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भारतीय मानक मासौदा

पेट्रोलियम और उसके उत्पाद — परीक्षण पद्धतियाँ भाग 7 गणना द्वारा ऊष्मीय मान का निर्धारण

(IS 1448 Part 7 **का दूसरा पुनरीक्षण)**

***Draft* Indian Standard**

PETROLEUM AND ITS PRODUCTS — TEST METHODS (PART 7) DETERMINATION OF CALORIFIC VALUE BY CALCULATION

(*Second Revision of* IS 1448 Part 7)

(ICS 75.080)

Methods of Sampling and Test for Petroleum and related Products of Natural or Synthetic Origin (excluding bitumen) Sectional Committee PCD 01	Last date for receipt of comments 04 March 2025

FOREWORD

(*Formal clause will be added later*)

This test method was first published in 1960 and subsequently revised in 2004. During the first revision, scope and terminology were modified. Summary of test method, significance and use were included. Presentation of calculation was updated.

The second revision has been brought out to keep pace with the latest technological developments and international practices. In this revision following major changes have been made:

a) Scope have been modified; and
b) Experimental determination has been modified.
c) Reference clause has been updated.

In the preparation of this standard, considerable assistance has been derived from the following standard:

ASTM D 4868-17 'Standard Test Method for Estimation of Net and Gross Heat of Combustion of Hydrocarbon Burner and Diesel Fuels' for formulation of this test method.

In reporting the results of a test or analysis 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: 2022 'Rules for rounding off numerical values (*second revision*)

1 SCOPE

1.1 This method is intended for the determination of the calorific value, gross or net, of petroleum fuels by calculation from the fuel density, sulphur, water and ash content.

1.2 This method is not applicable to fuels containing non-hydrocarbon fuels such as alcohols (e.g Methanol, Ethanol), ethers (e.g MTBE), esters (e.g Biodiesel).

1.3 This method is not applicable to pure hydrocarbon compounds.

1.4 This method shall be used only as a routine alternate method for the quick estimation of calorific value, and for accurate determination and in case of dispute the method prescribed in IS 1448 (Part 6) shall be adopted.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 1448	Methods of test for petroleum and its products
(Part 4/Sec1): 2021	Determination of Ash (*fourth revision*)
(Part 6): 1984	Heat of combustion of liquid hydrocarbon fuels by Bomb calorimeter method (*first revision*)
(Part 16): 2014/ ISO 3675 : 1998	Crude Petroleum and Liquid Petroleum Products — Laboratory Determination of Density — Hydrometer Method (*fourth revision*)
(Part 33) :2021	Sulphur by High Pressure Decomposition Device Method (*third revision*)
(Part 34) :1979	Determination of sulphur in petroleum products (Lamp method) (*second revision*)
(Part 40): 2015/ ISO 3733 : 1999	Petroleum Products and Bituminous Materials — Determination of Water — Distillation Method (*fourth revision*)
(Part 153): 2012/ ISO 20847 : 2004	Petroleum Products — Determination of Sulfur Content of Automotive Fuels — Energy-Dispersive X-Ray Fluorescence Spectrometry

(Part 159): 2018/ ISO 20884 : 2011	Determination of Sulphur Content of Automotive Fuels — Wavelength-Dispersive X-Ray Fluorescence Spectrometry
(Part 160): 2017/ ISO 20846 : 2011	Determination of Sulphur Content of Automotive Fuels — Ultraviolet Fluorescence Method
(Part 175): 2020/ ISO 6296 : 2000	Determination of Water Potentiometric Karl Fischer Titration Method
(Part 182): 2020/ ISO 12937 : 2000	Determination of Water — Coulometric Karl Fischer Titration Method

3 TERMINOLOGY

For the purpose of this test method, the following definitions shall apply.

3.1 Gross Calorific Value — The gross calorific value of a fuel at constant volume is the number of heat units which would be liberated when unit weight of fuel is burnt at constant volume in oxygen saturated with water vapour, the original and final materials being at 15 °C, the residual products being carbon dioxide, sulphur dioxide, nitrogen and water, the water other than that originally present as vapour, being in the liquid state.

3.2 Net Calorific Value — The net calorific value of a fuel is the number of heat units which would be liberated when unit weight of the fuel is burned in oxygen saturated with water vapour, the original and final materials being at 15 °C and the residual products being carbon dioxide and nitrogen. This value may be expressed either at constant pressure or constant volume.

3.3 Units of Measurement — The units of measurement employed in this method are the calorie and the British Thermal Unit, defined as follows:

1 calorie at 15 °C = 4.185 5 joule
1 calorie = 4.186 8 joule (exactly)
1 Btu/lb °F = 4.186 8 joule/g °C (exactly)

3.4 Most petroleum products consist essentially of a large number of different hydrocarbons which are so nearly alike physically that a mixture of them exhibits a thermodynamic behaviour somewhat analogous to that shown by a mixture of isotopes. It has been established experimentally that many of these properties, including the calorific value, are closely related to the density of the liquid which may easily be determined using a hydrometer. The relationship affords a very useful means of computing the calorific value of petroleum and its products.

The relation between total heat of combustion at constant volume and specific gravity for pure hydrocarbons, water, ash and Sulphur free, found in petroleum is given by:

$$q_v = 12\,400 - 2\,100\,d^2$$

where

q = calorific value at constant volume in cal/g, and
d = specific gravity at 15.56 °C/l5.56 °C.

The calorific value at constant pressure is given by:

$$q_p = q_v - H\,(WL - C)\ 0.0l$$

where

q_p = calorific value at constant pressure, in cal/g;
q_v = calorific value at constant volume, in cal/g; v
H = hydrocarbon content, percent by weight, in the material, calculated from the approximate relation:

$$H=26 - 15d$$

d = the specific gravity at 15.56 °C/15.56 °C;
W = number of grams of water formed from 1 g of hydrogen, equal to 9;
L = latent heat of vaporization of water at 20 °C equal to 585; and
C = correction to take into account the change in volume from initial to final products, equal to 220.

The calorific values of petroleum and its product which are mixtures of hydrocarbons containing certain impurities in the form of water, ash and sulphur are obtained from the relations given in **7**.

4 SUMMARY OF TEST METHOD

The density, sulphur, water and ash content of the sample are determined by experimental test methods. The heat of combustion is calculated using the values obtained by these test methods based on reported correlation.

5 SIGNIFICANCE AND USE

This test method is intended for use in case where an experimental determination of heat of combustion is not available and cannot be made, conveniently and where an estimate is considered satisfactory. It is not intended as a substitute for experimental measurement of heat of combustion.

6 METHOD

6.1 Experimental Determination

6.1.1 Determine the water content of the material by the method given in IS 1448 Part 40, IS 1448 Part 175, IS 1448 Part 182.
6.1.2 Determine the ash content by the method given in IS 1448 Part 4/sec 1.
6.1.3 Determine the sulphur content by the method given in IS 1448 Part 33, IS 1448 Part 34, IS 1448 Part 153, IS 1448 Part 159, IS 1448 Part 160.
6.1.4 Determine density by the method given in IS 1448 (Part 16.

6.1.5 Values of density at 15 °C can be converted using standard measurement tables 1 to equivalent values of Specific Gravity.

7 CALCULATION

7.1 Calculate the heat of combustion of the fuel corrected for sulphur, water and ash content in accordance with the following equations:

$$Q_v \text{ (gross)} = q_v - 0.0\text{l } q_v \text{ (W+A+S) +X(S)}$$
$$Q_P \text{ (Net)} = q_p - 0.\text{l } q_p \text{ (W+A +S) +X(S)-Y(W)}$$

where

Q_v = corrected calorific value of the material at constant volume, in cal/g;
q_v = calorific value at constant volume, in cal/g (12 400-2100 *d,);*
d = specific gravity at 15.56 °C/15.56 °C;
W= percent, water by mass, of the material (W= number of grams of water formed for 1 g of hydrogen equal to 9);
A = percent, ash by mass, of the material;
S = percent, sulphur by mass, of the material;
X = correction factor equal to 22.5 when Q is expressed, in cal/g;
Q_p= corrected calorific value of material at constant pressure in cal/g;
q_p= calorific value at constant pressure, in cal/g [$q_p = q_v$ - (WL – C) 0.01];
H = hydrogen content, percent by mass *(*H = 26-15 d);
Y = correction factor, equal to 5.85 when Q is expressed, in cal/g;
L = latent heat of vaporization of water at 20 °C, equal to 585; and
C = corrections to take into account the change in volume from initial to final products, equal to 220.

7.2 Increase the values given in Table 1 by about one percent to get the calorific value of the vapour in the case of volatile petroleum products.

8 REPORT

Report the result as the estimated gross or net to the nearest whole number.

9 PRECISION

The precision of the estimated value will be dependent upon the accuracy of the determined density, sulphur, water and ash contents.

Repeatability	*Reproducibility*
75 cal/g	150 cal/g

Table 1 Heat of Combustion of Crude Oils, Fuel Oils, Kerosene and Volatile Petroleum Products
(*Clause 6.1.5 and* 7.2)

Gravity		Density at 15 °C g/ml	Total Heat of Combustion at Constant Volume cal/g	Net Heat of Combustion at Constant Pressure cal/g
Degree API	Specific at 15.56 °C/15.56 °C			
(1)	(2)	(3)	(4)	(5)
10	1.0000	0.9994	10300	9740
11	0.9930	0.9924	10330	9770
12	0.9861	0.9855	10360	9790
13	0.9792	0.9787	10390	9810
14	0.9725	0.9719	10410	9840
15	0.9659	0.9653	10440	9860
16	0.9593	0.9588	10470	9880
17	0.9529	0.9523	10490	9900
18	0.9465	0.9459	10520	9920
19	0.9402	0.9397	10540	9940
20	0.9340	0.9335	10570	9960
21	0.9279	0.9273	10590	9980
22	0.9218	0.9213	10620	10000
23	0.9159	0.9153	10640	10020
24	0.9100	0.9095	10660	10040
25	0.9042	0.9037	10680	10050
56	0.8984	0.8979	10710	10070
27	0.8927	0.8923	10730	10090
28	0.8871	0.8867	10750	10110
29	0.8816	0.8811	10770	10120
30	0.8762	0.8757	10790	10140
31	0.8708	0.8703	10810	10150
32	0.8654	0.8650	10830	10170
33	0.8602	0.8597	10850	10180
34	0.8550	0.8545	10860	10200
35	0.8499	0.8494	10860	10210
36	0.8448	0.8443	10900	10230
37	0.8398	0.8393	10920	10240

38	0.8348	0.8344	10940	10260
39	0.8299	0.8295	10950	10270
40	0.8251	0.8247	10970	10280
41	0.8203	0.8199	10990	10300
42	0.8156	0.8156	11000	10310
43	0.8109	0.8105	11020	10320
44	0.8063	0.8059	11030	10330
45	0.8017	0.8013	11050	10340
46	0.7972	0.7968	11070	10363
47	0.7927	0.7924	11080	10373
48	0.7883	0.7880	11100	10380
49	0.7839	0.7836	11110	10390
50	0.7796	0.7793	11 120	10400
51	0.7753	0.7750	11140	10440
52	0.7711	0.7708	11150	10420
53	0.7669	0.7666	11160	10430
54	0.7628	0.7625	11180	10440
55	0.7587	0.7584	11190	10450
56	0.7547	0.7544	11200	10460
57	0.7507	0.7504	11220	10470
58	0.7467	0.7464	11230	10480
59	0.7428	0.7425	11240	10490
60	0.7389	0.7387	11250	10500
61	0.7351	0.7358	11270	10510
62	0.7313	0.7310	11280	10520
63	0.7275	0.7273	11290	10530
64	0.7238	0.7236	11300	10540
65	0.7201	0.7199	11310	10540
66	0.7165	0.7162	11320	10550
67	0.7128	0.7126	11330	10560
68	0.7093	0.7091	11340	10570
69	0.7057	0.7055	11350	10580
70	0.7022	0.7020	11360	10580
72	0.6953	0.6951	11380	10600
74	0.6886	0.6884	11400	10610
76	0.6819	0.6818	11420	10630

78	0.6757	0.6753	11440	10640
80	0.6690	0.6689	11460	10650
82	0.6628	0.6636	11480	10670
84	0.6566	0.6565	11490	10680
86	0.6506	0.6505	11510	10690
88	0.6446	0.6446	11530	10700
90	0.6388	0.6387	11540	10710
91	0.6331	0.6330	11560	10720
94	0.6275	0.6274	11570	10740
96	0.6220	0.6219	11590	10750
98	0.6166	0.6165	11600	10760
100	0.6112	0.6112	11620	10770
105	0.5983	0.598 2	11650	10790
110	0.5859	0.585 9	11680	10810
115	0.5740	0.574 1	11710	10830
120	0.5626	0.562 7	11740	10850
125	0.5517	0.5519	11760	10860
130	0.5411	0.5413	11790	10880
135	0.5310	0.5312	11810	10900
140	0.5212	0.5215	11830	10910
145	0.5118	0.5121	11850	10920