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CALORIFIC VALUE OF FUELS USED IN ENTERPRISES OF THE USSR PETROLEUM INDUSTRY

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The majority of enterprises of the USSR petroleum industry use predominantly liquid fuel, boiler mazuts, cracking residues, and straight-run mazuts, while natural and manufactured gas play a less important role in the total fuel consumption. To convert these natural fuels to standard fuel, one must first of all determine the calorific value of the fuel in question. The calorific value can be calculated theoretically in the absence of reliable experimental data. Using the Mendelezev formula, the calorific value of liquid fuels can be reliably obtained:

$$Qp = 81C + 300H - 26(O - S) - 6(9H+W) \text{ calories/kilogram},$$

where Qp is the calorific value; C, H, O, and S the constituent elements of the fuel given in percent by weight, and W the moisture content, also in percent by weight. Error in determining the calorific value by this formula does not usually exceed one percent.

Later, Kreg proposed a simpler formula for determining the calorific value for liquid value. This calculation required knowledge of only the specific gravity and the water content of the fuel:

$$Qp = 12{,}400 - 2{,}100d^2 - 50.45H \text{ calories/kilogram},$$

where d is the specific gravity at 15 degrees centigrade and H equals 25-15d (the formula for ash- and water-free fuel).

The formula for fuel containing water is

$$Qp(\text{containing water}) = Qp(\text{water-free}) - 0.01Qp(\text{water-free}) \times$$
$$\times W - 5.58W \text{ calories/kilogram},$$

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where W is the percent of water content of the fuel. According to information of the Thermal Technical Institute, the percentage error for fuels for straight-run mazuts, cracking mazuts, motor fuels, and oils ranged only from 0.1 to 1.0.

The calorific value for gas fuels can be obtained by the following generally accepted formula:

$$Q_p = Q_{p1}\,CO + Q_p{}^2\,H_2 + Q_{p3}\,CH_4 + Q_{p4}\,C_2H_6 + Q_{p5}\,C_3H_8 + \ldots \text{ calories/cubic millimeters.}$$

In this formula, Q_{p1}, Q_{p2}, etc., represent the calorific value of separate components and the second factors constitute the component gases in volume percent In this case, knowledge of the composition and specific gravity of the gases is necessary.

To facilitate the conversion to standard fuel in the absence of experimental data, the approximate calorific value for the majority of liquid fuels usually consumed in enterprises of the petroleum industry is given in Table 1. Tables 2-7 give the calorific value for the majority of gases used as fuel in individual enterprises. But, because of the instability of the various components of natural gas, these figures must only be used in cases when reliable data on the elementary composition of the gas and its specific gravity are available. Table 8 gives data on solid fuel. Because of the absence of experimental data, the calorific value for straight-run mazut has been determined theoretically by using the formula previously mentioned.

To further facilitate the conversion to standard fuel, it would be expedient to conceive of standard fuel as possessing a calorific value of 10,000 calories per kilogram instead of the present 7,000 calories. However, such a change would require a governmental decree.

Table 1. Liquid Fuel

Type	Calorific Value(cal/kg)
Boiler fuel mazuts (slight sulfur content)	
Mazut, Type 10	9,980
Mazut, Type 20	9,870
Mazut, Type 40	9,750
Mazut, Type 60	9,720
Mazut, Type 80	9,660
Boiler fuel mazuts (sulfur content 1-4%)	
Mazut, Type 10	9,760
Mazut, Type 20	9,690
Mazut, Type 40	9,620
Fleet mazut	9,820
Cracking mazut	9,730

Type	Calorific Value (cal/kg)
Straight-run mazuts (water-free)	
Straight-run mazuts from Groznyy petroleums	
Groznyy nonparaffin petroleums (sp gr 0.946)	9,830
Groznyy paraffin petroleums (sp gr 0.914)	9,985
Malgobek heavy petroleums (sp gr 0.934)	9,950
Malgobek light petroleums (sp gr 0.953)	9,875
Straight-run mazuts from Baku petroleums	
Kala petroleums (sp gr 0.924)	9,990
Surakhany paraffin petroleums (sp gr 0.907)	10,050
Surakhany choice petroleums (sp gr 0.893)	10,080
Kara-Chukhurskiy petroleums (sp gr 0.886)	10,100
Bibi-Eybatskiy light petroleums (sp gr 0.932)	9,950
Bibi-Eybatskiy heavy petroleums (sp gr 0.938)	9,930
Kergez petroleums (sp gr 0.958)	9,870
Ramaninskiy paraffin petroleums (sp gr 0.903)	10,045
Balakhany heavy petroleums (sp gr 0.944)	9,915
Binagady petroleums (sp gr 0.942)	9,925
Diesel and motor fuel	
Groznyy gas oil	10,175
Baku gas oil	10,175
Motor fuel	9,820
Straight-run gasolines	10,450
Tractor kerosene	10,260
Solar oil	10,175

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Table 2. Natural Gas in the Baku Petroleum Regions

Characteristics of Gases	Regions: Leninskiy	Imeni Ordzhonikidze	Imeni Kaganovich	Kala	Stalinskiy	Nefte-Gala
Content in vol percent						
CH_4	93.38	89.77	94.36	97.11	90.88	87.40
C_2H_6	0.06	0.16	0.85	2.51	3.00	3.74
C_3H_8	0.03	0.13	0.81	-	0.45	2.60
C_4H_{10}	0.23	0.28	0.35	-	1.37	2.25
Other gases of methane series	0.68	1.26	0.73	0.37	2.00	1.21
H_2	-	-	-	-	0.95	-
CO_2	5.60	8.40	2.90	-	1.35	2.80
Air	-	-	-	-	-	-
C_nH_{2n+2}	9.44 [sic]	91.6	97.10	100.0	97.7	97.2
Sp gr at 15°C, and 760 mm	0.77	0.82	0.755	0.710	0.808	0.85
Gasoline content of 1 cu m of gas (in gr)	28.00	52.10	26.50	15.78	65.90	51.70
Calorific value of dry gas						
Cal/cu m	7,615	7,560	7,983	8,000	8,612	8,915
Cal/kg	9,400	8,750	10,100	10,700	10,200	10,000

Table 3. Natural Gas of the Groznyy Petroleum Region

Characteristics of Gases	New Region					Old Region		
	Station at Plant No 4	Station at Plant No 4	Station at Plant No 2	Gas from Seam XXI	At Plant No 2	Solenaya Balka Gas	Station at Plant No 1	From Bore Holes
Content in volume percent								
CH_4	39.8	43	43	50.6	58.0	54.7	70.9	75.2
C_2H_6	9.5	9.7	7.6	10.8	7.0	7.4	7.1	6.0
C_3H_8	19.0	19.4	17.4	13.5	18.9	15.7	9.0	8.0
n-C_4H_{10} (normal)	6.1	17.3	7.5	14.8	3.9	13.7	7.0	5.7
i-C_4H_{10} (iso)	12.3	-	9.2	-	10.1	-	-	-
C_5H_{12} and other gases in series	13.3	10.6	15.3	10.9	-	8.5	6.0	5.1
Sp gr at 15° C and 760 mm	1.66	1.58	1.65	1.48	1.17	1.44	1.14	1.07
Calorific value of dry gas								
Cal/normal cu m	17,660	16,750	17,560	15,740	12,980	15,060	12,200	11,580
Cal/kg	10,100	10,100	10,100	10,100	10,500	10,000	10,200	10,300

Table 4. Natural Gas of Petroleum of Western Ukraine

Characteristics of Gases	Borislav	Dashava
Content in vol percent		
CH_4	83.0	97.9
C_2H_6	10.9	0.7
C_3H_8	4.8	0.2
C_4H_{10}	1.1	0.1
C_5H_{12} and other gases of series	-	-
CO_2	0.2	0.1
N_2 and other gases	-	1.0
Sp gr at 15°C and 760 mm	0.83	0.70
Calorific value of dry gas		
Cal/normal cu m	9,260	7,860
Cal/kg	10,600	10,700

Table 5. Natural Gas of Dagestan (Dag-Ogni Deposit)

Characteristics of Gases	Aul Khosh-Menzil	Dag-Ogni Natural Outlet	Dag-Ogni Gas Wells	Duzlak
Content in vol percent				
CH_4	87.9	88.2	92.1	90.2
Heavy unsaturated hydrocarbons	0.4	None	None	None
CO_2	2.5	7.5	7.0	4.10
O_2	None	None	None	0.1

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Table 5 (Contd)

Characteristics of Gases	Aul Khosh-Menzil	Dag-Ogni Natural Outlet	Dag-Ogni Gas Wells	Duzlak
Content in vol percent				
CO	None	1.7	0.4	1.6
N_2	9.2	2.6	0.5	4.0
Sp gr at 15° and 760 mm	0.8	0.83	0.8	0.79
Calorific value				
Cal/normal cu m	7,000	6,870	7,210	7,085
Cal/kg	8,350	8,200	8,600	8,500

Table 6. Natural Gas of Deposits in Eastern Regions

Character-istics of Gases	Tuymazy	Ishimbay	Buguruslan	Yablonovyy Ovrag (Gully)	Andizhan	Molotov
Content in vol percent						
CH_4	40.2	42.4	71.0	46.0	67.1	29.6
C_2H_6	19.7	22.2	7.0	10.2	14.4	12.1
C_3H_8	15.6	18.3	4.0	6.9	5.2	11.3
C_4H_8	5.4	4.0	-	3.0	-	2.3
C_4H_{10}	5.0	2.2	3.0	1.8	2.3	1.8
C_5H_{12}	3.4	1.9	1.5	2.7	0.3	2.0
CO_2	0.2	1.4	1.0	0.7	0.6	0.6
H_2S	-	4.6	2.5	-	0.8	0.2
N_2	10.5	4.0	10.0	28.7	9.3	40.1
Sp gr at 15°C and 760 mm	1.37	1.42	1.01	1.19	0.985	1.32
Calorific value						
Cal/normal cu m	12,800	12,250	8,750	9,270	9,000	8,000
Cal/kg	9,000	8,200	8,250	7,400	8,800	5,800

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Table 7. Manufactured Gas

Characteristics of Gases	Pyrolysis Gas	Cracking Gas
Content in vol percent		
H_2	15	4.4
CH_4	45	37
C_2H_4	17	3.7
C_2H_6	7	14.3
C_3H_6	8	5.9
C_3H_8	1	12.4
C_4H_8	2.8	6.0
C_4H_{10}	0.2	5.3
Butadiene	1.5	
Other gases of the series	2.0	9.4
CO	0.5	0.6
Sp gr at 15°C and 760 mm	0.96	1.54
Calorific value		
Cal/normal cu m	10,620	16,980
Cal/kg	11,000	10,500

Table 8. Solid Fuel

Fuel Deposits	Type	Moisture Content (%)	Ash Content (%)	Calorific Value (cal/kg)
Donets coal	D	12	19.8	4,900
Donets coal	G	8	14,7	5,900
Donets coal	PZh	6	18.8	5,980
Donets coal	T	6	17.0	6,320
Donets coal	AS	6	13.2	6,400
Donets coal	ASh	8	20.0	5,660

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Table 8 (Contd)

Fuel Deposits	Type	Moisture Content (%)	Ash Content (%)	Calorific value (cal/kg)
Donets coal	P/P	7	41.8	3,850
Karaganda coal	PZh/PS	8	26.0	5,230
Karaganda coal	BR	28	15.0	3,650
Moscow Basin coal	BR	33	27.0	2,300
Ural Kizel coal	PZh	9	30.0	4,700
Ural Kizel coal	P/P	8	36.8	4,150
Ural Bogoslovskiy coal	BR	28	25.0	2,700
Ural Chelyabinsk coal	B	19	24.3	3,700
Bashkir Kuyurgazinskiy coal	BR	46	17.8	1,940
Irkutsk Cheremkhovo coal	D	12	15.0	5,300
Primorskiy Suchan coal	PZh	10	21.0	5,450
Khabarovsk El'genskiy coal	BR	40	13.8	2,550
Khabarovsk Bureya coal	G	8	27.6	4,950
Ukrainian Aleksandreyskiy coal	BR	55	15.8	1,500
Georgian Tkvarcheli coal	PZh	6	32.9	4,600
Georgian Tkibuli coal	G	12	26.4	4,470
Kazakh Mangyshlakskiy coal	BR	30	13.0	3,750
Leningrad Gdov shale	-	11.5	46 + 16.4	2,000
Kuybyshev Kashpirskiy shale	-	16.0	50.2 + 8.8	1,550
Saratov Savel'yevskiy shale	-	17.0	48 + 10.8	1,500
Coke fines, 15-25 mm	-	15.0	11	5,600
Coke fines, 0-15 mm	-	18	16.4	5,000
Lump peat	-	40	6.6	2,550
Milled peat	-	50	5.5	2,000
Hard wood	-	30	-	2,900
Soft wood	-	30	-	2,980

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