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Estimation of Net Enthalpies of Combustion of Some Aviation Fuels Expressed in the International System of Units (SI)

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Contents

Symbols

A	Aniline point
D	density at 15 °C
g	relative density at 60 °F (density at 60 °F/density of water at 60 °F)
G	API Gravity (G/°API = 141.5/g - 131.5)
$-Q$	net enthalpy of combustion
$-Q'$	net enthalpy of combustion "sulfur free"
$-Q_v$(Gross)	gross energy of combustion
S	mass percent of sulfur
H	mass percent of hydrogen
V	vaporization temperature (average of 10%, 50% and 90% distillation temperatures)
Ar	volume percent of aromatics
SD(R)	estimate of standard deviation of R
SS	sum of squares of deviations
DEV	deviation (observed - calculated)
STZD	standardized deviation
Q(C)	calculated value of Q
Q(O)	observed value of Q
B(n)	fitted or defined constants
C(n)	fitted or defined constants

Estimation of Net Enthalpies of Combustion of Aviation Fuels Expressed in the International System of Units (SI)

Ralph L. Nuttall and George T. Armstrong

Abstract

A new correlation has been made of the net enthalpy of combustion of some aviation fuels with their aniline point, density, and sulfur content. Previous correlations gave a set of five equations relating the enthalpy of combustion to the aniline point gravity product for five classes of fuels ranging from aviation gasoline to kerosine. These equations were in non-SI units.

The correlation reported here gives similar sets of equations using SI units and also gives a single equation which can be used to adequately predict the net enthalpy of combustion of all five classes of fuels from measurements of aniline point, density, and sulfur content. This equation is:

$$Q = [B(0) + B(1) \times A + B(2) \times (1/D) + B(3) \times (A/D) + B(4) \times (A)^2 + B(5) \times (1/D)^2 + B(6) * S]\ \mathrm{MJ/kg}.$$

$B(0) = 22.9596\ \mathrm{MJ \cdot kg^{-1}}$

$B(1) = -1.26587 \times 10^{-2}\ \mathrm{MJ \cdot kg^{-1} \cdot {}^\circ C^{-1}}$

$B(2) = 26.6409\ \mathrm{MJ \cdot kg^{-1} \cdot g^{-1} \cdot cm^{3}}$

$B(3) = 0.032622\ \mathrm{MJ \cdot kg^{-1} \cdot {}^\circ C^{-1} \cdot g^{-1} \cdot cm^{3}}$

$B(4) = -6.6903 \times 10^{-5}\ \mathrm{MJ \cdot kg^{-1} \cdot {}^\circ C^{-2}}$

$B(5) = -9.21776\ \mathrm{MJ \cdot kg^{-1} \cdot g^{-2} \cdot cm^{6}}$

$B(6) = 50.\ \mathrm{MJ \cdot kg^{-1} \cdot S^{-1}}$

Keywords: Aniline point; API gravity; aviation fuels; enthalpy of combustion; fuels; gasoline; gravity; heat content; heat of combustion; kerosine.

1. Introduction

The commercial desirability of predicting enthalpies of combustion of hydrocarbon fuels from more easily measured physical properties has been recognized for many years. Correlations have been made [1-6][1], and used for such predictions for several classes of aviation fuels. However, these correlating equations use input data in non-SI units and thus are difficult of application in much of the world. As a result of the move toward metrication in the United States, it is to be anticipated that an increasing number of laboratories will be making measurements in SI units. For these reasons it seems desirable to have correlating equations and tables which use input data in SI units. Also the validity of the correction used in these equations to convert the net enthalpy of combustion to a "sulfur free" basis has been questioned in its use with fuel oils [8-11].

As a result of these considerations, for this report the data from references 1 through 5 have been recorrelated to obtain equations and tables for estimating the net enthalpy of combustion of aviation fuels from measurements of aniline point and density made in SI units. The effect of sulfur has been obtained by including it in the regression analysis. Also a single equation, quadratic in aniline point and reciprocal density, has been found satisfactory to predict the enthalpy of combustion of all the fuels.

The equations whose replacement is recommended are described briefly below.

[1] Figures in brackets indicate the literature references on page 54.

For aviation fuels five sets of accurate measurements [1], [2], [3], [4], [5] have been reported from the National Bureau of Standards. The authors of these papers correlated the measured net enthalpies of combustion (negative net heats of combustion at constant pressure) with the product of aniline point and gravity as in equation 1.

$$Q' = B(0) + B(1)*A*G \qquad (1)$$

Values of the parameters B(0) and B(1) were given for each of five classes of fuels. These correlating equations have been incorporated into standard methods ASTM D1405-IP193 and draft ISO/DIS3648. These equations are shown in table 1.

Another correlation of net heats of combustion at constant pressures by Bert and Painter [6] using mostly data from the references [1] and [5] with some added data from [7] has been made using as variables: Gravity, G; vaporization, V; and volume percent of aromatics, Ar. The resulting correlating equation has been adopted in a standard method ASTM D3338. It applies a single equation, equation (2), claimed to be applicable to all aviation fuels from gasolines to aircraft turbine and jet engine fuels.

$$Q = B(0) + B(1)*G + B(2)*Ar + B(3)*G*V + B(4)*Ar*G + B(5)*Ar*G*V)*(1 - .01*S) + B(6)*S \qquad (2)$$

This equation is also given in table 1.

In the above correlations the net enthalpy of combustion has been corrected to a "sulfur free" basis by equation (3). A value for B(6) of 43.7 $Btu \cdot lb^{-1} \cdot S^{-1}$ or 0.1016 $MJ \cdot kg^{-1} \cdot S^{-1}$ was derived from thermochemical data on organic sulfur compounds, [4].

$$Q' = Q(\text{sulfur free}) = (Q - B(6)*S/(1 - .01*S) \qquad (3)$$

Table 1.

Q' = (Q - B(6)*S)/(1 - .01*S)

For Q and Q' in Btu/lb, B(6) = 43.7

For Q and Q' in MJ/kg, B(6) = 0.1016

ASTM D1405

Q' = B(0) + B(1)*A*G

Units of A are °F
Units of G are °API
For Q' in Btu/lb use B parameters
For Q' in MJ/kg use C parameters

Fuel: Gasoline 100/130 and 115/145

B(0) = 18037.7
B(1) = 0.0883

C(0) = 41.9557
C(1) = 0.00020543

Fuel: ANF-58 and ANF-28 (JP-3)

B(0) = 17940
B(1) = 0.1056

C(0) = 41.7284
C(1) = 0.00024563

Fuel: JP-4

B(0) = 17977
B(1) = 0.1056

C(0) = 41.8145
C(1) = 0.00024563

Table 1 continued:

Fuel: JP-5

B(0) = 17914
B(1) = 0.1056

C(0) = 41.6680
C(1) = 0.00024563

- -

Fuel: Kerosine

B(0) = 17919
B(1) = 0.10923

C(0) = 41.6796
C(1) = 0.00025407

- -

ASTM D3338

Q' = B(0) + B(1)*G + B(2)*Ar + B(3)*G*V + B(4)*Ar*G + B(5)*Ar*G*V

Units of G are °API
Units of Ar are volume percent
Units of V are °F
Units of Q' are Btu/lb

B(0) = 17685
B(1) = 16.24
B(2) = -3.007
B(3) = 0.01714
B(4) = -0.2983
B(5) = 0.00053

or

Q' = [5525.57 - 92.5969*Ar + 10.15429*V + 0.313989*A*V]/g +

79.0589*A - 9.43667*V - 0.291799*A*V + 36000.24

Units of V are °C
Units of Q' are kJ/kg

2. Source Data

The data for this correlation are taken from references [1] through [5]. Armstrong, Jessup and Mears [1] reported data on aviation gasolines: 7 samples of grade 100/130 and 33 samples of grade 115/145.

Jessup and Cragoe [2] reported data on two sets of samples, one of 31 and the other of 26, of fuels specified as ANF-28. They give equations for calculating net enthalpy of combustion from the gross energy which is measured in a bomb combustion experiment

$$Q = Q_v(\text{gross}) - 91.23*H \text{ Btu/lb} \tag{4}$$

and for cases where hydrogen analysis is not available

$$Q = 4310 + 0.7195*Q_v(\text{gross}) \text{ Btu/lb.} \tag{5}$$

Equation (4) was used by the authors of all the other reports of measurements.

Rothberg and Jessup [3] report data on 32 samples of fuels specified as ANF-58.

Jessup and Cogliano [4] report data on 17 samples of JP-4 fuel, 11 samples of JP-5 fuel. They introduce equation (3) with a value of 43.7 (Btu/lb)/(%S) for B(6) to correct for sulfur content of the fuels.

Armstrong, Fano, Jessup, Marantz, Mears, and Walker [5] report data on 110 samples of kerosine.

The data in all of the above reports are presented in units of aniline point in °F, gravity in degrees API and net heat of combustion in Btu/lb. The energy units obtained in the calorimetric experiments were J/g (in air against brass weight) or J(international)/g. The data were converted to Btu/lb by the relations

$$1 \text{ Btu/lb} = 0.429917 \text{ J/g} \qquad (6)$$

or

$$1 \text{ Btu/lb} = 0.43 \text{ J(international)/g}. \qquad (7)$$

Relation (6) was used in this report to convert the reported data from Btu/lb to J/g despite the fact that this constant differs from the value 1/2.326 that currently defines the Btu. Data reported as x °F were converted to y °C by the relation

$$y = (x - 32)/1.8 \qquad (8)$$

Data given as gravity were converted to relative density by the defining equation

$$G = \frac{141.5}{g} - 131.5 \qquad (9)$$

Corresponding values of G, g, and D are given in ASTM-IP Petroleum Measurement Tables [12]. Over the range of densities covered by the fuel samples considered here it is found that the quadratic equations (10) and (11) relating g to D will reproduce the corresponding tables.

$$D = 2.9431 \times 10^{-3} + 0.993367\ g + 3.1251 \times 10^{-3} g^2\ \text{g/cm}^3 \quad (10)$$

$$g = -2.953 \times 10^{-3} + 1.00666\ D - 3.14 \times 10^{-3}\ D^2 \quad (11)$$

Equations (9) and (10) have been used to convert data given as gravity to density.

The experimental data given in the above reports are shown in table 2. The original data from the reports are in columns 2 through 6. Data in columns 7 through 9 were calculated using the above conversion relations.

TABLE 2 SOURCE DATA

ALL FUELS

NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	D/(g·cm^{-3})	Q/(MJ/kg)
MIN	80.60	31.80			18230.0	27.00	.6881	42.4035
MAX	173.46	74.10			19099.2	78.59	.8660	44.4253
MEAN	137.07	52.79			18685.6	58.37	.7675	43.4634

AVIATION GASOLINE 100/115 REF 1

NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	D/(g·cm^{-3})	Q/(MJ/kg)
MIN	120.10	63.00	14.40		18686.6	48.94	.7000	43.4656
MAX	166.60	70.60	15.90		19057.3	74.78	.7273	43.4656
MEAN	140.03	66.79	15.03		18882.8	60.02	.7134	43.9219
1	161.70	69.60	15.70		19046.7	72.06	.7035	44.3032
2	120.10	63.00	14.40		18686.6	48.94	.7273	43.4656
3	161.40	68.50	15.80		19057.3	71.89	.7073	44.3279
4	166.60	70.60	15.90		19051.6	74.78	.7000	44.3146
5	121.10	64.90	14.40		18754.9	49.50	.7203	43.6245
6	126.90	66.60	14.50		18808.5	52.72	.7141	43.7491
7	122.40	64.30	14.50		18773.7	50.22	.7225	43.6682

TABLE 2 (continued)

AVIATION GASOLINE 115/145 REF 1

NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	D/(g cm^{-3})	Q/(MJ/kg)
MIN	117.00	65.10	14.10		18679.2	47.22	.6881	43.4484
MAX	164.40	74.10	16.20		19099.2	73.56	.7195	43.4484
MEAN	151.08	69.64	15.45		18964.2	66.15	.7033	44.1113
8	164.30	72.90	16.20		19089.7	73.50	.6921	44.4032
9	163.80	70.40	16.00		19050.3	73.22	.7007	44.3116
10	164.40	74.10	16.10		19099.2	73.56	.6881	44.4253
11	150.20	69.00	15.30		18934.7	65.67	.7056	44.0427
12	146.80	67.00	15.30		18875.7	63.78	.7126	43.9055
13	153.30	68.80	15.40		18994.0	67.39	.7063	44.1806
14	160.20	69.70	15.90		19049.9	71.22	.7031	44.3106
15	156.20	71.10	15.80		19054.9	69.00	.6983	44.3223
16	145.30	67.30	15.00		18872.8	62.94	.7116	43.8987
17	145.90	68.30	15.20		18888.3	63.28	.7080	43.9348
18	143.30	67.90	15.00		18907.9	61.83	.7094	43.9803
19	155.20	69.50	15.70		19030.0	68.44	.7038	44.2644
20	144.80	68.50	15.20		18925.7	62.67	.7073	44.0218
21	164.30	70.20	16.00		19086.9	73.50	.7014	44.3967
22	163.00	73.30	16.10		19094.0	72.78	.6908	44.4132
23	145.90	68.40	15.30		18897.6	63.28	.7077	43.9564
24	149.30	68.80	15.40		18935.4	65.17	.7063	44.0443
25	148.20	70.10	15.20		18923.1	64.56	.7017	44.0157
26	151.80	69.70	15.30		18988.6	66.56	.7031	44.1681
27	149.80	69.10	15.30		18935.0	65.44	.7052	44.0434
28	154.60	71.40	15.70		19019.4	68.11	.6972	44.2397
29	144.20	68.40	15.20		18889.7	62.33	.7077	43.9380
30	146.00	68.40	15.20		18916.0	63.33	.7077	43.9992
31	149.20	69.30	15.20		18918.9	65.11	.7045	44.0059
32	149.90	68.70	15.40		18925.1	65.50	.7066	44.0204
33	119.90	65.60	14.20		18731.6	48.83	.7177	43.5703
34	159.70	73.60	16.00		19075.5	70.94	.6898	44.3702
35	117.00	65.10	14.10		18679.2	47.22	.7195	43.4484
36	159.00	73.80	16.00		19068.6	70.56	.6891	44.3541
37	162.40	72.00	15.90		19043.3	72.44	.6952	44.2953
38	152.60	68.70	15.50		18954.6	67.00	.7066	44.0890
39	149.10	69.20	15.20		18960.5	65.06	.7049	44.1027
40	155.90	69.90	15.60		19002.5	68.83	.7024	44.2004

TABLE 2 (continued)

AVIATION GASOLINE ANF-58 REF 3

NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	D/(g·cm^{-3})	Q/(MJ/kg)
MIN	80.60	38.80	12.40		18230.0	27.00	.7236	42.4035
MAX	164.30	64.00	15.30		19014.0	73.50	.8305	42.4035
MEAN	119.64	52.44	13.91		18602.7	48.69	.7690	43.2704
41	117.00	49.70	13.70		18532.0	47.22	.7806	43.1060
42	141.30	57.60	14.90		18823.0	60.72	.7480	43.7829
43	120.40	52.40	14.00		18548.0	49.11	.7691	43.1432
44	122.20	50.60	13.80		18594.0	50.11	.7767	43.2502
45	104.90	45.00	12.90		18376.0	40.50	.8013	42.7431
46	139.80	61.50	14.90		18858.0	59.89	.7329	43.8643
47	136.40	61.00	14.90		18772.0	58.00	.7348	43.6642
48	134.40	60.30	14.80		18828.0	56.89	.7375	43.7945
49	113.50	48.70	13.60		18578.0	45.28	.7849	43.2130
50	104.20	44.10	13.40		18386.0	40.11	.8054	42.7664
51	121.50	50.80	13.90		18571.0	49.72	.7759	43.1967
52	119.80	48.30	13.60		18536.0	48.78	.7866	43.1153
53	125.40	53.40	14.20		18680.0	51.89	.7650	43.4502
54	106.20	48.70	13.50		18493.0	41.22	.7849	43.0153
55	112.10	51.50	13.70		18570.0	44.50	.7729	43.1944
56	139.30	55.80	14.60		18772.0	59.61	.7552	43.6642
57	80.60	51.20	12.90		18400.0	27.00	.7742	42.7990
58	139.10	56.90	14.70		18758.0	59.50	.7508	43.6317
59	106.70	53.80	13.70		18607.0	41.50	.7633	43.2804
60	117.10	38.80	13.40		18399.0	47.28	.8305	42.7966
61	141.30	56.00	14.60		18790.0	60.72	.7544	43.7061
62	120.70	51.20	13.90		18605.0	49.28	.7742	43.2758
63	134.60	56.20	14.50		18683.0	57.00	.7536	43.4572
64	90.70	50.20	13.00		18369.0	32.61	.7784	42.7269
65	128.70	55.20	14.20		18681.0	53.72	.7576	43.4526
66	125.20	56.00	14.20		18717.0	51.78	.7544	43.5363
67	129.00	58.20	14.50		18778.0	53.89	.7456	43.6782
68	95.70	47.20	13.00		18397.0	35.39	.7915	42.7920
69	94.60	47.20	12.90		18398.0	34.78	.7915	42.7943
70	110.10	56.30	13.60		18543.0	43.39	.7532	43.1316
71	164.30	64.00	15.30		19014.0	73.50	.7236	44.2271
72	91.80	40.20	12.40		18230.0	33.22	.8237	42.4035

TABLE 2 (continued)

AVIATION GASOLINE ANF-28 REF 2

NO	A/(°F)	G/(° API)	H	S	Q/(Btu/lb)	A/(° C)	D/(g·cm^{-3})	Q/(MJ/kg)
MIN	100.40	59.30			18558.0	38.00	.7077	43.1665
MAX	146.50	68.40			18963.0	63.61	.7414	44.1085
MEAN	120.36	63.81			18750.1	49.09	.7243	43.6132
73	121.30	64.80	14.80		18771.0	49.61	.7206	43.6619
74	136.40	66.80	15.20		18863.0	58.00	.7134	43.8759
75	123.80	65.10	14.80		18802.0	51.00	.7195	43.7340
76	146.50	67.70	15.70		18963.0	63.61	.7101	44.1085
77	135.00	65.70	15.10		18876.0	57.22	.7173	43.9061
78	122.80	60.50	14.70		18736.0	50.44	.7367	43.5805
79	108.30	60.70	14.30		18608.0	42.39	.7360	43.2828
80	131.50	68.00	14.90		18888.0	55.28	.7091	43.9341
81	127.20	65.00	14.90		18832.0	52.89	.7199	43.8038
82	132.80	66.20	15.20		18854.0	56.00	.7155	43.8550
83	126.10	65.90	14.80		18841.0	52.28	.7166	43.8247
84	130.60	67.40	15.00		18829.0	54.78	.7112	43.7968
85	127.00	65.70	14.90		18811.0	52.78	.7173	43.7550
86	132.30	63.20	14.70		18850.0	55.72	.7265	43.8457
87	120.00	64.60	14.60		18717.0	48.89	.7214	43.5363
88	115.20	63.30	14.20		18704.0	46.22	.7262	43.5061
89	127.80	63.80	14.70		18830.0	53.22	.7243	43.7992
90	142.30	67.80	15.50		18941.0	61.28	.7098	44.0573
91	127.40	64.40	15.00		18803.0	53.00	.7221	43.7363
92	119.70	62.70	14.30		18788.0	48.72	.7284	43.7015
93	127.20	64.70	14.60		18813.0	52.89	.7210	43.7596
94	119.30	63.80	14.50		18729.0	48.50	.7243	43.5642
95	115.90	63.60	14.50		18674.0	46.61	.7250	43.4363
96	121.60	63.10	14.60		18709.0	49.78	.7269	43.5177
97	120.90	64.50	14.70		18794.0	49.39	.7217	43.7154
98	120.90	64.30	14.50		18760.0	49.39	.7225	43.6363
99	113.00	61.80	14.60		18667.0	45.00	.7318	43.4200
100	127.00	64.10	14.60		18764.0	52.78	.7232	43.6456
101	118.20	62.40	14.80		18708.0	47.89	.7295	43.5154
102	139.30	68.40	15.30		18920.0	59.61	.7077	44.0085
103	102.90	59.30	14.00		18558.0	39.39	.7414	43.1665

TABLE 2 (continued)

AVIATION GASOLINE ANF-28 (continued)

104	111.90	62.70	18690.0	44.39	.7284	43.4735
105	116.10	63.40	18660.0	46.72	.7258	43.4037
106	109.90	63.60	18693.0	43.28	.7250	43.4805
107	128.90	66.00	18817.0	53.83	.7163	43.7689
108	118.00	63.50	18720.0	47.78	.7254	43.5433
109	120.40	64.20	18762.0	49.11	.7228	43.6410
110	120.70	63.90	18735.0	49.28	.7239	43.5782
111	100.40	59.90	18587.0	38.00	.7390	43.2339
112	121.80	63.60	18748.0	49.89	.7250	43.6084
113	131.20	65.90	18832.0	55.11	.7166	43.8038
114	116.20	63.90	18739.0	46.78	.7239	43.5875
115	109.80	61.30	18667.0	43.22	.7337	43.4200
116	126.50	66.20	18815.0	52.50	.7155	43.7643
117	113.50	63.20	18710.0	45.28	.7265	43.5200
118	127.20	65.10	18828.0	52.89	.7195	43.7945
119	111.20	61.30	18671.0	44.00	.7337	43.4293
120	109.90	62.10	18654.0	43.28	.7307	43.3898
121	110.10	61.20	18663.0	43.39	.7341	43.4107
122	105.10	60.60	18637.0	40.61	.7363	43.3502
123	122.20	64.70	18761.0	50.11	.7210	43.6387
124	108.10	61.40	18652.0	42.28	.7333	43.3851
125	111.90	63.00	18683.0	44.39	.7273	43.4572
126	110.80	62.50	18670.0	43.78	.7291	43.4270
127	111.40	62.70	18674.0	44.11	.7284	43.4363
128	106.00	61.10	18685.0	41.11	.7344	43.4619
129	101.10	60.90	18597.0	38.39	.7352	43.2572

TABLE 2 (continued)

FUEL JP-4 REF 4

NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	$D/(g \cdot cm^{-3})$	Q/(MJ/kg)
MIN	108.50	40.10	13.30	.013	18468.0	42.50	.7596	42.9571
MAX	138.90	54.70	14.70	.372	18766.0	59.39	.8242	43.6503
MEAN	126.74	49.33	14.03	.139	18619.4	52.63	.7822	43.3092
130	130.50	54.70	14.70	.013	18727.0	54.72	.7596	43.5596
131	129.70	45.20	14.00	.171	18538.0	54.28	.8004	43.1200
132	126.10	53.50	14.30	.115	18683.0	52.28	.7646	43.4572
133	135.00	52.90	14.40	.122	18721.0	57.22	.7670	43.5456
134	138.90	53.40	14.50	.045	18766.0	59.39	.7650	43.6503
135	136.90	54.70	14.50	.109	18760.0	58.28	.7596	43.6363
136	129.00	50.20	14.10	.092	18635.0	53.89	.7784	43.3456
137	108.50	48.90	13.60	.235	18544.0	42.50	.7840	43.1339
138	129.20	45.00	13.90	.207	18550.0	54.00	.8013	43.1479
139	116.10	46.50	13.80	.372	18516.0	46.72	.7946	43.0688
140	128.50	40.10	13.50	.132	18471.0	53.61	.8242	42.9641
141	125.80	47.00	13.90	.164	18598.0	52.11	.7924	43.2595
142	136.00	51.30	14.30	.064	18707.0	57.78	.7738	43.5131
143	134.40	52.60	14.20	.103	18696.0	56.89	.7683	43.4875
144	121.10	49.90	13.90	.110	18602.0	49.50	.7797	43.2688
145	112.60	44.40	13.30	.224	18468.0	44.78	.8041	42.9571
146	116.20	48.30	13.60	.085	18547.0	46.78	.7866	43.1409

FUEL JP-5 REF4

NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	$D/(g \cdot cm^{-3})$	Q/(MJ/kg)
MIN	120.90	31.80	12.70	.026	18288.0	49.39	.8091	42.5384
MAX	150.80	43.30	14.00	.447	18595.0	66.00	.8660	43.2525
MEAN	134.61	37.15	13.35	.120	18428.1	57.01	.8386	42.8643
147	129.90	33.80	13.20	.106	18377.0	54.39	.8556	42.7455
148	144.10	43.30	14.00	.125	18579.0	62.28	.8091	43.2153
149	128.80	34.30	12.70	.088	18288.0	53.78	.8530	42.5384
150	148.50	43.00	14.00	.112	18572.0	64.72	.8105	43.1990
151	120.90	36.20	13.30	.026	18393.0	49.39	.8433	42.7827
152	127.60	31.80	12.90	.072	18300.0	53.11	.8660	42.5664
153	139.80	38.30	13.40	.048	18469.0	59.89	.8329	42.9595
154	131.40	36.90	13.20	.068	18430.0	55.22	.8398	42.8687
155	128.10	36.80	13.30	.447	18365.0	53.39	.8403	42.7175
156	130.80	32.00	13.10	.154	18341.0	54.89	.8650	42.6617
157	150.80	42.20	13.80	.076	18595.0	66.00	.8142	43.2525

TABLE 2 (continued)

KEROSINE							REF 5	
NO	A/(°F)	G/(°API)	H	S	Q/(Btu/lb)	A/(°C)	D/(g·cm^{-3})	Q/(MJ/kg)
MIN	116.76	35.70	12.89	0.000	18370.0	47.09	.7581	42.7292
MAX	173.46	55.09	14.90	.960	18861.0	78.59	.8459	43.8713
MEAN	148.25	43.34	13.85	.086	18616.3	64.58	.8089	43.3020
158	159.27	44.21	13.96	.030	18640.0	70.71	.8049	43.3572
159	145.27	43.81	13.88	.040	18611.0	62.93	.8068	43.2898
160	148.17	41.09	13.62	.050	18575.0	64.54	.8195	43.2060
161	152.67	40.57	13.70	.040	18574.0	67.04	.8219	43.2037
162	150.60	41.30	13.67	.040	18557.0	65.89	.8185	43.1641
163	150.42	43.82	13.98	.120	18639.0	65.79	.8067	43.3549
164	135.90	39.05	13.19	.030	18461.0	57.72	.8293	42.9408
165	136.47	38.36	13.27	.960	18441.0	58.04	.8326	42.8943
166	151.86	42.72	13.86	.060	18621.0	66.59	.8118	43.3130
167	157.62	43.17	14.01	.040	18639.0	69.79	.8097	43.3549
168	153.90	42.76	13.98	0.000	18662.0	67.72	.8116	43.4084
169	162.00	43.46	14.00	0.000	18700.0	72.22	.8084	43.4968
170	156.78	43.06	14.12	.010	18679.0	69.32	.8102	43.4479
171	163.44	43.90	14.30	0.000	18720.0	73.02	.8064	43.5433
172	150.04	43.37	13.81	.030	18606.0	65.58	.8088	43.2781
173	150.19	44.54	13.78	.040	18646.0	65.66	.8034	43.3712
174	150.55	42.16	13.78	.120	18610.0	65.86	.8144	43.2874
175	156.56	43.80	14.17	.030	18679.0	69.20	.8068	43.4479
176	148.93	43.50	13.93	.050	18624.0	64.96	.8082	43.3200
177	150.40	43.03	13.82	.050	18605.0	65.78	.8104	43.2758
178	148.93	42.53	13.69	.070	18589.0	64.96	.8127	43.2386
179	146.66	42.55	13.76	.100	18590.0	63.70	.8126	43.2409
180	145.76	45.43	14.04	.040	18614.0	63.20	.7994	43.2967
181	153.26	45.28	14.06	.040	18658.0	67.37	.8001	43.3991
182	150.62	42.19	13.79	.090	18609.0	65.90	.8143	43.2851
183	152.42	44.22	13.94	.060	18627.0	66.90	.8049	43.3270
184	153.01	45.74	14.14	.070	18662.0	67.23	.7980	43.4084
185	157.53	45.47	14.30	.120	18711.0	69.74	.7992	43.5224
186	165.63	47.05	14.61	.010	18781.0	74.24	.7921	43.6852
187	164.19	44.53	14.38	.010	18724.0	73.44	.8035	43.5526
188	151.70	55.09	14.89	.170	18783.0	66.50	.7581	43.6898
189	144.91	45.29	14.01	.080	18635.0	62.73	.8000	43.3456
190	150.69	43.22	13.85	.060	18635.0	65.94	.8095	43.3456
191	149.52	43.70	13.93	.040	18625.0	65.29	.8073	43.3223
192	148.62	41.98	13.74	.030	18588.0	64.79	.8153	43.2363
193	152.67	43.80	13.98	.060	18655.0	67.04	.8068	43.3921
194	142.45	42.30	13.69	.020	18578.0	61.36	.8138	43.2130
195	151.32	43.00	13.89	.060	18624.0	66.29	.8105	43.3200
196	147.18	41.30	13.63	.090	18575.0	63.99	.8185	43.2060
197	156.00	43.55	14.06	.070	18663.0	68.89	.8080	43.4107
198	148.98	44.12	13.99	.050	18655.0	64.99	.8053	43.3921

TABLE 2 (continued)

KEROSINE (continued)

199	166.93	45.90	14.26	.010	18782.0	74.96	.7973	43.6875
200	141.96	41.70	13.55	.050	18546.0	61.09	.8166	43.1386
201	135.48	43.23	13.61	.080	18550.0	57.49	.8094	43.1479
202	133.88	38.27	13.16	.100	18479.0	56.60	.8331	42.9827
203	124.34	47.32	13.44	.070	18623.0	51.30	.7909	43.3177
204	128.66	40.10	13.07	.130	18465.0	53.70	.8242	42.9502
205	157.84	42.70	14.03	0.000	18670.0	69.91	.8119	43.4270
206	147.90	41.80	13.60	.050	18566.0	64.39	.8161	43.1851
207	145.74	43.42	13.81	.060	18608.0	63.19	.8086	43.2828
208	149.10	43.54	13.73	.080	18624.0	65.06	.8080	43.3200
209	160.00	43.76	14.24	0.000	18691.0	71.11	.8070	43.4758
210	149.16	43.50	13.84	.110	18618.0	65.09	.8082	43.3060
211	146.22	41.65	13.65	.070	18580.0	63.46	.8168	43.2176
212	127.06	37.82	13.07	.020	18445.0	52.81	.8353	42.9036
213	148.20	43.75	13.91	.120	18628.0	64.56	.8070	43.3293
214	144.61	41.32	13.59	.040	18563.0	62.56	.8184	43.1781
215	145.15	43.75	13.84	.010	18619.0	62.86	.8070	43.3084
216	144.43	41.35	13.73	.030	18500.0	62.46	.8182	43.0316
217	144.52	42.57	13.75	.040	18582.0	62.51	.8125	43.2223
218	129.40	35.70	12.95	.340	18410.0	54.11	.8459	42.8222
219	136.60	38.79	13.26	.100	18472.0	58.11	.8305	42.9664
220	145.54	43.19	13.84	.090	18606.0	63.08	.8096	43.2781
221	151.39	39.90	13.40	.460	18523.0	66.33	.8252	43.0851
222	161.65	49.59	14.53	.020	18766.0	72.03	.7810	43.6503
223	160.39	51.44	14.00	.010	18808.0	71.33	.7732	43.7480
224	141.35	41.17	13.61	.120	18561.0	60.75	.8191	43.1734
225	125.69	36.97	13.06	.270	18388.0	52.05	.8395	42.7710
226	145.85	43.78	13.64	.130	18621.0	63.25	.8069	43.3130
227	139.37	41.41	13.53	.050	18548.0	59.65	.8180	43.1432
228	142.72	43.10	13.79	.010	18621.0	61.51	.8100	43.3130
229	145.00	43.10	13.77	.080	18603.0	62.78	.8100	43.2711
230	149.86	42.65	12.89	.040	18584.0	65.48	.8121	43.2269
231	145.72	45.20	13.87	.100	18620.0	63.18	.8004	43.3107
232	147.97	43.83	13.89	.040	18617.0	64.43	.8067	43.3037
233	146.61	43.62	13.73	.200	18610.0	63.67	.8076	43.2874
234	149.85	44.90	14.02	.060	18647.0	65.47	.8018	43.3735
235	148.84	44.31	14.04	.060	18660.0	64.91	.8045	43.4037
236	148.66	42.96	13.81	.120	18593.0	64.81	.8107	43.2479
237	148.93	42.64	13.82	.100	18604.0	64.96	.8122	43.2735
238	149.13	42.64	13.83	.190	18609.0	65.07	.8122	43.2851
239	129.33	41.82	13.39	.050	18486.0	54.07	.8160	42.9990
240	146.05	43.03	13.82	.050	18590.0	63.36	.8104	43.2409
241	151.65	43.25	13.87	.130	18621.0	66.47	.8093	43.3130
242	144.61	41.36	13.70	.050	18581.0	62.56	.8182	43.2200
243	163.69	44.20	14.34	.010	18725.0	73.16	.8050	43.5549
244	139.77	47.40	14.01	.140	18640.0	59.87	.7906	43.3572
245	146.43	45.90	13.96	.180	18638.0	63.57	.7973	43.3526
246	146.77	46.83	13.85	.230	18686.0	63.76	.7931	43.4642
247	140.47	48.05	14.11	.210	18668.0	60.26	.7877	43.4223
248	119.07	39.97	13.40	.030	18511.0	48.37	.8248	43.0571

TABLE 2 (continued)

KEROSINE (continued)

249	158.16	45.38	14.29	.120	18703.0	70.09	.7996	43.5037
250	138.09	42.53	13.60	.280	18547.0	58.94	.8127	43.1409
251	152.58	43.21	13.92	.040	18619.0	66.99	.8095	43.3084
252	154.38	50.55	14.80	.010	18795.0	67.99	.7769	43.7177
253	173.46	50.62	14.90	.080	18861.0	78.59	.7766	43.8713
254	158.95	44.68	14.30	.050	18716.0	70.53	.8028	43.5340
255	135.67	40.03	13.50	.340	18477.0	57.59	.8245	42.9781
256	146.07	42.06	13.80	.050	18566.0	63.37	.8149	43.1851
257	152.36	44.88	14.10	.020	18652.0	66.87	.8019	43.3851
258	157.77	46.40	14.40	.040	18685.0	69.87	.7950	43.4619
259	149.34	43.37	13.90	.040	18618.0	65.19	.8088	43.3060
260	131.70	39.94	13.40	.120	18484.0	55.39	.8250	42.9943
261	116.76	37.80	13.00	.130	18370.0	47.09	.8354	42.7292
262	158.94	42.09	13.90	.020	18666.0	70.52	.8148	43.4177
263	159.84	44.18	14.20	.020	18709.0	71.02	.8051	43.5177
264	159.47	44.20	14.20	.020	18732.0	70.82	.8050	43.5712
265	155.32	44.71	14.11	.090	18674.0	68.51	.8027	43.4363
266	148.12	43.62	14.01	.140	18600.0	64.51	.8076	43.2642
267	157.66	43.14	14.27	.010	18691.0	69.81	.8099	43.4758

3. Equations for Predicting Net Enthalpy of Combustion

Some previously developed equations for predicting net heat of combustion are given in table 1. All but one of these are in the form of equation (1). The input to these equations are aniline point in °F and gravity in °API. Converting equation (1) to use aniline point in °C and relative density in place of gravity by use of equations (8) and (9) gives

$$Q' = (Q - B(6)*S)/(1 - .01*S) = B(0) + B(1)(-4208 - 236.7A + \frac{4528}{g} + 254.7\frac{A}{g}) \qquad (12)$$

This equation contains linear terms in A and 1/g and a quadratic, A/g, term.

The full quadratic equation, (13), in A and 1/D with seven adjustable parameters has been chosen as the most general to be considered.

$$Q' = (Q - B(6)*S)/(1 - .01*S) = B(0) + B(1)\,A + B(2) \times 1/D + B(3) \times A/D + B(4) \times A^2 + B(5) \times (1/D)^2. \qquad (13)$$

Variations of this equation were obtained by:

1. Setting B(6) = 43.7(Btu/lb);
2. Setting the (1 - .01*S) factor = 1;
3. Setting B(6) = 0 and (1 - .01*S) = 1 (no sulfur correction);
4. Setting the coefficient B(1) through B(5) to 0 singly or in combinations of 2, 3, or 4.

Equation (13) and the variations obtained by combining each of 1., 2., and 3. with those obtained in 4. were used to fit the experimental data on each fuel type, each class of fuel, and on all fuels, by a least squares procedure. The results of these fits were examined by an analysis of variance to find the simplest equation that would adequately fit the data. The results of this analysis lead to some conclusions and recommendations.

First consider the sulfur correction as included in the left side of equation (13) and its variations

$$Q' = (Q - B(6)*S)/(1 - .01*S) \quad (14)$$

or

$$Q' = (Q - 43.7*S)/(1 - .01*S) \text{ Btu/lb} \quad (15)$$

or

$$Q' = Q + B(6)*S \quad (16)$$

or

$$Q' = Q \text{ (no sulfur correction)} \quad (17)$$

All the data were used to fit these variations of equations (13). The results are shown in table 3. The variations are shown in order of goodness of fit. SS is the sum of squares of deviations. SD is the estimate of standard deviation.

Table 3. Comparison of sulfur corrections

Fuel class: All; No. of pts: 267

Eqn.	SS $(Btu/lb)^2$	SD(Q) (Btu/lb)	B(6) (Btu/lb)	SD(B(6)) (Btu/lb)
14	168974	25.5	134.6	20.0
16	169004	25.5	50.4	20.1
17	173111	25.8	--	--
15	182689	26.5	43.7	--

It is seen that a value of 135 for B(6) in eq. 14 gives significantly better fit than the value of 43.7 previously used. Further there is no improvement by including the factor (1 - .01*S). The recommended sulfur correction is, therefore, eqn. (16) with a value of 50 Btu/lb for B(6) which gives equations (18) and (19).

$$Q' = Q + 50*S \text{ Btu/lb} \tag{18}$$

$$Q' = Q + 0.1163*S \text{ MJ/kg} \tag{19}$$

This sulfur correction is purely empirical and derived from the low sulfur fuels considered here. It may not apply either in value or form to other fuels, particularly those with high sulfur content.

Now considering the terms on the right side of eqn. (13) the results of the analysis of variance are shown in table 4 and it is found that within each of four of the five classes of fuels the fit is not improved by using more than three terms. One term must contain A and one 1/D. The linear equation

$$Q' = B(0) + B(1)*A + B(2)*1/D \tag{20}$$

fits all classes except kerosine as well as any other variation. For kerosine addition of quadratic terms gives a significant improvement in fit.

The linear equations for each of the classes of fuel are given in table 5. Table 6 and 7 give values of Q' calculated from the equations in table 5.

All the data in table 2 were combined, corrected for sulfur by eqn. (18) and fitted to the quadratic equation (21). Values of the coefficients are given in table 8. Tables 9 and 10 give values of Q' calculated from equation (21) and table 8.

$$Q' = B(0) + B(1)*A + B(2)*(1/D) + B(3)*(A/D) + B(4)*A^2 + B(5)*(1/D^2) \tag{21}$$

Table 4. Analysis of Variance

Equation:

$$Q' = B(0) + B(1)X(1) + B(2)X(2) + B(3)X(3) + B(4)X(4) + B(5)X(5)$$

No*	X(1)	X(2)	X(3)	X(4)	X(5)
1	A	1/D	A/D	A^2	$1/D^2$
2	A	1/D	A/D	A^2	
3	A	1/D	A/D	$1/D^2$	
4	A	1/D	A^2	$1/D^2$	
5	A	A/D	A^2	$1/D^2$	
6	1/D	A/D	A^2	$1/D^2$	
7	A	1/D	A/D		
8	A	1/D	A^2		
9	A	A/D	A^2		
10	1/D	A/D	A^2		
11	A	1/D	$1/D^2$		
12	A	A/D	$1/D^2$		
13	1/D	A/D	$1/D^2$		
14	A	A^2	$1/D^2$		
15	1/D	A^2	$1/D^2$		
16	A/D	A^2	$1/D^2$		
17	A	1/D			
18	A	A/D			
19	A	A^2			
20	A	$1/D^2$			
21	1/D	A/D			
22	1/D	A^2			
23	1/D	$1/D^2$			
24	A/D	A^2			
25	A/D	$1/D^2$			
26	A^2	$1/D^2$			
27	A				
28	1/D				
29	A/D				
30	A^2				
31	$1/D^2$				
32	A*G				
33	A*G				

Table 4 (continued)

Units of Q' are Btu/lb
Units of A are °C except in eqn. 33
Units of A are °F in eqn. 33
Units of D are g/cm^3
Units of G are °API

*Equation numbers here are not the same as those in the text. Equation 1 here corresponds to eqn. 21 in the text. Equation 17 here corresponds to eqn. 20 in the text. Equation 33 here corresponds to eqn. 1 in the text.

Definitions:

No = eqn. number given above
PAR = number of adjustable parameters in equation
DF = degrees of freedom
SS = sum of squares of deviations
MS = mean square = SS/DF
DELDF = DF - DF(eqn 1)
DELSS = SS - SS(eqn 1)
DELMS = DELSS/DELDF
F = DELMS/MS(eqn 1)
F(.95) = critical value of F at 95% confidence level

Table 4 (continued)

FUEL: ALL; 267 PTS.

EQN	PAR	DF	SS	MS	DELDF	DELSS	DELMS	F	F(.95)
1	6	261	168173	644					
2	5	262	221394	845	1	53221	53221	82.6	3.9
3	5	262	170695	651	1	2522	2522	3.9	
4	5	262	184890	705	1	16717	16717	25.9	
5	5	262	243109	927	1	74936	74936	116.3	
6	5	262	169681	647	1	1508	1508	2.3	
7	4	263	221410	841	2	53237	26618	41.3	3.1
8	4	263	221394	841	2	53221	26610	41.3	
9	4	263	339829	1292	2	171656	85828	133.2	
10	4	263	227233	864	2	59060	29530	45.8	
11	4	263	185238	704	2	17065	8532	13.2	
12	4	263	243111	924	2	74938	37469	58.2	
13	4	263	173246	658	2	5073	2536	3.9	
14	4	263	243155	924	2	74982	37491	58.2	
15	4	263	214122	814	2	45949	22974	35.7	
16	4	263	247131	939	2	78958	39479	61.3	
17	3	264	221411	838	3	53238	17746	27.5	2.7
18	3	264	343231	1300	3	175057	58352	90.6	
19	3	264	5985312	22671	3	5817139	1939046	*3009.3	
20	3	264	243155	921	3	74982	24994	38.8	
21	3	264	227817	862	3	59644	19881	30.9	
22	3	264	244227	925	3	76054	25351	39.3	
23	3	264	2294979	8693	3	2126806	708935	*1100.2	
24	3	264	527394	1997	3	359221	119740	185.8	
25	3	264	247475	937	3	79302	26434	41.0	
26	3	264	264244	1000	3	96071	32023	49.7	
27	2	265	6013541	22692	4	5845368	1461342	*2268.0	2.4
28	2	265	2374336	8959	4	2206163	551540	856.0	
29	2	265	3539311	13355	4	3371138	842784	*1308.0	
30	2	265	5987512	22594	4	5819339	1454834	*2257.9	
31	2	265	2348819	8863	4	2180646	545161	846.1	
32	2	265	459990	1735	4	291817	72954	113.2	
33	2	265	295221	1114	4	127048	31762	49.3	

Table 4 (continued)

FUEL: GASØLINE 100/130, 115/145; 40 PTS.

EQN	PAR	DF	SS	MS	DELDF	DELSS	DELMS	F	F(.95)
1	6	34	18945	557					
2	5	35	19052	544	1	107	107	.2	4.1
3	5	35	19546	558	1	601	601	1.1	
4	5	35	19102	545	1	157	157	.3	
5	5	35	19039	543	1	93	93	.2	
6	5	35	19094	545	1	148	148	.3	
7	4	36	19813	550	2	868	434	.8	3.3
8	4	36	19128	531	2	182	91	.2	
9	4	36	19342	537	2	396	198	.4	
10	4	36	19116	531	2	171	85	.2	
11	4	36	20339	564	2	1394	697	1.3	
12	4	36	19799	549	2	853	426	.8	
13	4	36	20194	560	2	1248	624	1.1	
14	4	36	19138	531	2	193	96	.2	
15	4	36	19167	532	2	221	110	.2	
16	4	36	19128	531	2	182	91	.2	
17	3	37	20904	564	3	1958	652	1.2	2.9
18	3	37	20015	540	3	1069	356	.6	
19	3	37	26242	709	3	7297	2432	4.4	
20	3	37	20842	563	3	1896	632	1.1	
21	3	37	20516	554	3	1570	523	.9	
22	3	37	19167	518	3	221	73	.1	
23	3	37	74917	2024	3	55971	18657	33.5	
24	3	37	23298	629	3	4353	1451	2.6	
25	3	37	20485	553	3	1539	513	.9	
26	3	37	19167	518	3	221	73	.1	
27	2	38	29215	768	4	10269	2567	4.6	2.7
28	2	38	93043	2448	4	74097	18524	33.2	
29	2	38	23322	613	4	4376	1094	2.0	
30	2	38	26314	692	4	7368	1842	3.3	
31	2	38	94642	2490	4	75697	18924	34.0	
32	2	38	20016	526	4	1071	267	.5	
33	2	38	20478	538	4	1533	383	.7	

Table 4 (continued)

FUEL: ANF-28, ANF-58; 89 PTS

EQN	PAR	DF	SS	MS	DELDF	DELSS	DELMS	F	F(.95)
1	6	83	61311	738					
2	5	84	63269	753	1	1957	1957	2.7	4.0
3	5	84	61313	729	1	2	2	0.0	
4	5	84	61744	735	1	432	432	.6	
5	5	84	64667	769	1	3355	3355	4.5	
6	5	84	61373	730	1	61	61	.1	
7	4	85	64185	755	2	2874	1437	1.9	3.1
8	4	85	63607	748	2	2296	1148	1.6	
9	4	85	77476	911	2	16164	8082	10.9	
10	4	85	64627	760	2	3316	1658	2.2	
11	4	85	62433	734	2	1121	560	.8	
12	4	85	65748	773	2	4436	2218	3.0	
13	4	85	61439	722	2	127	63	.1	
14	4	85	65226	767	2	3914	1957	2.6	
15	4	85	66427	781	2	5115	2557	3.5	
16	4	85	66295	779	2	4983	2491	3.4	
17	3	86	64186	746	3	2874	958	1.3	2.7
18	3	86	81238	944	3	19926	6642	9.0	
19	3	86	547297	6363	3	485985	161995	219.3	
20	3	86	65752	764	3	4441	1480	2.0	
21	3	86	64921	754	3	3609	1203	1.6	
22	3	86	68534	796	3	7223	2407	3.3	
23	3	86	537414	6249	3	476102	158700	214.8	
24	3	86	126714	1473	3	65402	21800	29.5	
25	3	86	66544	773	3	5232	1744	2.4	
26	3	86	70297	817	3	8986	2995	4.1	
27	2	87	564902	6493	4	503590	125897	170.4	2.5
28	2	87	537724	6180	4	476412	119103	161.2	
29	2	87	317480	3649	4	256168	64042	86.7	
30	2	87	623453	7166	4	562142	140535	190.2	
31	2	87	537442	6177	4	476130	119032	161.1	
32	2	87	99783	1146	4	38471	9617	13.0	
33	2	87	73407	843	4	12095	3023	4.1	

Table 4 (continued)

FUEL: JP-4; 17 PTS.

EQN	PAR	DF	SS	MS	DELDF	DELSS	DELMS	F	F(.95))
1	6	11	1839	167					
2	5	12	1840	153	1	1	1	0.0	4.8
3	5	12	2234	186	1	394	394	2.4	
4	5	12	1841	153	1	2	2	0.0	
5	5	12	1859	154	1	20	20	.1	
6	5	12	1853	154	1	14	14	.1	
7	4	13	2238	172	2	399	199	1.2	4.0
8	4	13	1843	141	2	4	2	0.0	
9	4	13	2048	157	2	208	104	.6	
10	4	13	1853	142	2	14	7	0.0	
11	4	13	2394	184	2	554	277	1.7	
12	4	13	2241	172	2	402	201	1.2	
13	4	13	2344	180	2	505	252	1.5	
14	4	13	1861	143	2	21	10	.1	
15	4	13	2124	163	2	284	142	.9	
16	4	13	1876	144	2	36	18	.1	
17	3	14	2394	171	3	554	184	1.1	3.6
18	3	14	2251	160	3	412	137	.8	
19	3	14	55735	3981	3	53895	17965	107.4	
20	3	14	2403	171	3	564	188	1.1	
21	3	14	2345	167	3	505	168	1.0	
22	3	14	2125	151	3	285	95	.6	
23	3	14	16609	1186	3	14770	4923	29.4	
24	3	14	5537	395	3	3698	1232	7.4	
25	3	14	2354	168	3	515	171	1.0	
26	3	14	2140	152	3	300	100	.6	
27	2	15	68840	4589	4	67000	16750	100.2	3.4
28	2	15	21179	1411	4	19339	4834	28.9	
29	2	15	40931	2728	4	39091	9772	58.4	
30	2	15	65978	4398	4	64139	16034	95.9	
31	2	15	20603	1373	4	18764	4691	28.1	
32	2	15	8574	571	4	6734	1683	10.1	
33	2	15	4427	295	4	2587	646	3.9	

Table 4 (continued)

FUEL: JP-5; 11 PTS.

EQN	PAR	DF	SS	MS	DELDF	DELSS	DELMS	F	F(.95)
1	6	5	4606	921					
2	5	6	7004	1167	1	2398	2398	2.6	6.6
3	5	6	7527	1254	1	2921	2921	3.2	
4	5	6	7309	1218	1	2703	2703	2.9	
5	5	6	6652	1108	1	2045	2045	2.2	
6	5	6	7137	1189	1	2531	2531	2.7	
7	4	7	7618	1088	2	3012	1506	1.6	5.8
8	4	7	7315	1045	2	2709	1354	1.5	
9	4	7	7606	1086	2	2999	1499	1.6	
10	4	7	7177	1025	2	2570	1285	1.4	
11	4	7	7578	1082	2	2972	1486	1.6	
12	4	7	7592	1084	2	2986	1493	1.6	
13	4	7	7588	1084	2	2982	1491	1.6	
14	4	7	7310	1044	2	2703	1351	1.5	
15	4	7	7480	1068	2	2874	1437	1.6	
16	4	7	7147	1021	2	2540	1270	1.4	
17	3	8	7619	952	3	3012	1004	1.1	5.4
18	3	8	7716	964	3	3110	1036	1.1	
19	3	8	21072	2634	3	16466	5488	6.0	
20	3	8	7597	949	3	2991	997	1.1	
21	3	8	7619	952	3	3013	1004	1.1	
22	3	8	7505	938	3	2899	966	1.0	
23	3	8	9622	1202	3	5016	1672	1.8	
24	3	8	9260	1157	3	4654	1551	1.7	
25	3	8	7602	950	3	2996	998	1.1	
26	3	8	7490	936	3	2883	961	1.0	
27	2	9	27076	3008	4	22469	5617	6.1	5.2
28	2	9	11158	1239	4	6551	1637	1.8	
29	2	9	17912	1990	4	13306	3326	3.6	
30	2	9	25415	2823	4	20808	5202	5.6	
31	2	9	10910	1212	4	6304	1576	1.7	
32	2	9	8960	995	4	4353	1088	1.2	
33	2	9	8140	904	4	3534	883	1.0	

Table 4 (continued)

FUEL: KEROSINE; 110 PTS.

EQN	PAR	DF	SS	MS	DELDF	DELSS	DELMS	F	F(.95)
1	6	104	35338	339					
2	5	105	35763	340	1	425	425	1.3	4.0
3	5	105	43386	413	1	8047	8047	23.7	
4	5	105	36173	344	1	834	834	2.5	
5	5	105	36533	347	1	1195	1195	3.5	
6	5	105	35553	338	1	215	215	.6	
7	4	106	45488	429	2	10149	5074	14.9	3.1
8	4	106	39121	369	2	3783	1891	5.6	
9	4	106	45838	432	2	10500	5250	15.5	
10	4	106	37545	354	2	2207	1103	3.2	
11	4	106	45110	425	2	9772	4886	14.4	
12	4	106	45921	433	2	10583	5291	15.6	
13	4	106	44562	420	2	9224	4612	13.6	
14	4	106	39967	377	2	4628	2314	6.8	
15	4	106	40326	380	2	4988	2494	7.3	
16	4	106	38614	364	2	3276	1638	4.8	
17	3	107	45670	426	3	10331	3443	10.1	2.7
18	3	107	47549	444	3	12211	4070	12.0	
19	3	107	210359	1965	3	175020	58340	171.7	
20	3	107	46100	430	3	10762	3587	10.6	
21	3	107	45497	425	3	10159	3386	10.0	
22	3	107	41403	386	3	6065	2021	5.9	
23	3	107	165431	1546	3	130093	43364	127.6	
24	3	107	78063	729	3	42725	14241	41.9	
25	3	107	45936	429	3	10598	3532	10.4	
26	3	107	41979	392	3	6641	2213	6.5	
27	2	108	219784	2035	4	184446	46111	135.7	2.5
28	2	108	195794	1812	4	160455	40113	118.1	
29	2	108	140631	1302	4	105292	26323	77.5	
30	2	108	212306	1965	4	176968	44242	130.2	
31	2	108	200480	1856	4	165142	41285	121.5	
32	2	108	52571	486	4	17233	4308	12.7	
33	2	108	46873	434	4	11535	2883	8.5	

TABLE 5. LINEAR EQUATIONS

$Q' = B(0) + B(1)*A + B(2)*(1/D)$

UNITS OF A ARE ^{o}C.
UNITS OF D ARE $g \cdot cm^{-1}$.
FOR Q' IN Btu/lb USE B PARAMETERS.
FOR Q' IN MJ/kg USE C PARAMETERS.

GASOLINE 100/130 AND 115/145

N= 40

	PARAMETERS	STD DEV
B(0)	15908.1	546.499
B(1)	11.2799	.998234
B(2)	1627.07	424.217
C(0)	37.0028	1.27117
C(1)	2.62373E-2	2.32192E-3
C(2)	3.78461	.98674

STD DEV= 23.7692 Btu/lb = 5.52879E-2 MJ/kg
MAX DEV= 46.928 .109156

ANF-28 AND ANF-58 (JP3)

N= 89

	PARAMETERS	STD DEV
B(0)	15750.3	85.6108
B(1)	10.8968	.432609
B(2)	1786.26	68.9638
C(0)	36.6358	.199133
C(1)	2.53463E-2	1.00626E-3
C(2)	4.15489	.160412

STD DEV= 27.3195 Btu/lb = .063546 MJ/kg
MAX DEV= 69.0038 .160505

Table 5 (continued)

JP-4

N= 17

PARAMETERS		STD DEV
B(0)	15084.6	145.538
B(1)	7.71892	.736492
B(2)	2452.45	124.418
C(0)	35.0873	.338526
C(1)	1.79545E-2	1.71310E-3
C(2)	5.70447	.2894

STD DEV= 13.0773 Btu/lb = 3.04182E-2 MJ/kg
MAX DEV= 24.2408 5.63849E-2

JP-5

N= 11

PARAMETERS		STD DEV
B(0)	14921.4	556.939
B(1)	6.21346	3.2234
B(2)	2648.77	586.03
C(0)	34.7076	1.29546
C(1)	1.44527E-2	7.49774E-3
C(2)	6.16112	1.36312

STD DEV= 30.8611 Btu/lb = 7.17838E-2 MJ/kg
MAX DEV=-68.4062 -.159115

KEROSINE

N= 110

PARAMETERS		STD DEV
B(0)	15107.5	134.22
B(1)	8.1416	.43412
B(2)	2416.48	119.644
C(0)	35.1405	.3122
C(1)	1.89376E-2	1.00978E-3
C(2)	5.6208	.278295

STD DEV= 20.6597 Btu/lb = 4.80552E-2 MJ/kg
MAX DEV= 81.4428 .189438

TABLE 6. NET ENTHALPY OF COMBUSTION

GASOLINE 100/130 AND 115/145

Q'/(Btu /lb)

D/(g/cm ^{3})	A/(°C) 20	30	40	50	60	70	80
.6500	18636.9	18749.7	18862.5	18975.3	19088.1	19200.9	19313.7
.6600	18599.0	18711.8	18824.6	18937.4	19050.2	19163.0	19275.7
.6700	18562.2	18675.0	18787.8	18900.6	19013.4	19126.2	19239.0
.6800	18526.4	18639.2	18752.0	18864.8	18977.6	19090.4	19203.2
.6900	18491.8	18604.6	18717.4	18830.2	18943.0	19055.8	19168.6
.7000	18458.1	18570.9	18683.7	18796.5	18909.3	19022.1	19134.9
.7100	18425.3	18538.1	18650.9	18763.7	18876.5	18989.3	19102.1
.7200	18393.5	18506.3	18619.1	18731.9	18844.7	18957.5	19070.3
.7300	18362.6	18475.4	18588.2	18701.0	18813.8	18926.6	19039.4
.7400	18332.4	18445.2	18558.0	18670.8	18783.6	18896.4	19009.2
.7500	18303.1	18415.9	18528.7	18641.5	18754.3	18867.1	18979.9
.7600	18274.6	18387.4	18500.2	18613.0	18725.8	18838.6	18951.4
.7700	18246.8	18359.6	18472.4	18585.2	18698.0	18810.8	18923.6
.7800	18219.7	18332.5	18445.3	18558.1	18670.9	18783.7	18896.5
.7900	18193.3	18306.1	18418.9	18531.7	18644.5	18757.3	18870.1
.8000	18167.5	18280.3	18393.1	18505.9	18618.7	18731.5	18844.3
.8100	18142.4	18255.2	18368.0	18480.8	18593.6	18706.4	18819.2
.8200	18117.9	18230.7	18343.5	18456.3	18569.1	18681.9	18794.7
.8300	18094.0	18206.8	18319.6	18432.4	18545.2	18658.0	18770.8
.8400	18070.7	18183.5	18296.3	18409.1	18521.9	18634.7	18747.5
.8500	18047.9	18160.7	18273.5	18386.3	18499.1	18611.9	18724.7
.8600	18025.6	18138.4	18251.2	18364.0	18476.8	18589.6	18702.4
.8700	18003.9	18116.7	18229.5	18342.3	18455.1	18567.9	18680.7
.8800	17982.6	18095.4	18208.2	18321.0	18433.8	18546.6	18659.4
.8900	17961.9	18074.7	18187.5	18300.3	18413.1	18525.9	18638.7

Table 6 (continued)

ANF-28 AND ANF-58 (JP3)

Q'/(Btu/lb)

D/(g/cm³)	A/(°C) 20	30	40	50	60	70	80
.6500	18716.3	18825.3	18934.3	19043.2	19152.2	19261.2	19370.1
.6600	18674.7	18783.7	18892.6	19001.6	19110.6	19219.5	19328.5
.6700	18634.3	18743.3	18852.2	18961.2	19070.2	19179.1	19288.1
.6800	18595.1	18704.1	18813.0	18922.0	19031.0	19139.9	19248.9
.6900	18557.0	18666.0	18775.0	18883.9	18992.9	19101.9	19210.8
.7000	18520.0	18629.0	18738.0	18846.9	18955.9	19064.9	19173.8
.7100	18484.1	18593.1	18702.0	18811.0	18920.0	19028.9	19137.9
.7200	18449.2	18558.1	18667.1	18776.1	18885.0	18994.0	19103.0
.7300	18415.2	18524.1	18633.1	18742.1	18851.0	18960.0	19069.0
.7400	18382.1	18491.1	18600.0	18709.0	18818.0	18926.9	19035.9
.7500	18349.9	18458.9	18567.9	18676.8	18785.8	18894.8	19003.7
.7600	18318.6	18427.5	18536.5	18645.5	18754.5	18863.4	18972.4
.7700	18288.1	18397.0	18506.0	18615.0	18723.9	18832.9	18941.9
.7800	18258.3	18367.3	18476.2	18585.2	18694.2	18803.2	18912.1
.7900	18229.3	18338.3	18447.3	18556.2	18665.2	18774.2	18883.1
.8000	18201.1	18310.0	18419.0	18528.0	18636.9	18745.9	18854.9
.8100	18173.5	18282.5	18391.4	18500.4	18609.4	18718.3	18827.3
.8200	18146.6	18255.6	18364.5	18473.5	18582.5	18691.4	18800.4
.8300	18120.4	18229.3	18338.3	18447.3	18556.2	18665.2	18774.2
.8400	18094.7	18203.7	18312.7	18421.6	18530.6	18639.6	18748.5
.8500	18069.7	18178.7	18287.7	18396.6	18505.6	18614.6	18723.5
.8600	18045.3	18154.3	18263.2	18372.2	18481.2	18590.1	18699.1
.8700	18021.4	18130.4	18239.3	18348.3	18457.3	18566.2	18675.2
.8800	17998.1	18107.0	18216.0	18325.0	18433.9	18542.9	18651.9
.8900	17975.3	18084.2	18193.2	18302.2	18411.1	18520.1	18629.1

Table 6 (continued)

JP-4

Q'/(Btu/lb)

D/(g/cm3)	A/(°C) 20	30	40	50	60	70	80
.6500	19012.0	19089.2	19166.4	19243.5	19320.7	19397.9	19475.1
.6600	18954.8	19032.0	19109.2	19186.4	19263.6	19340.8	19417.9
.6700	18899.4	18976.5	19053.7	19130.9	19208.1	19285.3	19362.5
.6800	18845.5	18922.7	18999.9	19077.1	19154.3	19231.5	19308.7
.6900	18793.3	18870.4	18947.6	19024.8	19102.0	19179.2	19256.4
.7000	18742.5	18819.7	18896.9	18974.0	19051.2	19128.4	19205.6
.7100	18693.1	18770.3	18847.5	18924.7	19001.9	19079.1	19156.3
.7200	18645.2	18722.3	18799.5	18876.7	18953.9	19031.1	19108.3
.7300	18598.5	18675.7	18752.9	18830.1	18907.3	18984.4	19061.6
.7400	18553.1	18630.3	18707.5	18784.7	18861.9	18939.0	19016.2
.7500	18508.9	18586.1	18663.3	18740.5	18817.7	18894.9	18972.0
.7600	18465.9	18543.1	18620.3	18697.5	18774.6	18851.8	18929.0
.7700	18424.0	18501.2	18578.4	18655.5	18732.7	18809.9	18887.1
.7800	18383.1	18460.3	18537.5	18614.7	18691.9	18769.1	18846.3
.7900	18343.3	18420.5	18497.7	18574.9	18652.1	18729.3	18806.5
.8000	18304.5	18381.7	18458.9	18536.1	18613.3	18690.5	18767.7
.8100	18266.7	18343.9	18421.1	18498.3	18575.5	18652.6	18729.8
.8200	18229.8	18307.0	18384.1	18461.3	18538.5	18615.7	18692.9
.8300	18193.7	18270.9	18348.1	18425.3	18502.5	18579.7	18656.9
.8400	18158.6	18235.8	18312.9	18390.1	18467.3	18544.5	18621.7
.8500	18124.2	18201.4	18278.6	18355.8	18433.0	18510.2	18587.3
.8600	18090.7	18167.9	18245.0	18322.2	18399.4	18476.6	18553.8
.8700	18057.9	18135.1	18212.3	18289.5	18366.6	18443.8	18521.0
.8800	18025.9	18103.0	18180.2	18257.4	18334.6	18411.8	18489.0
.8900	17994.5	18071.7	18148.9	18226.1	18303.3	18380.5	18457.7

Table 6 (continued)

JP-5

D/(g/cm³)	Q'/(Btu/lb) A/(°C) 20	30	40	50	60	70	80
.6500	19120.7	19182.8	19245.0	19307.1	19369.2	19431.4	19493.5
.6600	19059.0	19121.1	19183.2	19245.4	19307.5	19369.6	19431.8
.6700	18999.1	19061.2	19123.3	19185.5	19247.6	19309.7	19371.9
.6800	18940.9	19003.1	19065.2	19127.3	19189.5	19251.6	19313.7
.6900	18884.5	18946.6	19008.7	19070.9	19133.0	19195.1	19257.3
.7000	18829.6	18891.8	18953.9	19016.0	19078.2	19140.3	19202.4
.7100	18776.3	18838.5	18900.6	18962.7	19024.9	19087.0	19149.1
.7200	18724.5	18786.7	18848.8	18910.9	18973.1	19035.2	19097.3
.7300	18674.1	18736.3	18798.4	18860.5	18922.7	18984.8	19046.9
.7400	18625.1	18687.2	18749.4	18811.5	18873.6	18935.8	18997.9
.7500	18577.4	18639.5	18701.6	18763.8	18825.9	18888.0	18950.2
.7600	18530.9	18593.0	18655.2	18717.3	18779.4	18841.6	18903.7
.7700	18485.6	18547.8	18609.9	18672.0	18734.2	18796.3	18858.4
.7800	18441.5	18503.7	18565.8	18627.9	18690.1	18752.2	18814.3
.7900	18398.5	18460.7	18522.8	18584.9	18647.1	18709.2	18771.4
.8000	18356.6	18418.8	18480.9	18543.0	18605.2	18667.3	18729.4
.8100	18315.8	18377.9	18440.0	18502.2	18564.3	18626.4	18688.6
.8200	18275.9	18338.0	18400.1	18462.3	18524.4	18586.5	18648.7
.8300	18237.0	18299.1	18361.2	18423.4	18485.5	18547.6	18609.8
.8400	18199.0	18261.1	18323.2	18385.4	18447.5	18509.6	18571.8
.8500	18161.9	18224.0	18286.1	18348.3	18410.4	18472.5	18534.7
.8600	18125.6	18187.8	18249.9	18312.0	18374.2	18436.3	18498.4
.8700	18090.2	18152.4	18214.5	18276.6	18338.8	18400.9	18463.0
.8800	18055.6	18117.8	18179.9	18242.0	18304.2	18366.3	18428.4
.8900	18021.8	18083.9	18146.1	18208.2	18270.4	18332.5	18394.6

Table 6 (continued)

KEROSINE

D/(g/cm^3)	A/(°C) 20	30	40	50	60	70	80
	Q'/(Btu/lb)						
.6500	18988.0	19069.4	19150.8	19232.2	19313.7	19395.1	19476.5
.6600	18931.7	19013.1	19094.5	19175.9	19257.3	19338.7	19420.2
.6700	18877.0	18958.4	19039.9	19121.3	19202.7	19284.1	19365.5
.6800	18824.0	18905.4	18986.8	19068.2	19149.6	19231.1	19312.5
.6900	18772.5	18853.9	18935.3	19016.7	19098.1	19179.6	19261.0
.7000	18722.4	18803.9	18885.3	18966.7	19048.1	19129.5	19210.9
.7100	18673.8	18755.2	18836.7	18918.1	18999.5	19080.9	19162.3
.7200	18626.6	18708.0	18789.4	18870.8	18952.2	19033.6	19115.1
.7300	18580.6	18662.0	18743.4	18824.8	18906.2	18987.7	19069.1
.7400	18535.8	18617.3	18698.7	18780.1	18861.5	18942.9	19024.3
.7500	18492.3	18573.7	18655.1	18736.6	18818.0	18899.4	18980.8
.7600	18449.9	18531.3	18612.7	18694.2	18775.6	18857.0	18938.4
.7700	18408.6	18490.0	18571.4	18652.9	18734.3	18815.7	18897.1
.7800	18368.4	18449.8	18531.2	18612.6	18694.0	18775.5	18856.9
.7900	18329.2	18410.6	18492.0	18573.4	18654.8	18736.2	18817.7
.8000	18290.9	18372.3	18453.8	18535.2	18616.6	18698.0	18779.4
.8100	18253.6	18335.1	18416.5	18497.9	18579.3	18660.7	18742.1
.8200	18217.3	18298.7	18380.1	18461.5	18542.9	18624.3	18705.8
.8300	18181.8	18263.2	18344.6	18426.0	18507.4	18588.8	18670.2
.8400	18147.1	18228.5	18309.9	18391.3	18472.8	18554.2	18635.6
.8500	18113.2	18194.7	18276.1	18357.5	18438.9	18520.3	18601.7
.8600	18080.2	18161.6	18243.0	18324.4	18405.9	18487.3	18568.7
.8700	18047.9	18129.3	18210.7	18292.1	18373.6	18455.0	18536.4
.8800	18016.3	18097.7	18179.2	18260.6	18342.0	18423.4	18504.8
.8900	17985.5	18066.9	18148.3	18229.7	18311.1	18392.6	18474.0

TABLE 7. NET ENTHALPY OF COMBUSTION

GASOLINE 100/130 AND 115/145

Q'/(MJ/kg)

D/(g/cm^3)	A/(°C) 20	30	40	50	60	70	80
.6500	43.3500	43.6124	43.8748	44.1371	44.3995	44.6619	44.9243
.6600	43.2618	43.5242	43.7865	44.0489	44.3113	44.5737	44.8360
.6700	43.1762	43.4386	43.7010	43.9633	44.2257	44.4881	44.7505
.6800	43.0931	43.3555	43.6179	43.8803	44.1426	44.4050	44.6674
.6900	43.0125	43.2749	43.5372	43.7996	44.0620	44.3244	44.5867
.7000	42.9341	43.1965	43.4589	43.7213	43.9836	44.2460	44.5084
.7100	42.8580	43.1204	43.3827	43.6451	43.9075	44.1698	44.4322
.7200	42.7839	43.0463	43.3087	43.5711	43.8334	44.0958	44.3582
.7300	42.7119	42.9743	43.2367	43.4991	43.7614	44.0238	44.2862
.7400	42.6419	42.9043	43.1666	43.4290	43.6914	43.9537	44.2161
.7500	42.5737	42.8361	43.0984	43.3608	43.6232	43.8856	44.1479
.7600	42.5073	42.7697	43.0320	43.2944	43.5568	43.8192	44.0815
.7700	42.4426	42.7050	42.9674	43.2297	43.4921	43.7545	44.0169
.7800	42.3796	42.6420	42.9044	43.1667	43.4291	43.6915	43.9538
.7900	42.3182	42.5806	42.8429	43.1053	43.3677	43.6301	43.8924
.8000	42.2583	42.5207	42.7831	43.0454	43.3078	43.5702	43.8325
.8100	42.1999	42.4623	42.7247	42.9870	43.2494	43.5118	43.7741
.8200	42.1429	42.4053	42.6677	42.9300	43.1924	43.4548	43.7172
.8300	42.0873	42.3497	42.6121	42.8744	43.1368	43.3992	43.6616
.8400	42.0330	42.2954	42.5578	42.8202	43.0825	43.3449	43.6073
.8500	41.9800	42.2424	42.5048	42.7671	43.0295	43.2919	43.5543
.8600	41.9283	42.1906	42.4530	42.7154	42.9777	43.2401	43.5025
.8700	41.8777	42.1400	42.4024	42.6648	42.9272	43.1895	43.4519
.8800	41.8282	42.0906	42.3530	42.6154	42.8777	43.1401	43.4025
.8900	41.7799	42.0423	42.3047	42.5670	42.8294	43.0918	43.3542

Table 7 (continued)

ANF-28 AND ANF-58 (JP3)

Q'/(MJ/kg)

D/(g/cm^3)	A/(°C) 20	30	40	50	60	70	80
.6500	43.5349	43.7883	44.0418	44.2953	44.5487	44.8022	45.0556
.6600	43.4380	43.6915	43.9449	44.1984	44.4519	44.7053	44.9588
.6700	43.3441	43.5975	43.8510	44.1044	44.3579	44.6114	44.8648
.6800	43.2529	43.5063	43.7598	44.0132	44.2667	44.5202	44.7736
.6900	43.1643	43.4178	43.6712	43.9247	44.1782	44.4316	44.6851
.7000	43.0783	43.3317	43.5852	43.8387	44.0921	44.3456	44.5991
.7100	42.9947	43.2481	43.5016	43.7551	44.0085	44.2620	44.5155
.7200	42.9134	43.1669	43.4203	43.6738	43.9273	44.1807	44.4342
.7300	42.8344	43.0878	43.3413	43.5947	43.8482	44.1017	44.3551
.7400	42.7574	43.0109	43.2644	43.5178	43.7713	44.0248	44.2782
.7500	42.6826	42.9360	43.1895	43.4430	43.6964	43.9499	44.2034
.7600	42.6097	42.8631	43.1166	43.3701	43.6235	43.8770	44.1305
.7700	42.5387	42.7922	43.0456	43.2991	43.5525	43.8060	44.0595
.7800	42.4695	42.7230	42.9764	43.2299	43.4834	43.7368	43.9903
.7900	42.4021	42.6555	42.9090	43.1625	43.4159	43.6694	43.9229
.8000	42.3363	42.5898	42.8433	43.0967	43.3502	43.6037	43.8571
.8100	42.2722	42.5257	42.7791	43.0326	43.2861	43.5395	43.7930
.8200	42.2097	42.4631	42.7166	42.9701	43.2235	43.4770	43.7304
.8300	42.1486	42.4021	42.6555	42.9090	43.1625	43.4159	43.6694
.8400	42.0890	42.3425	42.5959	42.8494	43.1029	43.3563	43.6098
.8500	42.0308	42.2843	42.5378	42.7912	43.0447	43.2981	43.5516
.8600	41.9740	42.2275	42.4809	42.7344	42.9878	43.2413	43.4948
.8700	41.9185	42.1719	42.4254	42.6789	42.9323	43.1858	43.4392
.8800	41.8642	42.1177	42.3711	42.6246	42.8780	43.1315	43.3850
.8900	41.8111	42.0646	42.3181	42.5715	42.8250	43.0785	43.3319

Table 7 (continued)

Jp-4

D/(g/cm³)	Q'/(MJ/kg) A/(°C) 20	30	40	50	60	70	80
.6500	44.2225	44.4020	44.5816	44.7611	44.9407	45.1202	45.2998
.6600	44.0895	44.2691	44.4486	44.6282	44.8077	44.9873	45.1668
.6700	43.9605	44.1401	44.3196	44.4992	44.6787	44.8582	45.0378
.6800	43.8353	44.0149	44.1944	44.3740	44.5535	44.7330	44.9126
.6900	43.7137	43.8933	44.0728	44.2524	44.4319	44.6115	44.7910
.7000	43.5956	43.7752	43.9547	44.1343	44.3138	44.4934	44.6729
.7100	43.4809	43.6604	43.8399	44.0195	44.1990	44.3786	44.5581
.7200	43.3693	43.5488	43.7284	43.9079	44.0874	44.2670	44.4465
.7300	43.2607	43.4403	43.6198	43.7994	43.9789	44.1585	44.3380
.7400	43.1551	43.3347	43.5142	43.6938	43.8733	44.0529	44.2324
.7500	43.0524	43.2319	43.4114	43.5910	43.7705	43.9501	44.1296
.7600	42.9523	43.1318	43.3114	43.4909	43.6705	43.8500	44.0295
.7700	42.8548	43.0343	43.2139	43.3934	43.5730	43.7525	43.9321
.7800	42.7598	42.9394	43.1189	43.2984	43.4780	43.6575	43.8371
.7900	42.6672	42.8468	43.0263	43.2059	43.3854	43.5650	43.7445
.8000	42.5770	42.7565	42.9361	43.1156	43.2952	43.4747	43.6542
.8100	42.4889	42.6685	42.8480	43.0276	43.2071	43.3867	43.5662
.8200	42.4031	42.5826	42.7622	42.9417	43.1212	43.3008	43.4803
.8300	42.3192	42.4988	42.6783	42.8579	43.0374	43.2170	43.3965
.8400	42.2374	42.4170	42.5965	42.7761	42.9556	43.1352	43.3147
.8500	42.1575	42.3371	42.5166	42.6962	42.8757	43.0553	43.2348
.8600	42.0795	42.2590	42.4386	42.6181	42.7977	42.9772	43.1568
.8700	42.0033	42.1828	42.3623	42.5419	42.7214	42.9010	43.0805
.8800	41.9287	42.1083	42.2878	42.4674	42.6469	42.8265	43.0060
.8900	41.8559	42.0355	42.2150	42.3945	42.5741	42.7536	42.9332

Table 7 (continued)

JP-5

Q'/(MJ/kg)

D/(g/cm³)	A/(°C) 20	30	40	50	60	70	80
.6500	44.4753	44.6198	44.7644	44.9089	45.0534	45.1979	45.3425
.6600	44.3317	44.4762	44.6207	44.7653	44.9098	45.0543	45.1988
.6700	44.1924	44.3369	44.4814	44.6259	44.7705	44.9150	45.0595
.6800	44.0571	44.2017	44.3462	44.4907	44.6352	44.7798	44.9243
.6900	43.9258	44.0703	44.2149	44.3594	44.5039	44.6484	44.7930
.7000	43.7983	43.9428	44.0873	44.2318	44.3764	44.5209	44.6654
.7100	43.6743	43.8188	43.9633	44.1079	44.2524	44.3969	44.5414
.7200	43.5538	43.6983	43.8428	43.9873	44.1319	44.2764	44.4209
.7300	43.4365	43.5811	43.7256	43.8701	44.0147	44.1592	44.3037
.7400	43.3225	43.4670	43.6115	43.7561	43.9006	44.0451	44.1897
.7500	43.2115	43.3560	43.5005	43.6451	43.7896	43.9341	44.0786
.7600	43.1034	43.2479	43.3924	43.5370	43.6815	43.8260	43.9706
.7700	42.9981	43.1426	43.2872	43.4317	43.5762	43.7207	43.8653
.7800	42.8955	43.0401	43.1846	43.3291	43.4736	43.6182	43.7627
.7900	42.7955	42.9401	43.0846	43.2291	43.3736	43.5182	43.6627
.8000	42.6981	42.8426	42.9871	43.1316	43.2762	43.4207	43.5652
.8100	42.6030	42.7475	42.8920	43.0366	43.1811	43.3256	43.4701
.8200	42.5102	42.6547	42.7993	42.9438	43.0883	43.2328	43.3774
.8300	42.4197	42.5642	42.7087	42.8533	42.9978	43.1423	43.2869
.8400	42.3313	42.4758	42.6204	42.7649	42.9094	43.0540	43.1985
.8500	42.2450	42.3896	42.5341	42.6786	42.8231	42.9677	43.1122
.8600	42.1607	42.3053	42.4498	42.5943	42.7389	42.8834	43.0279
.8700	42.0784	42.2229	42.3675	42.5120	42.6565	42.8010	42.9456
.8800	41.9979	42.1425	42.2870	42.4315	42.5760	42.7206	42.8651
.8900	41.9193	42.0638	42.2083	42.3528	42.4974	42.6419	42.7864

Table 7 (continued)

KEROSINE

D/(g/cm³)	Q'/(MJ/kg) A/(°C) 20	30	40	50	60	70	80
.6500	44.1666	44.3560	44.5454	44.7348	44.9241	45.1135	45.3029
.6600	44.0356	44.2250	44.4144	44.6037	44.7931	44.9825	45.1719
.6700	43.9085	44.0979	44.2873	44.4766	44.6660	44.8554	45.0448
.6800	43.7851	43.9745	44.1639	44.3533	44.5426	44.7320	44.9214
.6900	43.6653	43.8547	44.0441	44.2335	44.4228	44.6122	44.8016
.7000	43.5490	43.7383	43.9277	44.1171	44.3065	44.4958	44.6852
.7100	43.4359	43.6252	43.8146	44.0040	44.1934	44.3828	44.5721
.7200	43.3259	43.5153	43.7047	43.8940	44.0834	44.2728	44.4622
.7300	43.2190	43.4084	43.5977	43.7871	43.9765	44.1659	44.3552
.7400	43.1149	43.3043	43.4937	43.6831	43.8724	44.0618	44.2512
.7500	43.0137	43.2030	43.3924	43.5818	43.7712	43.9605	44.1499
.7600	42.9150	43.1044	43.2938	43.4832	43.6725	43.8619	44.0513
.7700	42.8190	43.0084	43.1977	43.3871	43.5765	43.7659	43.9552
.7800	42.7254	42.9148	43.1042	43.2935	43.4829	43.6723	43.8617
.7900	42.6342	42.8236	43.0129	43.2023	43.3917	43.5811	43.7704
.8000	42.5453	42.7346	42.9240	43.1134	43.3028	43.4921	43.6815
.8100	42.4585	42.6479	42.8373	43.0266	43.2160	43.4054	43.5948
.8200	42.3739	42.5633	42.7526	42.9420	43.1314	43.3208	43.5101
.8300	42.2913	42.4807	42.6701	42.8594	43.0488	43.2382	43.4276
.8400	42.2107	42.4001	42.5894	42.7788	42.9682	43.1576	43.3469
.8500	42.1320	42.3213	42.5107	42.7001	42.8895	43.0788	43.2682
.8600	42.0551	42.2444	42.4338	42.6232	42.8126	43.0019	43.1913
.8700	41.9799	42.1693	42.3587	42.5481	42.7374	42.9268	43.1162
.8800	41.9065	42.0959	42.2853	42.4747	42.6640	42.8534	43.0428
.8900	41.8348	42.0241	42.2135	42.4029	42.5923	42.7816	42.9710

TABLE 8.   QUADRATIC EAUATION

==

Q'=B(Ø)+B(1)*A+B(2)*(1/D)+B(3)*A*(1/D)+B(4)*A↑2+B(5)*(1/D↑2)

UNITS OF A ARE °C.
UNITS OF D ARE g/cm^3.
FOR Q' IN Btu/lb USE B PARAMETERS
FOR Q' IN MJ/kg USE C PARAMETERS.

FUEL: ALL

N= 267

	PARAMETERS	STD DEV
B(Ø)	987Ø.73	665.628
B(1)	-5.44218	3.55698
B(2)	11453.4	1Ø62.Ø5
B(3)	14.Ø247	2.7534
B(4)	-2.87627E-2	1.45368E-2
B(5)	-3962.87	436.Ø38
C(Ø)	22.9596	1.54827
C(1)	-1.26587E-2	8.27364E-3
C(2)	26.64Ø9	2.47Ø36
C(3)	.Ø32622	6.4Ø448E-3
C(4)	-6.69Ø3ØE-5	3.38131E-5
C(5)	-9.21776	1.Ø1424

STD DEV= 25.3839 Btu/lb = 5.9Ø437E-2 MJ/kg
MAX DEV= 88.841 .2Ø6647

TABLE 9. NET ENTHALPY ØF CØMBUSTIØN

FUEL: ALL

Q'/(Btu/lb)

D/(g/cm^3)	A/(°C) 20	30	40	50	60	70	80
.6500	18423.0	18569.9	18711.1	18846.6	18976.3	19100.2	19218.4
.6600	18431.5	18575.2	18713.1	18845.3	18971.8	19092.4	19207.4
.6700	18435.7	18576.2	18711.0	18840.0	18963.3	19080.8	19192.5
.6800	18435.9	18573.3	18705.0	18831.0	18951.1	19065.6	19174.3
.6900	18432.4	18566.9	18695.6	18818.5	18935.7	19047.2	19152.8
.7000	18425.6	18557.1	18682.9	18803.0	18917.3	19025.8	19128.6
.7100	18415.7	18544.4	18667.4	18784.6	18896.1	19001.8	19101.8
.7200	18403.0	18529.0	18649.2	18763.7	18872.5	18975.4	19072.6
.7300	18387.8	18511.1	18628.7	18740.5	18846.5	18946.8	19041.4
.7400	18370.2	18490.9	18605.9	18715.1	18818.6	18916.3	19008.2
.7500	18350.5	18468.7	18581.1	18687.8	18788.7	18883.9	18973.3
.7600	18328.8	18444.5	18554.5	18658.7	18757.2	18849.9	18936.9
.7700	18305.3	18418.7	18526.2	18628.1	18724.2	18814.5	18899.1
.7800	18280.2	18391.2	18496.5	18596.0	18689.7	18777.7	18860.0
.7900	18253.7	18362.4	18465.4	18562.6	18654.1	18739.8	18819.7
.8000	18225.8	18332.3	18433.0	18528.0	18617.3	18700.8	18778.5
.8100	18196.6	18301.0	18399.6	18492.4	18579.5	18660.8	18736.4
.8200	18166.4	18268.6	18365.1	18455.8	18540.8	18620.0	18693.5
.8300	18135.1	18235.3	18329.7	18418.4	18501.3	18578.5	18649.9
.8400	18103.0	18201.1	18293.6	18380.2	18461.1	18536.3	18605.6
.8500	18070.0	18166.2	18256.7	18341.3	18420.3	18493.5	18560.9
.8600	18036.3	18130.6	18219.1	18301.9	18378.9	18450.2	18515.7
.8700	18002.0	18094.4	18181.0	18261.9	18337.0	18406.4	18470.1
.8800	17967.0	18057.6	18142.4	18221.5	18294.8	18362.3	18424.1
.8900	17931.5	18020.3	18103.3	18180.6	18252.1	18317.9	18377.9

TABLE 10 NET ENTHALPY OF COMBUSTION

FUEL: ALL

Q'/(MJ/kg)

D/(g/cm³)	A/(°C) 20	30	40	50	60	70	80
.6500	42.8522	43.1941	43.5225	43.8376	44.1393	44.4276	44.7026
.6600	42.8721	43.2064	43.5272	43.8347	44.1288	44.4095	44.6768
.6700	42.8819	43.2087	43.5222	43.8223	44.1090	44.3824	44.6423
.6800	42.8823	43.2020	43.5083	43.8013	44.0808	44.3470	44.5998
.6900	42.8743	43.1870	43.4864	43.7723	44.0449	44.3042	44.5500
.7000	42.8584	43.1644	43.4570	43.7362	44.0021	44.2545	44.4936
.7100	42.8354	43.1348	43.4209	43.6935	43.9528	44.1987	44.4313
.7200	42.8059	43.0990	43.3786	43.6449	43.8978	44.1373	44.3635
.7300	42.7704	43.0573	43.3307	43.5908	43.8375	44.0708	44.2908
.7400	42.7295	43.0103	43.2778	43.5318	43.7725	43.9997	44.2136
.7500	42.6837	42.9586	43.2201	43.4683	43.7031	43.9245	44.1325
.7600	42.6332	42.9024	43.1582	43.4007	43.6297	43.8454	44.0477
.7700	42.5787	42.8423	43.0925	43.3294	43.5529	43.7630	43.9597
.7800	42.5203	42.7785	43.0233	43.2547	43.4728	43.6775	43.8687
.7900	42.4585	42.7114	42.9509	43.1771	43.3898	43.5892	43.7752
.8000	42.3936	42.6413	42.8757	43.0967	43.3043	43.4985	43.6793
.8100	42.3258	42.5685	42.7978	43.0138	43.2163	43.4055	43.5813
.8200	42.2555	42.4933	42.7177	42.9287	43.1264	43.3106	43.4815
.8300	42.1828	42.4158	42.6354	42.8417	43.0345	43.2140	43.3801
.8400	42.1080	42.3363	42.5513	42.7528	42.9410	43.1158	43.2772
.8500	42.0313	42.2551	42.4655	42.6624	42.8460	43.0163	43.1731
.8600	41.9529	42.1722	42.3781	42.5707	42.7498	42.9156	43.0680
.8700	41.8730	42.0879	42.2895	42.4777	42.6524	42.8138	42.9619
.8800	41.7917	42.0024	42.1997	42.3836	42.5541	42.7112	42.8550
.8900	41.7092	41.9157	42.1088	42.2886	42.4549	42.6079	42.7475

Values of Q(C) have been calculated by eqn. (21) for each of the observed fuel samples and compared with the observed value, Q(0). Table 11 gives the results of this comparison. Columns 2 and 3 give th values of Q(0) and Q(C). Column 4 gives the deviation, DEV = Q(0) - Q(C). Column 5 gives the estimate of the standard deviation of the calculated value, SD(Q(C)). Column 6 gives the standardized deviation, STZD, which is the deviation measured in units of its standard deviation.

$$\text{STZD} = \text{DEV}/\text{SD(DEV)}$$

$$\text{SD(DEV)} = ((\text{SD(Q(0))})^2 + (\text{SD(Q(C))})^2)^{1/2}$$

Figures 1 through 5 show deviation plots where the ordinates are the standardized deviations shown in column 6 of table 12 plotted against abscissas of the variables A, D, S, Q, and NO.

TABLE 11. NET ENTHALPY OF COMBUSTION, COMPARISON OF OBSERVED AND CALCULATED VALUES.

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EQN: Q=B(Ø)+B(1)*A+B(2)*(1/D)+B(3)*A*D+B(4)*A↑2+B(5)*(1/D↑2)+B(6)*S

UNITS OF A ARE °C.
UNITS OF D ARE g/cm^3.
FOR Q IN Btu/lb USE B PARAMETERS.
FOR Q IN MJ/kg USE C PARAMETERS.
UNITS OF Q IN THE TABLE ARE Btu/lb.

N= 267
SS= 168173.
V= 644.341

	PARAMETERS	STD DEV
B(Ø)	987Ø.73	665.628
B(1)	-5.44217	3.55698
B(2)	11453.4	1Ø62.Ø5
B(3)	14.Ø247	2.7534
B(4)	-2.87627E-2	1.45368E-2
B(5)	-3962.87	436.Ø38
B(6)	-5Ø	2Ø
C(Ø)	22.9596	1.54827
C(1)	-1.26587E-2	8.27364E-3
C(2)	26.64Ø9	2.47Ø36
C(3)	.Ø32622	6.4Ø448E-3
C(4)	-6.69Ø3ØE-5	3.38131E-5
C(5)	-9.21776	1.Ø1424
C(6)	-.1163	.Ø465

STD DEV= 25.3839 Btu/lb = 5.9Ø437E-2 MJ/kg
MAX DEV= 88.841 .2Ø6647 AT PT 248

Table 11 (continued)

FUEL: AV. GAS 100/130, 115/145

MEAN DEV = -11.   RMS DEV = 28.4

NO	Q(O)	Q(C)	DEV	SD(Q(C))	STZD
1	19046.7	19039.2	7.5	4.9	.3
2	18686.6	18735.4	-48.8	2.9	-1.9
3	19057.3	19028.0	29.3	4.8	1.1
4	19051.6	19075.7	-24.1	6.2	-.9
5	18754.9	18757.5	-2.6	3.4	-.1
6	18808.5	18807.0	1.5	3.5	.1
7	18773.7	18760.7	13.0	3.1	.5
8	19089.7	19080.3	9.4	6.2	.4
9	19050.3	19057.9	-7.6	5.5	-.3
10	19099.2	19089.3	9.9	6.7	.4
11	18934.7	18967.1	-32.4	3.4	-1.3
12	18875.7	18930.4	-54.7	3.0	-2.1
13	18994.0	18983.8	10.2	3.6	.4
14	19049.9	19031.4	18.5	4.7	.7
15	19054.9	19019.1	35.8	4.4	1.4
16	18872.8	18924.1	-51.3	3.0	-2.0
17	18888.3	18935.9	-47.6	3.1	-1.9
18	18907.9	18917.2	-9.3	3.1	-.4
19	19030.0	19000.6	29.4	3.9	1.1
20	18925.7	18931.0	-5.3	3.2	-.2
21	19086.9	19059.2	27.7	5.6	1.1
22	19094.0	19075.5	18.5	6.2	.7
23	18897.6	18936.7	-39.1	3.2	-1.5
24	18935.4	18960.2	-24.8	3.3	-1.0
25	18923.1	18963.7	-40.6	3.7	-1.6
26	18988.6	18982.2	6.4	3.7	.3
27	18935.0	18965.6	-30.6	3.4	-1.2
28	19019.4	19011.8	7.6	4.4	.3
29	18889.7	18926.6	-36.9	3.2	-1.4
30	18916.0	18937.3	-21.3	3.2	-.8
31	18918.9	18963.6	-44.7	3.4	-1.7
32	18925.1	18962.9	-37.8	3.4	-1.5
33	18731.6	18755.6	-24.0	3.8	-.9
34	19075.5	19057.8	17.7	5.8	.7
35	18679.2	18733.5	-54.3	3.9	-2.1
36	19068.6	19055.0	13.6	5.8	.5
37	19043.3	19062.4	-19.1	5.6	-.7
38	18954.6	18978.8	-24.2	3.5	-.9
39	18960.5	18962.2	-1.7	3.4	-.1
40	19002.5	19008.0	-5.5	4.1	-.2

Table 11 (continued)

FUEL: ANF-58,ANF-28 (JP-3)

MEAN DEV = 2.1 RMS DEV = 28.3

NO	Q(O)	Q(C)	DEV	SD(Q(C))	STZD
41	18532.0	18562.6	-30.6	3.6	-1.2
42	18823.0	18801.8	21.2	3.7	.8
43	18548.0	18621.9	-73.9	3.5	-2.9
44	18594.0	18607.6	-13.6	3.6	-.5
45	18376.0	18433.2	-57.2	5.2	-2.2
46	18858.0	18836.3	21.7	3.2	.8
47	18772.0	18806.0	-34.0	3.2	-1.3
48	18828.0	18790.3	37.7	3.2	1.5
49	18578.0	18533.3	44.7	3.8	1.7
50	18386.0	18407.0	-21.0	5.5	-.8
51	18571.0	18600.4	-29.4	3.6	-1.1
52	18536.0	18555.1	-19.1	3.6	-.7
53	18680.0	18661.9	18.1	3.6	.7
54	18493.0	18489.8	3.2	4.5	.1
55	18570.0	18559.4	10.6	3.6	.4
56	18772.0	18766.6	5.4	3.8	.2
57	18400.0	18368.3	31.7	11.8	1.1
58	18758.0	18779.0	-21.0	3.7	-.8
59	18607.0	18556.5	50.5	3.8	2.0
60	18399.0	18390.4	8.6	4.8	.3
61	18790.0	18777.5	12.5	3.8	.5
62	18605.0	18605.5	-.5	3.6	-0.0
63	18683.0	18743.1	-60.1	3.7	-2.3
64	18369.0	18421.1	-52.1	7.9	-2.0
65	18681.0	18701.8	-20.8	3.6	-.8
66	18717.0	18692.4	24.6	3.3	1.0
67	18778.0	18737.4	40.6	3.3	1.6
68	18397.0	18407.1	-10.1	6.8	-.4
69	18398.0	18403.7	-5.7	7.1	-.2
70	18543.0	18606.1	-63.1	3.3	-2.5
71	19014.0	18997.4	16.6	5.3	.6
72	18230.0	18269.7	-39.7	9.5	-1.5
73	18771.0	18758.0	13.0	3.3	.5
74	18863.0	18866.7	-3.7	3.0	-.1
75	18802.0	18775.9	26.1	3.2	1.0
76	18963.0	18934.6	28.4	3.1	1.1
77	18876.0	18849.1	26.9	2.8	1.1
78	18736.0	18728.3	7.7	2.8	.3
79	18608.0	18642.2	-34.2	3.8	-1.3
80	18888.0	18846.1	41.9	3.6	1.6
81	18832.0	18796.0	36.0	3.0	1.4
82	18854.0	18840.0	14.0	3.0	.5
83	18841.0	18796.5	44.5	3.3	1.7
84	18829.0	18836.0	-7.0	3.5	-.3
85	18811.0	18800.5	10.5	3.1	.4
86	18850.0	18810.7	39.3	2.8	1.5
87	18717.0	18748.3	-31.3	3.4	-1.2

Table 11 (continued)

88	18704.0	18707.7	-3.7	3.5	-.1
89	18830.0	18789.3	40.7	2.8	1.6
90	18941.0	18910.4	30.6	3.0	1.2
91	18803.0	18792.1	10.9	2.8	.4
92	18788.0	18730.3	57.7	2.9	2.3
93	18813.0	18793.4	19.6	2.9	.8
94	18729.0	18737.3	-8.3	3.2	-.3
95	18674.0	18714.6	-40.6	3.5	-1.6
96	18709.0	18745.4	-36.4	2.9	-1.4
97	18794.0	18753.1	40.9	3.2	1.6
98	18760.0	18751.4	8.6	3.2	.3
99	18667.0	18681.1	-14.1	3.3	-.6
100	18764.0	18787.1	-23.1	2.8	-.9
101	18708.0	18718.4	-10.4	2.9	-.4
102	18920.0	18897.0	23.0	3.3	.9
103	18558.0	18595.8	-37.8	4.7	-1.5
104	18690.0	18682.0	8.0	3.8	.3
105	18660.0	18714.1	-54.1	3.4	-2.1
106	18693.0	18676.8	16.2	4.5	.6
107	18817.0	18814.6	2.4	3.1	.1
108	18720.0	18726.8	-6.8	3.2	-.3
109	18762.0	18747.5	14.5	3.2	.6
110	18735.0	18746.8	-11.8	3.1	-.5
111	18587.0	18585.6	1.4	5.5	.1
112	18748.0	18751.0	-3.0	2.9	-.1
113	18832.0	18827.8	4.2	3.0	.2
114	18739.0	18718.9	20.1	3.5	.8
115	18667.0	18656.8	10.2	3.7	.4
116	18815.0	18801.4	13.6	3.3	.5
117	18710.0	18696.2	13.8	3.7	.5
118	18828.0	18796.8	31.2	3.0	1.2
119	18671.0	18665.5	5.5	3.5	.2
120	18654.0	18664.4	-10.4	3.9	-.4
121	18663.0	18657.8	5.2	3.6	.2
122	18637.0	18621.3	15.7	4.4	.6
123	18761.0	18762.7	-1.7	3.2	-.1
124	18652.0	18647.1	4.9	4.0	.2
125	18683.0	18684.6	-1.6	3.9	-.1
126	18670.0	18673.5	-3.5	3.9	-.1
127	18674.0	18678.9	-4.9	3.8	-.2
128	18685.0	18631.4	53.6	4.4	2.1
129	18597.0	18598.7	-1.7	5.6	-.1

Table 11 (continued)

FUEL: JP-4

MEAN DEV = 15.4 RMS DEV = 21.3

NO	Q(O)	Q(C)	DEV	SD(Q(C))	STZD
130	18727.0	18706.4	20.6	3.7	.8
131	18538.0	18556.8	-18.8	3.2	-.7
132	18683.0	18661.8	21.2	3.6	.8
133	18721.0	18701.6	19.4	3.8	.8
134	18766.0	18732.9	33.1	3.8	1.3
135	18760.0	18736.3	23.7	3.8	.9
136	18635.0	18633.8	1.2	3.6	0.0
137	18544.0	18497.5	46.5	4.2	1.8
138	18550.0	18549.2	.8	3.2	0.0
139	18516.0	18497.3	18.7	3.8	.7
140	18471.0	18464.6	6.4	3.5	.2
141	18598.0	18566.0	32.0	3.5	1.3
142	18707.0	18687.5	19.5	3.7	.8
143	18696.0	18695.3	.7	3.8	0.0
144	18602.0	18586.6	15.4	3.6	.6
145	18468.0	18454.0	14.0	4.3	.5
146	18547.0	18538.7	8.3	3.7	.3

FUEL: JP-5

MEAN DEV = -7. RMS DEV = 30.1

NO	Q(O)	Q(C)	DEV	SD(Q(C))	STZD
147	18377.0	18349.0	28.0	6.5	1.1
148	18579.0	18595.6	-16.6	2.3	-.7
149	18288.0	18355.4	-67.4	6.2	-2.6
150	18572.0	18611.0	-39.0	2.3	-1.5
151	18393.0	18360.9	32.1	5.5	1.2
152	18300.0	18298.4	1.6	8.1	.1
153	18469.0	18486.3	-17.3	3.7	-.7
154	18430.0	18420.4	9.6	4.5	.4
155	18365.0	18384.6	-19.6	4.7	-.8
156	18341.0	18312.2	28.8	7.9	1.1
157	18595.0	18608.3	-13.3	2.6	-.5

Table 11 (continued)

FUEL: KEROSINE

MEAN DEV = .5 RMS DEV = 20.7

NO	Q(O)	Q(C)	DEV	SD(Q(C))	STZD
158	18640.0	18685.2	-45.2	3.6	-1.8
159	18611.0	18614.4	-3.4	2.3	-.1
160	18575.0	18577.1	-2.1	2.7	-.1
161	18574.0	18587.2	-13.2	3.5	-.5
162	18557.0	18592.3	-35.3	2.9	-1.4
163	18639.0	18634.1	4.9	2.4	.2
164	18461.0	18484.3	-23.3	3.4	-.9
165	18441.0	18427.1	13.9	3.7	.5
166	18621.0	18623.5	-2.5	2.6	-.1
167	18639.0	18658.3	-19.3	3.5	-.8
168	18662.0	18636.3	25.7	2.9	1.0
169	18700.0	18684.7	15.3	4.4	.6
170	18679.0	18654.0	25.0	3.3	1.0
171	18720.0	18699.1	20.9	4.7	.8
172	18606.0	18628.8	-22.8	2.4	-.9
173	18646.0	18650.0	-4.0	2.4	-.2
174	18610.0	18604.3	5.7	2.6	.2
175	18679.0	18665.8	13.2	3.1	.5
176	18624.0	18625.1	-1.1	2.3	-0.0
177	18605.0	18623.2	-18.2	2.5	-.7
178	18589.0	18606.4	-17.4	2.4	-.7
179	18590.0	18595.0	-5.0	2.3	-.2
180	18614.0	18644.9	-30.9	2.4	-1.2
181	18658.0	18677.1	-19.1	2.6	-.7
182	18609.0	18606.6	2.4	2.6	.1
183	18627.0	18653.4	-26.4	2.5	-1.0
184	18662.0	18682.5	-20.5	2.7	-.8
185	18711.0	18695.8	15.2	3.2	.6
186	18781.0	18765.4	15.6	4.9	.6
187	18724.0	18713.6	10.4	4.8	.4
188	18783.0	18816.2	-33.2	4.0	-1.3
189	18635.0	18636.5	-1.5	2.4	-.1
190	18635.0	18627.5	7.5	2.5	.3
191	18625.0	18631.9	-6.9	2.3	-.3
192	18588.0	18596.8	-8.8	2.5	-.3
193	18655.0	18646.9	8.1	2.6	.3
194	18578.0	18575.3	2.7	2.4	.1
195	18624.0	18626.3	-2.3	2.5	-.1
196	18575.0	18574.6	.4	2.6	0.0
197	18663.0	18656.7	6.3	3.1	.2

Table 11 (continued)

198	18655.0	18636.5	18.5	2.3	.7
199	18782.0	18750.6	31.4	5.4	1.2
200	18546.0	18560.6	-14.6	2.4	-.6
201	18550.0	18556.2	-6.2	2.7	-.2
202	18479.0	18456.7	22.3	3.8	.9
203	18623.0	18568.0	55.0	3.5	2.1
204	18465.0	18465.5	-.5	3.5	-0.0
205	18670.0	18652.4	17.6	3.6	.7
206	18566.0	18589.2	-23.2	2.5	-.9
207	18608.0	18608.6	-.6	2.3	-0.0
208	18624.0	18625.1	-1.1	2.3	-0.0
209	18691.0	18681.6	9.4	3.9	.4
210	18618.0	18623.2	-5.2	2.3	-.2
211	18580.0	18577.9	2.1	2.5	.1
212	18445.0	18420.9	24.1	4.3	.9
213	18628.0	18622.8	5.2	2.3	.2
214	18563.0	18566.0	-3.0	2.5	-.1
215	18619.0	18614.3	4.7	2.3	.2
216	18500.0	18566.3	-66.3	2.5	-2.6
217	18582.0	18588.7	-6.7	2.3	-.3
218	18410.0	18374.0	36.0	5.3	1.4
219	18472.0	18479.0	-7.0	3.5	-.3
220	18606.0	18602.0	4.0	2.3	.2
221	18523.0	18547.6	-24.6	3.6	-1.0
222	18766.0	18789.9	-23.9	4.2	-.9
223	18808.0	18813.9	-5.9	4.2	-.2
224	18561.0	18544.5	16.5	2.6	.6
225	18388.0	18385.7	2.3	4.8	.1
226	18621.0	18612.0	9.0	2.3	.4
227	18548.0	18543.4	4.6	2.6	.2
228	18621.0	18591.4	29.6	2.3	1.2
229	18603.0	18598.5	4.5	2.3	.2
230	18584.0	18614.3	-30.3	2.5	-1.2
231	18620.0	18637.8	-17.8	2.4	-.7
232	18617.0	18627.2	-10.2	2.3	-.4

Table 11 (continued)

233	18610.0	18609.2	.8	2.3	0.0
234	18647.0	18653.7	-6.7	2.4	-.3
235	18660.0	18638.7	21.3	2.3	.8
236	18593.0	18610.6	-17.6	2.3	-.7
237	18604.0	18606.9	-2.9	2.4	-.1
238	18609.0	18603.3	5.7	2.4	.2
239	18486.0	18503.6	-17.6	3.1	-.7
240	18590.0	18603.5	-13.5	2.3	-.5
241	18621.0	18628.8	-7.8	2.5	-.3
242	18581.0	18566.3	14.7	2.5	.6
243	18725.0	18705.3	19.7	4.7	.8
244	18640.0	18643.7	-3.7	3.1	-.1
245	18638.0	18649.1	-11.1	2.5	-.4
246	18686.0	18663.8	22.2	2.7	.9
247	18668.0	18654.0	14.0	3.1	.5
248	18511.0	18422.2	88.8	4.3	3.5
249	18703.0	18697.0	6.0	3.3	.2
250	18547.0	18546.2	.8	2.5	0.0
251	18619.0	18636.8	-17.8	2.6	-.7
252	18795.0	18771.2	23.8	3.5	.9
253	18861.0	18857.8	3.2	7.2	.1
254	18716.0	18691.4	24.6	3.5	1.0
255	18477.0	18486.3	-9.3	3.0	-.4
256	18566.0	18585.9	-19.9	2.4	-.8
257	18652.0	18666.9	-14.9	2.5	-.6
258	18685.0	18717.2	-32.2	3.3	-1.3
259	18618.0	18625.1	-7.1	2.3	-.3
260	18484.0	18477.3	6.7	3.3	.3
261	18370.0	18366.5	3.5	5.2	.1
262	18666.0	18644.5	21.5	4.1	.8
263	18709.0	18687.7	21.3	3.7	.8
264	18732.0	18686.4	45.6	3.7	1.8
265	18674.0	18673.8	.2	2.9	0.0
266	18600.0	18619.1	-19.1	2.3	-.7
267	18691.0	18659.4	31.6	3.5	1.2

4. Summary

Data from accurate measurements of the net heat of combustion of aviation fuels had been previously correlated with their aniline-gravity product and sulfur content. Correlating equations had been derived for each of five classes of fuel: A: Avgas 100/130 and 115/145; B: Avgas ANF-28 and ANF-58 (JP-3); C: JP-4; D: JP-5; E: Kerosine.

New correlating equations which are linear in each of the variables aniline point in °C, reciprocal of density in g/cm^3 and sulfur mass percent have been obtained by a recorrelation of the same data. These new equations are shown in tables 4 and 5 and fit the observed values at least as well as the previous aniline point-gravity product equations.

An equation, quadratic in aniline point and reciprocal density, has been found to fit all the data with a standard deviation of 25.4 BTU/lb = 0.05904 MJ/kg. Thus this equation can be used to predict the net heat of combustion of fuels in the classes considered to within 50 Btu/lb or 0.11808 MJ/kg at a 95% confidence level.

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Legend for figures:

△	Gasoline 100/130
▽	Gasoline 115/145
◁	ANF-58
▷	ANF-28
⊡	JP-4
◇	JP-5
⬠	Kerosine

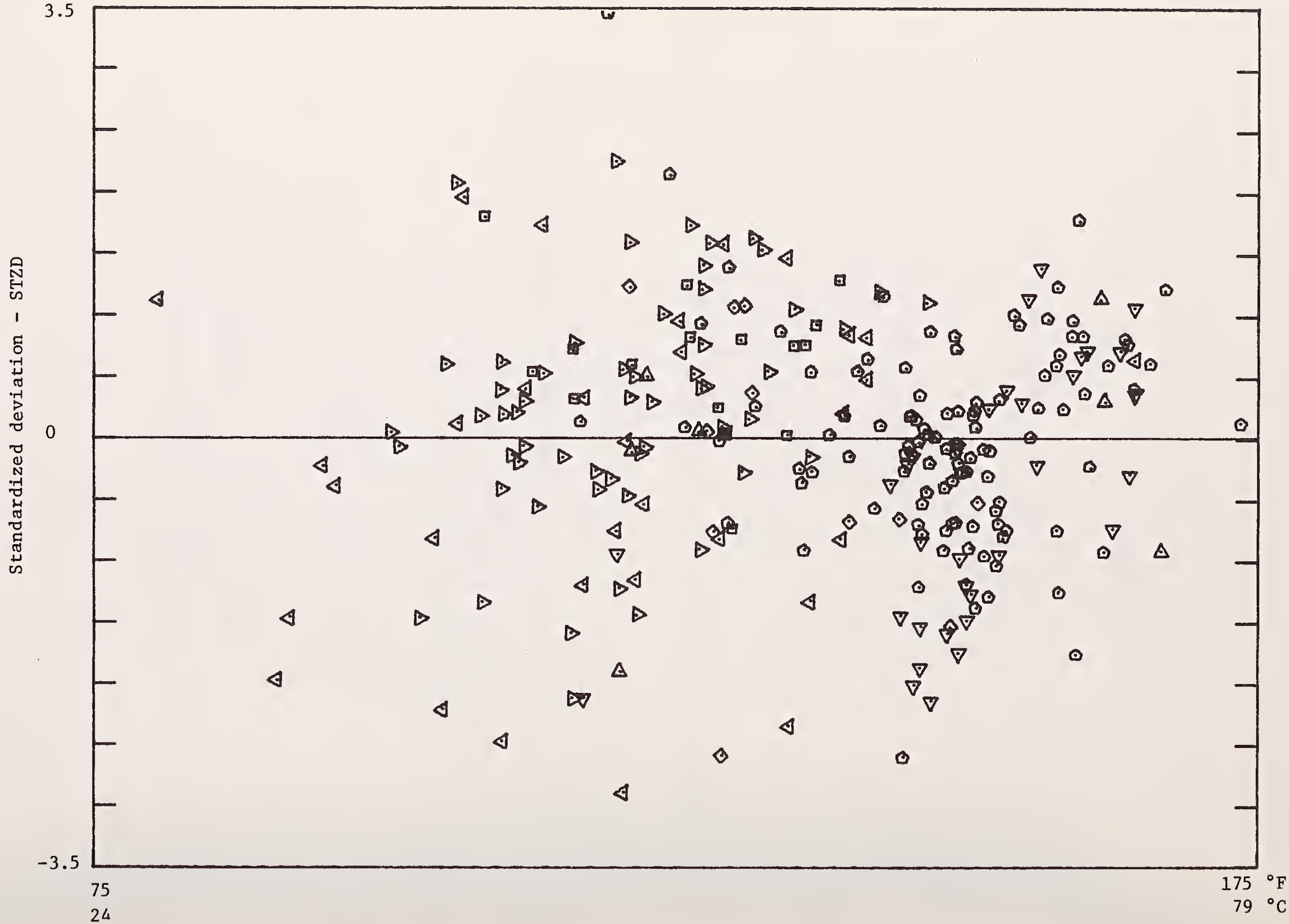

Figure 1. Aniline point.

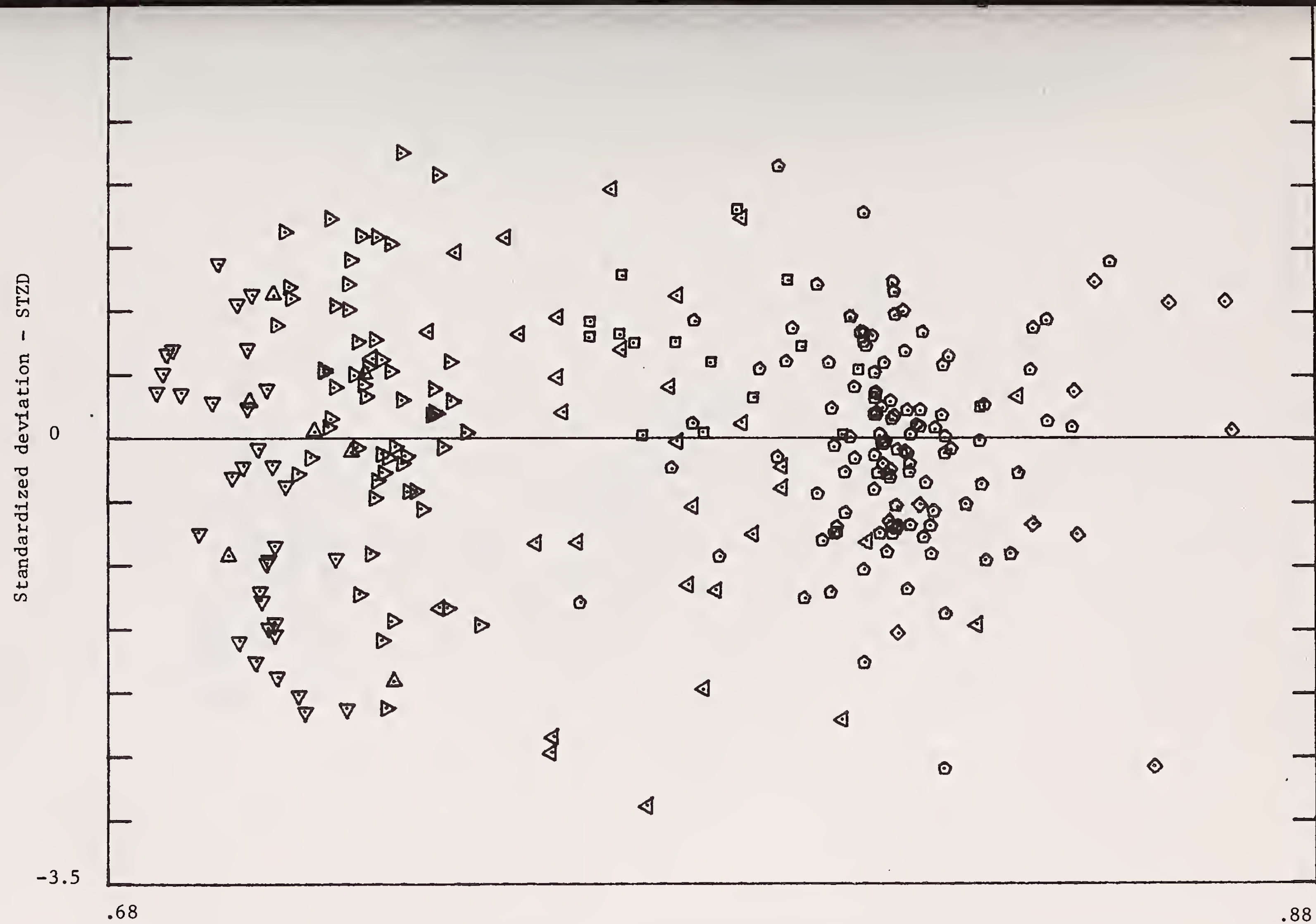

Figure 2. Density/(g·cm^{-3}).

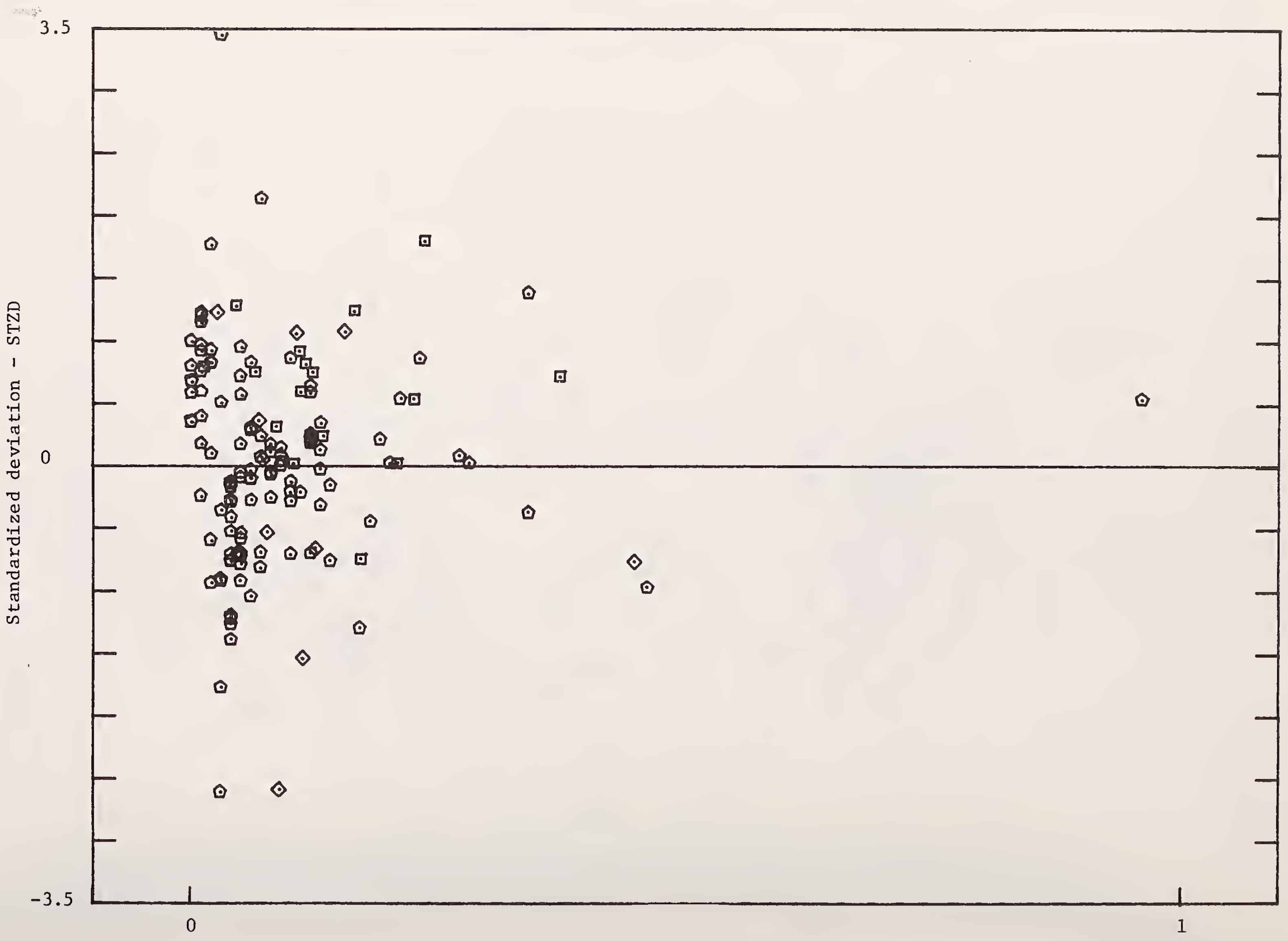

Figure 3. Sulfur mass percent.

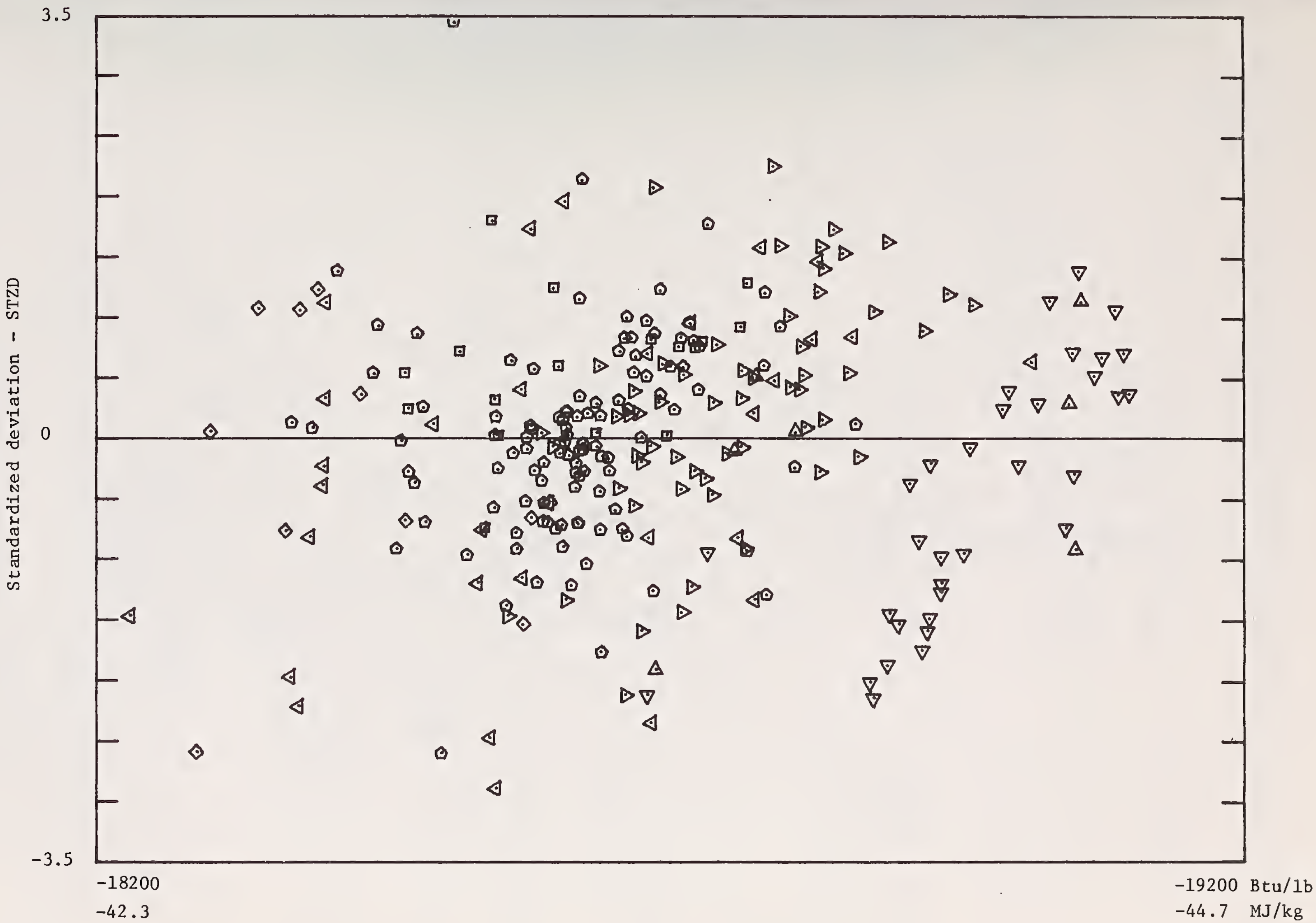

Figure 4. Net enthalpy of combustion.

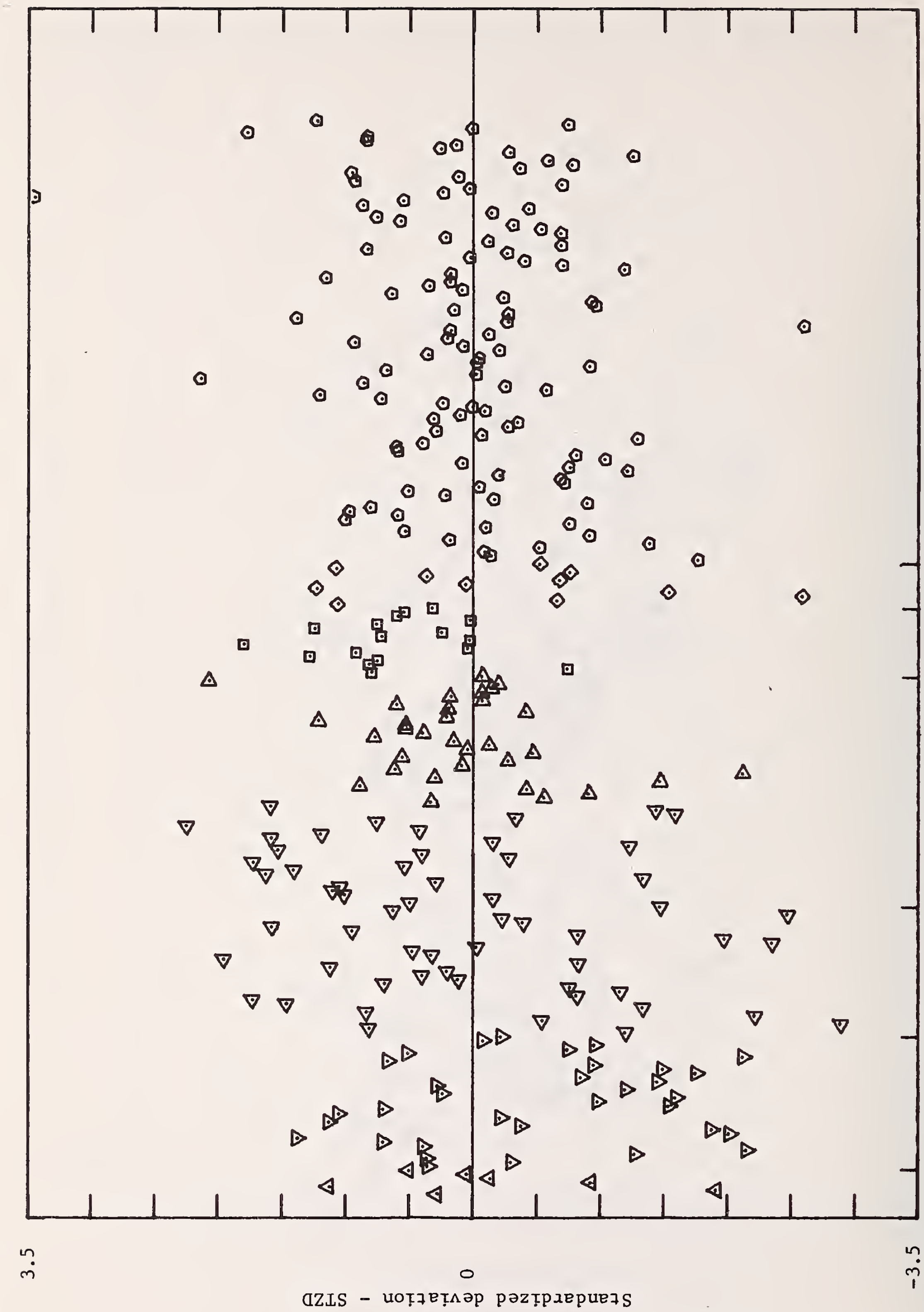

Figure 5. Sample number.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

A new correlation has been made of the net enthalpy of combustion of some aviation fuels with their aniline point, density, and sulfur content. Previous correlations gave a set of five equations relating the enthalpy of combustion to the aniline point gravity product for five classes of fuels ranging from aviation gasoline to kerosine. These equations were in non-SI units.

The correlation reported here gives similar sets of equations using SI units and also gives a single equation which can be used to adequately predict the net enthalpy of combustion of all five classes of fuels from measurements of aniline point, density and sulfur content. This equation is:

$$Q = [B(0) + B(1) \times A + B(2) \times (1/D) + B(3) \times (A/D) + B(4) \times (A)^2 + B(5) \times (1/D)^2 + B(6) * S] \text{ MJ/kg.}$$

$B(0) = 22.9596 \text{ MJ} \cdot \text{kg}^{-1}$

$B(1) = -1.26587 \times 10^{-2} \text{ MJ} \cdot \text{kg}^{-1} \cdot {}^\circ\text{C}^{-1}$

$B(2) = 26.6409 \text{ MJ} \cdot \text{kg}^{-1} \cdot \text{g}^{-1} \cdot \text{cm}^3$

$B(3) = 0.032622 \text{ MJ} \cdot \text{kg}^{-1} \cdot {}^\circ\text{C}^{-1} \cdot \text{g}^{-1} \text{cm}^3$

$B(4) = -6.6903 \times 10^{-5} \text{ MJ} \cdot \text{kg}^{-1} \cdot {}^\circ\text{C}^{-2}$

$B(5) = -9.21776 \text{ MJ} \cdot \text{kg}^{-1} \cdot \text{g}^{-2} \cdot \text{cm}^6$

$B(6) = 50. \text{ MJ} \cdot \text{kg}^{-1} \cdot \text{S}^{-1}$

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Aniline point; API gravity; aviation fuels; enthalpy of combustion; fuels; gasoline; gravity; heat content; heat of combustion; kerosine.

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