 8 594 416 ÷ 0·987 1 = 8 706 732 litres at 26°C.

To calculate the weight of oil, multiply the net volume of oil at 15°C by the factor 0·721 4 obtained from ASTM/IP Table No. 56. That is, the weight of oil is 8 594 416 × 0·721 4 = 6 200 012 kg
= 6 200·012 tonnes.

Alternative method

Proceed in a similar way as the above example to get:

Net measured volume at 15°C (before accounting for roof displacement)	8 712 539 litres
Factor giving kilograms per litre for density at 15°C (ASTM/IP Table No. 56)	0·721 4

Therefore, weight of oil = (8 712 539 × 0·721 4) − 85 214 kg
= 6 200·012 tonnes.

If net volume of oil at 15°C is required, then divide the weight of oil by the factor giving kilograms per litre for density at 15°C (ASTM/IP Table No. 56). That is, net volume of oil is 6 200 012 ÷ 0·721 4 = 8 594 416 litres at 15°C.

If net volume of oil at observed temperature of 26°C is required, then divide the net volume of oil at 15°C by the factor 0·987 1 obtained from ASTM/IP Table No. 54.

Therefore, net volume of oil is 8 594 416 ÷ 0·987 1 = 8 706 732 litres at 26°C.

NOTE — During normal conditions, the roof remains in the floating position before and after any oil movement. Therefore, for any delivery or receipt, the corrections for the weight of the oil displaced by the roof need not be made because it is the same before and after the oil movement. However, this does not apply in calculation of the volume of oil received or delivered, because there might be a change of gravity before and after the oil movement.

10.5 Liquids Under High Pressure — Liquids under high pressure, for example propane, butane, etc, usually termed liquefied petroleum gases, are normally dealt with in relatively small bulk quantities. Railcar quantities, for example, are often involved, and in such cases it is usually possible to employ methods of direct weighing. When it is required to take into account the vapour contained in the space above the liquid, the gauger will be called upon to report the temperature and gauge pressure of this vapour space, in addition to the normal measurements reported. It should be noted that in cases of direct weighing, vapour quantities are included in the weights which are weights in vacuum because with a closed container the volume of air displaced is the same before and after the oil movement.

10.5.1 *Calculation of Volume at Standard Reference Temperature*

10.5.1.1 When quantities concerned have been directly weighed, divide the weights by the density at standard reference temperature.

10.5.1.2 When the quantities cannot be directly weighed, volumes at standard reference temperature shall be determined as follows:

a) Carry out such portions of the procedure specified in **6**, as are applicable.

b) Where the vapour contained in the vapour space above the liquid has to be accounted for, calculate the liquid equivalent at standard reference temperature of such vapour by first reducing the volume of vapour from its volume at given temperature and gauge pressure to its equivalent volume at standard reference temperature and zero gauge pressure, and then apply an appropriate gas volume to liquid volume ratio. This ratio may be obtained from the table in Appendix B. In the case of normal commercial blends of liquefied petroleum gases (**LPG**), the ratio shall be calculated by taking the mean of the values given for the appropriate pure components weighted for the mole fraction present in the liquid as shown by an analysis.

NOTE — Liquefied petroleum gases referred to commercially as 'propane or butane' are blends containing varying proportions of saturated and unsaturated C_3 and C_4 with smaller quantities of the lighter and heavier hydrocarbons, although 'propane' consists principally of C_3's and 'butane' of C_4's.

10.5.1.3 Hydrocarbon vapours at or near saturation do not follow the ideal gas laws and the composition of the vapour in equilibrium with the liquid will vary with temperature, and will differ from that of the liquid. The calculations involved in the accurate determination of an appropriate vapour/liquid ratio are, therefore, complicated. However, for normal calculations involved in the commercial measurement of liquefied petroleum gases, it is recommended that the procedure in **10.5.1.2** (b) should be followed.

10.5.2 *Calculation of Weights* — When the quantities cannot be directly weighed, weights shall be determined as follows:

a) Determine volumes at standard temperature by the procedure specified in **10.5.1.2** making allowance for vapour quantities where this is required.

b) Multiply volumes at standard reference temperature by the applicable factors giving weight per unit volume contained in the appropriate ASTM/IP tables.

10.5.3 *Calculation of Volume at Accepted Temperature*

10.5.3.1 When the quantities have been directly weighed, volumes at accepted temperature shall be determined as follows:

a) Determine volumes at standard reference temperature by the procedure specified in **10.5.1.1**.

b) Divide volumes at standard temperature by the applicable factors for reducing volumes at observed temperature to volumes at standard reference temperature obtained from the appropriate ASTM/IP tables, having due regard to the temperature and densities at standard temperature of the quantities involved.

10.5.3.2 When quantities cannot be directly weighed, volumes at accepted temperature shall be determined as follows:

a) Carry out such portions of the procedure specified in **5** as are applicable.

b) When the vapour contained in the vapour space above the liquid has to be accounted for, calculate the liquid equivalent of the vapour at the temperature of the liquid above which the vapour lies by suitable adaptation of the procedure given in **10.5.1.2** (b).

c) When applicable, treat the vapour space calculations carried out as specified in **10.5.3.2** (b) as for separate containers and add the net results of such calculation to those obtained in (a) above.

10.5.4 *Volatile Liquids in Vapour-Tight Storage*

10.5.4.1 The quantities of volatile products stored in vapour-tight containers shall be calculated as described in Section I, unless a container is gauged through a dip pipe. When a measurement is so taken, the gauger will report the pressure in the vapour space of the container as shown on the manometer fitted to the container, in addition to other relevant particulars. The observed dip shall first be corrected to the true dip of the oil in the container as follows:

a) Multiply the observed manometer reading by the density of the liquid in the manometer, and divide the result by the density of the oil in the tank.

b) Subtract the result obtained in (a) from the observed dip reading when the pressure in the vapour space of the container is above atmospheric; add the result when the pressure is below atmospheric. This gives the true dip reading which is taken into further calculation as in Section I.

10.5.4.2 In calculating the dip corrections outlined above, it shall be noted that the densities of both the manometer liquid and the oil in the container are required at the temperatures obtained at the time of measurement. These densities can be determined from the corresponding densities at standard reference temperature by means of appropriate ASTM/IP measurement tables for petroleum oils and International critical tables for other manometric fluids.

Examples:

Dip (through dip pipe)	7·358 m
Observed manometer reading	−0·044 m
Temperature of oil in tank	29°C
Temperature of manometric liquid	25°C
Density of oil in tank at 15°C	0·718 6 kg/l
Density of manometric liquid (glycerine) at 0°C	1·26 kg/l

Calculations

Density of oil in tank at 29°C = 0·706 9 kg/l
(According to ASTM/IP Table No. 53).

*Density of manometric liquid at 25°C $= 1{\cdot}26 - (25 \times 0{\cdot}000\,64)$

$= 1{\cdot}244$ kg/l

Therefore, correction to dip (to be added) $= \dfrac{0{\cdot}044 \times 1{\cdot}244}{0{\cdot}706\,9}$

$= 0{\cdot}077$ m

Corrected dip $= 7{\cdot}358 + 0{\cdot}077 = 7{\cdot}435$ m

If the pressure had been more than atmospheric (positive) it would have been necessary to subtract the correction from the dip reading.

10.5.5 *Examples of Calculation of Liquid Equivalents of Light Hydrocarbon Gases* — The following are the two typical examples.

10.5.5.1 *Calculation of liquid equivalent at standard reference temperature*

Example:

The vapour space above the liquid level in a storage tank containing propane is known to have a capacity of 44 800 litres at the time of gauging. If the temperature of the vapour is 23°C and the gauge pressure is 8·1 kg/cm², what is the liquid equivalent of the vapour in litres at 15°C ?

The vapour shall first be reduced to '*V*' litres at zero gauge pressure and 15°C.

Applying the formula

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

We have

$P_1 = (8{\cdot}10 + 1{\cdot}033\,5)$ kg/cm² absolute
$V_1 = 44\,800$ litres
$T_1 = (23 + 273)$°K
$P_2 = (0 + 1{\cdot}033\,5)$ kg/cm² absolute
$T_2 = (15 + 273)$°K
$V_2 =$ the required volume in litres at 15°C

*Density correction:

Cubical expansion of glycerine is 0·000 505.

(Ref Handbook of Chemistry and Physics by C. D. Hodgman & Others).

Therefore, change of density of glycerine per deg C

$$= \left(1{\cdot}26 - \frac{1{\cdot}26}{1{\cdot}000\,505} \right) = 0{\cdot}000\,64.$$

Density correction for temperature may be obtained also from International critical tables.

Then

$$V_2 = \frac{P_1 \times V_1 \times T_2}{T_1 \times P_2}$$

$$= \frac{9{\cdot}133\ 5 \times 448\ 00 \times 288}{296 \times 1{\cdot}033\ 5}$$

$$= \frac{117\ 844\ 070{\cdot}4}{305{\cdot}916}$$

$$= 385\ 217 \text{ litres at } 15°\text{C}$$

The gas volume/liquid volume ratio for propane is 272·7, and the equivalent volume of liquid propane is, therefore

$$\frac{385\ 217}{272{\cdot}7} \text{ or } 1\ 413 \text{ litres at } 15°\text{C}.$$

10.5.5.2 *Calculation of liquid equivalent at observed temperature*

Example 1:

In the conditions given in example under **10.5.5.1**, what is the liquid equivalent of the vapour in litres at 21·5°C ?

Proceeding as in example under **10.5.5.1**, we have P_1, P_2, V_1 and T_1, as before, and $T_2 = (21{\cdot}5 + 273)°\text{K}$ (on absolute scale). Then V_2, the required volume in litres at 21·5°C, is given by

$$V_2 = \frac{9{\cdot}133\ 5 \times 44\ 800 \times 294{\cdot}5}{296 \times 1{\cdot}033\ 5} = 393\ 911 \text{ litres at } 21{\cdot}5°\text{C}$$

The equivalent volume of liquid propane is, therefore

$$\frac{393\ 911}{272{\cdot}7} = 1\ 444 \text{ litres at } 21{\cdot}5°\text{C}.$$

Example 2:

Consider the example under **10.5.5.1** with the following composition of the vapour:

Propane	20 percent by weight
*Iso*butane	30 ,, ,, ,,
n-butane	50 ,, ,, ,,

Calculations

From the above analysis the mol percent will be calculated as follows:

		mol percent
Propane	= 20/44 = 0·454 5 mol	24·8
*Iso*butane	= 30/58 = 0·517 2 ,,	28·2
n-butane	= 50/58 = 0·862 1 ,,	47·0
	1·833 8 ,,	100·0

Therefore, the gas volume/liquid volume ratio for the vapour will be $= \dfrac{24{\cdot}8 \times 272{\cdot}7 + 28{\cdot}2 \times 229{\cdot}3 + 47{\cdot}0 \times 237{\cdot}8}{100}$

$= 244{\cdot}058$

And the equivalent volume of liquid of the mixed component will be $= 385\ 217/244{\cdot}058$

$= 1\ 578{\cdot}383$ litres at 15°C.

10.5.6 *Blends of Petroleum and Non-petroleum Products*

10.5.6.1 The basic procedure for the calculation of quantities of blends of petroleum and non-petroleum products is that given in Section I.

10.5.6.2 If the proportions of the petroleum and non-petroleum components of the blend are unknown, follow the procedure given in Section I, as for petroleum products. This procedure will result in quantity figures of doubtful accuracy and shall only be adopted when it is impossible to obtain even an approximate idea of the amount of non-petroleum products present in the blend.

10.5.6.3 Where the proportions of the petroleum and non-petroleum components of the blend are known, follow the procedure given in Section I with the following modifications:

a) The coefficients of change of density with temperature given in Appendices C and D will be found more convenient than the corresponding ASTM/IP density correction tables, and

b) The volume correction coefficients given in Appendices E and F will also be found more easily applicable than the corresponding ASTM/IP volume reduction tables. The appropriate volume reduction coefficient is calculated by proportion from the coefficients of the two components according to the percentage by volume of each present.

Example:

70 000 litres at 25°C of a 10 percent by volume benzole blend with gasoline have a density at 15°C of 0·740 1 kg/l. The densities at 15°C of the benzole and gasoline are 0·869 5 and 0·725 kg/l respectively. The volume at 15°C and the weight of the blend are required.

Calculation of volume at 15°C

Volume correction coefficient per deg C for benzole = 0·001 13 (*see* Appendix E)

Volume correction coefficient per deg C for gasoline = 0·001 17 (*see* Appendix D)

Therefore, the volume correction coefficient per deg C for blend = 10 percent of 0·001 13 + 90 percent of 0·001 17
= 0·001 166

The volume of oil is to be reduced over 10°C (from 25°C to 15°C)

Therefore, reduction of unit volume	= 0·001 166 × 10
	= 0·011 66
Reduction of 70 000 litres	= 70 000 × 0·011 66
	= 816·2 litres
and, volume at 15°C	= 70 000 − 816·2
	= 69 183·8 litres
	= 69 184 (after rounding off to litre)

Calculation of weight

Calculation of weight is the same as in the procedure outlined in Section I, using appropriate ASTM/IP weight/volume tables, entered with the density at 15°C.

One litre at 15°C of an oil whose density at 15°C is 0·740 1 kg/l weighs 0·739 0 kg in air (ASTM/IP Table No. 56).

Therefore, 69 184 litres at 15°C will weigh 69 184 × 0·739 0 kg
= 51 126·98 kg
= 51 127 kg
= 51·127 tonnes

APPENDIX A

(*Clause* 0.3.1)

A SHORT METHOD OF WEIGHT CALCULATION FOR SMALL QUANTITIES

A-1. METHOD

A-1.1 The method prescribed is simple in as far as the use of ASTM/IP petroleum measurement tables is avoided. It can be relied upon to give results correct to two places of decimal of a tonne and is intended primarily for the calculation of weights of furnace oil and light diesel oil moved in tank carts, tank lorries and rail tank wagons.

A-2. CORRECTION COEFFICIENTS

A-2.1 If a sample is drawn from a tank lorry, tank wagon, etc, for determination of density, and the temperature of the sample differs by more than 0·5°C from that of the oil in the tank lorry, tank wagon, etc, the sample density may be corrected to the temperature of the oil in the tank lorry, tank wagon, etc, using the following density correction coefficients:

Furnace oil	0·000 63 per deg C
Light diesel oil	0·000 65 per deg C

A-3. CALCULATION

A-3.1 The following formula may be used for the calculation of weights of small parcels carried in tank carts, tank lorries and rail tank wagons:

$$\text{Weight in tonnes} = \frac{V\,(\,D - F\,)}{1\,000}$$

where

V = volume in litres of oil at temperature T°C,

D = density of oil measured with a density hydrometer calibrated at 15°C, and

F = factor for converting weight in vacuum to weight in air.
= 0·000 02 (40 + T) where T is in °C.
= 0·001 1 (at 15°C).

A-4. EXAMPLE

A-4.1 The following example illustrates the use of this short method:

A rail tank wagon contains 20 000 litres of furnace oil at a temperature of 29°C. A sample drawn from the tank wagon was found to have a density of 0·924 5 at a temperature of 28·5°C. To determine the weight of the oil in the tank wagon:

Data

Density at 28·5°C	= 0·924 5 kg/l
Density correction coefficient	= 0·000 63 per deg C
Therefore density at 29°C	= 0·924 5 − 0·000 3
	= 0·924 2 kg/l
Factor F	= 0·000 02 (40 + 29)
	= 0·001 38
	= 0·001 4

Therefore weight in tonnes $= \frac{20\,000\,(0{\cdot}924\,2 - 0{\cdot}001\,4)}{1\,000}$

$= 18{\cdot}46$ tonnes (correct to 2 places of decimals)

A-4.1.1 The values of F for temperatures from 5°C to 40°C, in steps of 5°C, are given below for ready reference:

T°C	F	T°C	F
5	0·000 9	25	0·001 3
10	0·001 0	30	0·001 4
15	0·001 1	35	0·001 5
20	0·001 2	40	0·001 6

APPENDIX B

[*Clause* 10.5.1.2 (b)]

GAS VOLUME/LIQUID VOLUME RATIOS

(Taken from Natural Gasoline Association of America Standard 2145)

Propane	272·7
*Iso*butane	229·3
n-butane	237·8
*Iso*pentane	205·0
n-pentane	207·0

NOTE — These ratios are independent of the units used.

APPENDIX C

[*Clause* 10.5.6.3 (a)]

TEMPERATURE CORRECTION COEFFICIENTS PER DEGREE CENTIGRADE FOR DENSITIES DETERMINED IN GLASS APPARATUS

(To be used only for Blends of Petroleum with Non-petroleum Products)

Density at 15°C, g/ml	Correction Coefficient per deg C	Density at 15°C, g/ml	Correction Coefficient per deg C
0·596 7 to 0·604 9	0·001 03	0·742 2 to 0·753 4	0·000 79
0·605 0 ,, 0·613 3	0·001 01	0·753 5 ,, 0·764 6	0·000 77
0·613 4 ,, 0·621 9	0·000 99	0·764 7 ,, 0·775 7	0·000 76
0·622 0 ,, 0·631 9	0·000 97	0·775 8 ,, 0·786 6	0·000 74
0·632 0 ,, 0·641 8	0·000 95	0·786 7 ,, 0·798 4	0·000 72
0·641 9 ,, 0·652 9	0·000 94	0·798 5 ,, 0·802 0	0·000 70
0·653 0 ,, 0·664 8	0·000 92	0·802 1 ,, 0·827 9	0·000 68
0·664 9 ,, 0·677 3	0·000 90	0·828 0 ,, 0·859 4	0·000 67
0·677 4 ,, 0·689 7	0·000 88	0·859 5 ,, 0·924 5	0·000 65
0·689 8 ,, 0·702 3	0·000 86	0·924 6 ,, 1·024 3	0·000 63
0·702 4 ,, 0·716 4	0·000 85	1·024 4 ,, 1·074 2	0·000 61
0·716 5 ,, 0·729 8	0·000 83	1·074 3 ,, 1·124 1	0·000 59
0·729 9 ,, 0·742 1	0·000 81		

APPENDIX D

[*Clause* 10.5.6.3 (a)]

TEMPERATURE CORRECTION COEFFICIENTS PER DEGREE CENTIGRADE FOR DENSITIES DETERMINED IN GLASS APPARATUS

(Coal Tar Distillation Products and Alcohols)

Product	Correction Coefficient per deg C	Product	Correction Coefficient per deg C
Benzene	0·001 03	Heavy solvent naphtha	0·000 77
Benzole (commercial)	0·000 97	Creosote oil	0·000 74
Toluole	0·000 88	Coal tar	0·000 61
Xylole	0·000 85	Methyl alcohol	0·000 90
Solvent naphtha	0·000 83	Ethyl alcohol	0·000 79

APPENDIX E

[*Clause* 10.5.6.3 (b)]

VOLUME CORRECTION COEFFICIENTS OF PETROLEUM PRODUCTS

(To be used only for Blends of Petroleum with Non-petroleum Products)

Density at 15°C, kg/l	Volume Correction Coefficient per deg C	Density at 15°C, kg/l	Volume Correction Coefficient per deg C
0·599 4 to 0·602 2	0·001 73	0·741 6 to 0·746 8	0·001 10
0·602 3 ,, 0·605 3	0·001 71	0·746 9 ,, 0·752 0	0·001 08
0·605 4 ,, 0·608 2	0·001 69	0·752 1 ,, 0·757 1	0·001 06
0·608 3 ,, 0·611 2	0·001 67	0·757 2 ,, 0·761 8	0·001 04
0·611 3 ,, 0·614 4	0·001 66	0·761 9 ,, 0·766 8	0·001 03
0·614 5 ,, 0·617 6	0·001 64	0·766 9 ,, 0·772 1	0·001 01
0·617 7 ,, 0·621 1	0·001 62	0·772 2 ,, 0·777 3	0·000 99
0·621 2 ,, 0·623 9	0·001 60	0·777 4 ,, 0·782 9	0·000 97
0·624 0 ,, 0·626 9	0·001 58	0·783 0 ,, 0·789 0	0·000 95
0·627 0 ,, 0·629 8	0·001 57	0·789 1 ,, 0·794 5	0·000 94
0·629 9 ,, 0·633 5	0·001 55	0·794 6 ,, 0·800 2	0·000 92
0·633 6 ,, 0·636 7	0·001 53	0·800 3 ,, 0·807 0	0·000 90
0·636 8 ,, 0·640 0	0·001 51	0·807 1 ,, 0·815 4	0·000 88
0·640 1 ,, 0·643 2	0·001 49	0·815 5 ,, 0·824 0	0·000 86
0·643 3 ,, 0·646 5	0·001 48	0·824 1 ,, 0·832 5	0·000 85
0·646 6 ,, 0·650 5	0·001 46	0·832 6 ,, 0·841 9	0·000 83
0·650 6 ,, 0·653 8	0·001 44	0·842 0 ,, 0·851 4	0·000 81
0·653 9 ,, 0·658 1	0·001 42	0·851 5 ,, 0·862 1	0·000 79
0·658 2 ,, 0·663 3	0·001 40	0·862 2 ,, 0·874 3	0·000 77
0·663 4 ,, 0·667 6	0·001 39	0·874 4 ,, 0·890 3	0·000 76
0·667 7 ,, 0·671 8	0·001 37	0·890 4 ,, 0·907 3	0·000 74
0·671 9 ,, 0·676 4	0·001 35	0·907 4 ,, 0·929 9	0·000 72
0·676 5 ,, 0·680 8	0·001 33	0·930 0 ,, 0·951 7	0·000 70
0·680 9 ,, 0·684 7	0·001 31	0·951 8 ,, 0·974 9	0·000 68
0·684 8 ,, 0·690 0	0·001 30	0·975 0 ,, 0·999 4	0·000 67
0·690 1 ,, 0·695 6	0·001 28	0·999 5 ,, 1·017 8	0·000 65
0·695 7 ,, 0·700 5	0·001 26	1·017 9 ,, 1·036 9	0·000 63
0·700 6 ,, 0·705 2	0·001 24	1·037 0 ,, 1·054 5	0·000 61
0·705 3 ,, 0·710 6	0·001 22	1·054 6 ,, 1·075 2	0·000 59
0·710 7 ,, 0·715 9	0·001 21	1·075 3 ,, 1·124 9	0·000 58
0·716 0 ,, 0·721 0	0·001 19		
0·721 1 ,, 0·726 0	0·001 17		
0·726 1 ,, 0·731 3	0·001 15		
0·731 4 ,, 0·736 4	0·001 13		
0·736 5 ,, 0·741 5	0·001 12		

APPENDIX F

[*Clause* 10.5.6.3 (b)]

VOLUME CORRECTION COEFFICIENTS OF NON-PETROLEUM PRODUCTS

Product	Coefficient per deg C
Benzene	0·001 24
Benzole (commercial)	0·001 13
Toluole	0·001 04
Xylole	0·001 00
Solvent naphtha	0·000 99
Heavy solvent naphtha	0·000 92
Creosote oil	0·000 73
Coal tar	0·000 54
Methyl alcohol	0·001 18
Ethyl alcohol	0·001 08

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002
Telephones: 323 0131, 323 3375, 323 9402
Fax : 91 11 3234062, 91 11 3239399, 91 11 3239382

Telegrams : Manaksanstha
(Common to all Offices)

Central Laboratory:	Telephone
Plot No. 20/9, Site IV, Sahibabad Industrial Area, Sahibabad 201010	8-77 00 32
Regional Offices:	
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	323 76 17
*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	337 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43
Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113	235 23 15
†Western : Manakalaya, E9, Behind Marol Telephone Exchange, Andheri (East), MUMBAI 400093	832 92 95
Branch Offices:	
'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	550 13 48
‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road BANGALORE 560058	839 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001	40 36 27
Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No. 29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
E-52, Chitaranjan Marg, C-Scheme, JAIPUR 302001	37 29 25
117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
NIT Building, Second Floor, Gokulpat Market, NAGPUR 440010	52 51 71
Patliputra Industrial Estate, PATNA 800013	26 23 05
Institution of Engineers (India) Building 1332 Shivaji Nagar, PUNE 411005	32 36 35
T.C. No. 14/1421, University P.O. Palayam, THIRUVANANTHAPURAM 695034	6 21 17

*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072	27 10 85
†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007	309 65 28
‡Sales Office is at 'F' Block, Unity Building, Narashimaraja Square, BANGALORE 560002	222 39 71

Printed at Simco Printing Press, Delhi, India