Energy, Mines and Resources Canada / Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology / Centre canadien de la technologie des minéraux et de l'énergie

EVALUATION OF A LABORATORY METHOD FOR DETERMINATION OF CETANE NUMBER OF CANADIAN DIESEL FUELS

A.E. George and G.T. Smiley

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
REPORT ERP/ERL 81-76(TR)

CONTENTS

Page

INTRODUCTION i
EXPERIMENTAL 1
Apparatus 1
Samples 1
Procedure 2
RESULTS AND DISCUSSION 2
REFERENCES 3

TABLES

No.

1. Comparison of cetane number determination of diesel fuels by engine testing and autoignition temperatures 4
2. Comparison of cetane rating determinations for diesel fuels byb autoignition temperatures and engine testing 5

FIGURES

1. Laboratory instrument for determination of diesel fuel cetane number on the basis of autoignition temperature 6
2. Correlation of autoignition temperature with the cetane number of a primary reference fuel 7
3. Comparison of autoignition temperature of primary reference fuel and diesel fuels using a modified Moore S.I.T. apparatus .. 8

EVALUATION OF A LABORATORY METHOD FOR THE DETERMINATION OF CETANE NUMBER OF CANADIAN DIESEL FUELS

by

A.E. George and G.T. Smiley

INTRODUCTION

Cetane numbers are used to indicate the quality of a fuel oil for compression-ignition (CI) engines. Hexadecane (cetane) is readily ignited in a CI engine at low compression ratios and therefore it is arbitrarily assigned a rating of 100. The other primary reference fuel is α-methyl naphthalene, with an arbitrarily assigned value of 0 cetane. Therefore, a cetane rating of 45 assigned to a fuel oil means that the fuel will have auto ignition characteristics in a standard engine and standard operating conditions equivalent to those of a mixture of 45 parts by volume of n-cetane and 55 parts by volume of α-methyl naphthalene. Not only the inavailability of engine test units in may laboratories but also the large fuel sample size required (1 litre), hamper research into methods of assessing diesel fuel quality under laboratory conditions.

Many efforts have been made to correlate physical properties of diesel fuel to the cetane rating (1-7). Chemical analysis of diesel fuels does not give sufficient data for grading them according to autoignition characteristics (2). From gas chromatographic analysis it is suggested that an analyst might obtain evidence of the fractionation and blending of components, distribution of some types of hydrocarbons, the presence of additives, and a fast and approximate characterization of this fuel (3).

The type of crude oil used to produce diesel fuel determines the quality of the fuel. Crude oils have been defined in terms of the distribution of paraffins, naphthenes and aromatics in the straight-run product. The table cited by Bogen and Wilson (4) shows that the higher the paraffinic content, the higher the cetane number. Shefter et al, developed a chromatographic method for determining the C_8 - C_{25} n-paraffin content of diesel fuels using molecular sieves to quantitatively extract n-paraffins and compare the original and deparaffinized products by gas-liquid chromatography

(5). G.S. Shneider developed a mathematical correlation between the sulfonatables in light catalytic gas oil and cetane number (6). In 1973, Andrzyiwski and co-workers tried unsuccessfully to correlate cetane number with ignition quality of diesel fuels using a CI engine and a constant volume bomb (7). This laboratory adopted the method developed by V.S. Azev, et al, (8) and built a modified Moore Spontaneous Ignition Temperature (S.I.T.) apparatus to evaluate the potential of applying the method to diesel fuels produced from Canadian conventional and synthetic fuels. Cetane numbers of six diesel fuel samples obtained by this method were compared with the results of engine testing.

EXPERIMENTAL

Apparatus:

- Bomb 7.6 cm i.d. x 12.7 cm ht.
- Polished steel disc 6.35 cm diameter
- Air flow: 15 l/hr.

(see Figure 1)

Samples:

1. Primary Reference Fuels - various blends of cetane and α-methyl naphthalene to produce with cetane numbers of 30, 40, 50, 60 and 70.

2. Six diesel fuels with cetane numbers of 30, 34, 40, 42, 44 and 47 obtained from Imperial Oil Limited, Sarnia, Ontario (received December, 1980).

3. Six diesel fuels with cetane numbers of 24.0, 29.0, 30.2, 53.6, 54.0 and 56.2 from Imperial Oil Limited, Sarnia, Ontario (received July, 1981).

Samples under 1 and 2 were used to develop the method and calibration curves. Samples under 3 were used to assess the method for assigning accurate cetane numbers to diesel fuels.

Procedure:

The autoignition temperature is defined as the lowest temperature for ignition of a drop of fuel falling from a height of 15 cm onto a polished steel disc that has been heated to a given test temperature. The autoignition temperature is determined by testing every 2-4°C while the temperature of the polished disc is being lowered.

RESULTS AND DISCUSSION

The relationship between the lowest autoignition temperature and the composition of primary reference fuels is shown in Figure 2. The linearity of the results is in agreement with Azev and his co-workers' results. Figure 3 shows the autoignition temperatures of commercial diesel fuels with known cetane numbers when tested under the same conditions. On comparing the results for the primary reference fuel and diesel oils it can be seen that there is an autoignition temperature depression of 21°C at cetane 30 and 18°C at cetane 50. These diesel fuels did not have additives as ignition accelerators.

The diesel fuel with cetane number 34 is a syncrude distillate cut, whereas, the others are conventional oil distillates blended with syncrude distillates. It could be suggested that the depressed autoignition temperatures may be characteristic of syncrudes produced from Canadian crude oils.

The autoignition temperatures of another six diesel oils were determined by this method and by engine tests. The data are presented in Table 1. The method at this stage is accurate enough to provide a preliminary assessment of diesel fuel ignitability. However, industry's demand for accurate cetane ratings exceed the scope of this method of determining ignition quality.

REFERENCES

1. Obert, E.F. "Internal combustion engines, analysis and practice"; International Textbook Company; Scranton, Penn., 2nd ed; p 224-299; 1951.

2. Nash, A.W. and Howes, D.A. "The principles of motor fuel preparation and application"; Chapman and Hall Ltd. London, vol. 2, p 445-462; 1935.

3. Petrovic, K and Vitorovic, D. "Recognition and qualitative characterization of commercial petroleum fuels and synthetic fuels by a gas chromatographic fingerprinting technique"; Journal of Chromatography, 119, p 413-422; 1976.

4. Bogen, J.S. and Wilson, G.C. "Ignition accelerators for compression-ignition engine fuels"; Petroleum Refiner, vol. 23, No. 7, p 118-128; 1944.

5. Shefter, V.E., Kurchashova, N.A. and Blokh, N.V. "Gas chromatographic determination of C_8-C_{23} n-paraffins in petroleum products"; All-Union Scientific-Research Institute of Petrochemical Processes, Leningrad, Plenum Publishing Corp., p 446-449 (Russian translation); 1978.

6. G.S. Shneider. "Graphic-analytical method of determination of cetane number of light catalytic gas oils"; Khimiya i Tekhnologiya, Topliv i Masel, no. 6, p 40-43; June 1972.

7. Bochenski, C. and Saraghi, R. "Some considerations concerning the ignition quality criteria of diesel fuels"; Archiwun Procesow Spalania, vol 4, no. 3, p 293-304; 1973. (in Russian)

8. Azev, V.S., Tugolukov, V.M. Kukushkin, A.A. and Livshits, S.M. "Laboratory method for determining diesel fuel cetane number without engine test"; Khimiya i Tekhnologiya Topliv i Masel, no. 1, p 51-53 (English translation); 1978.

Table 1 - Comparison of cetane number determination of diesel fuels by engine testing and autoignition temperatures

Diesel Oil	Autoignition Temperature, (°C)				Cetane No (Bomb)	Cetane No (engine test)
	Test 1	Test 2	Test 3	Average		
1	218	213	215	215.3	22	24.0
2	213	209	205	209	32	29.0
3	208	214	215	212.3	28	30.2
4	198	196	200	198	50	53.6
5	197	198	194	196.3	52	54.0
6	196	192	191	193	58	56.2

Table 2 - Comparison of cetane rating determinations for diesel fuels by autoignition temperatures and engine testing

Diesel Fuel Sample	Bomb Method		Engine Test
	Autoignition Temp. °C *	Cetane No.	Cetane No.
1	215.3	22	24.0
2	209	32	29.0
3	212.3	28	30.2
4	198	50	53.6
5	196.3	52	54.0
6	193	58	56.2

* Each result represents the average of 3 readings

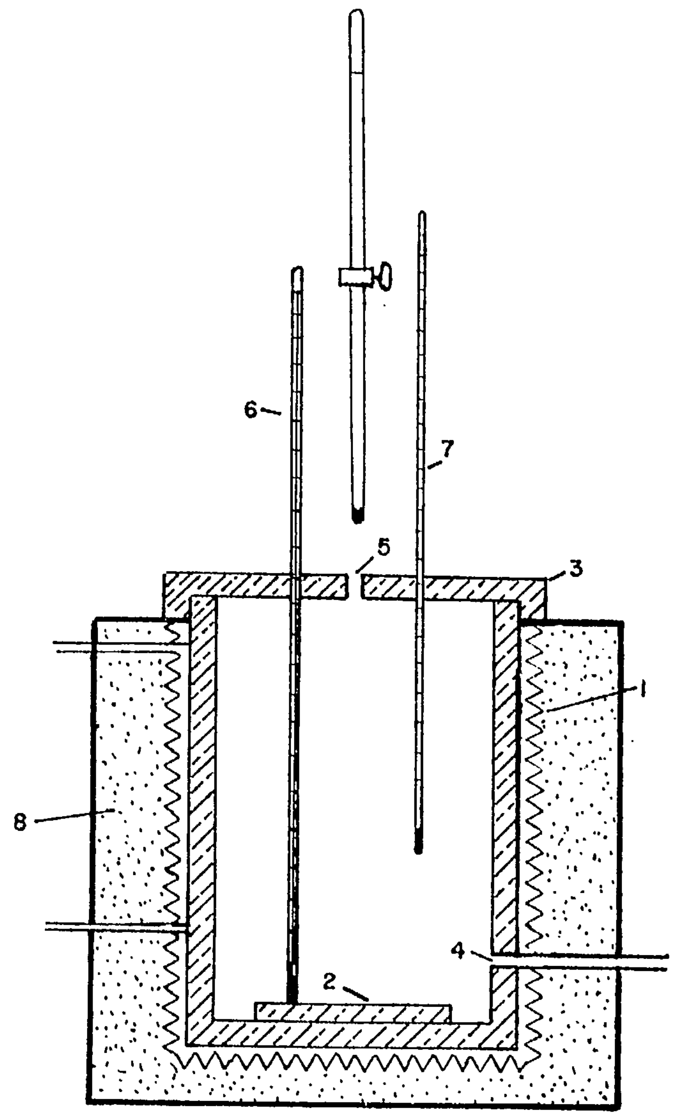

Fig. 1 - Laboratory instrument for determination of diesel fuel cetane number on the basis of autoignition temperature

1) electric heater ; 2) polished steel disc;
3) steel bomb ; 4) heated air inlet to bomb;
5) fuel inlet port ; 6,7) thermometers
8) insulation

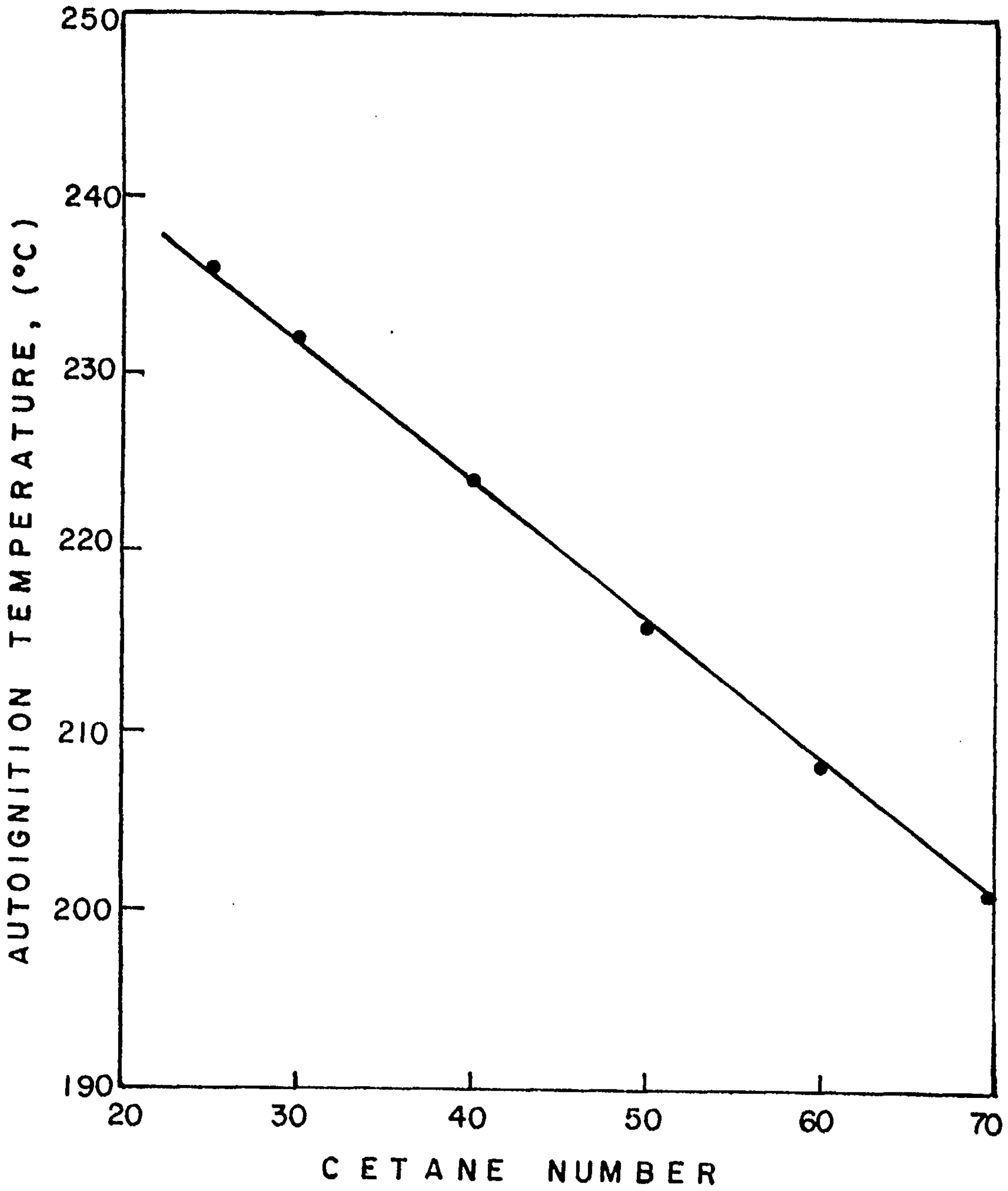

Fig. 2 - Correlation of autoignition temperature with the cetane number of a primary reference fuel

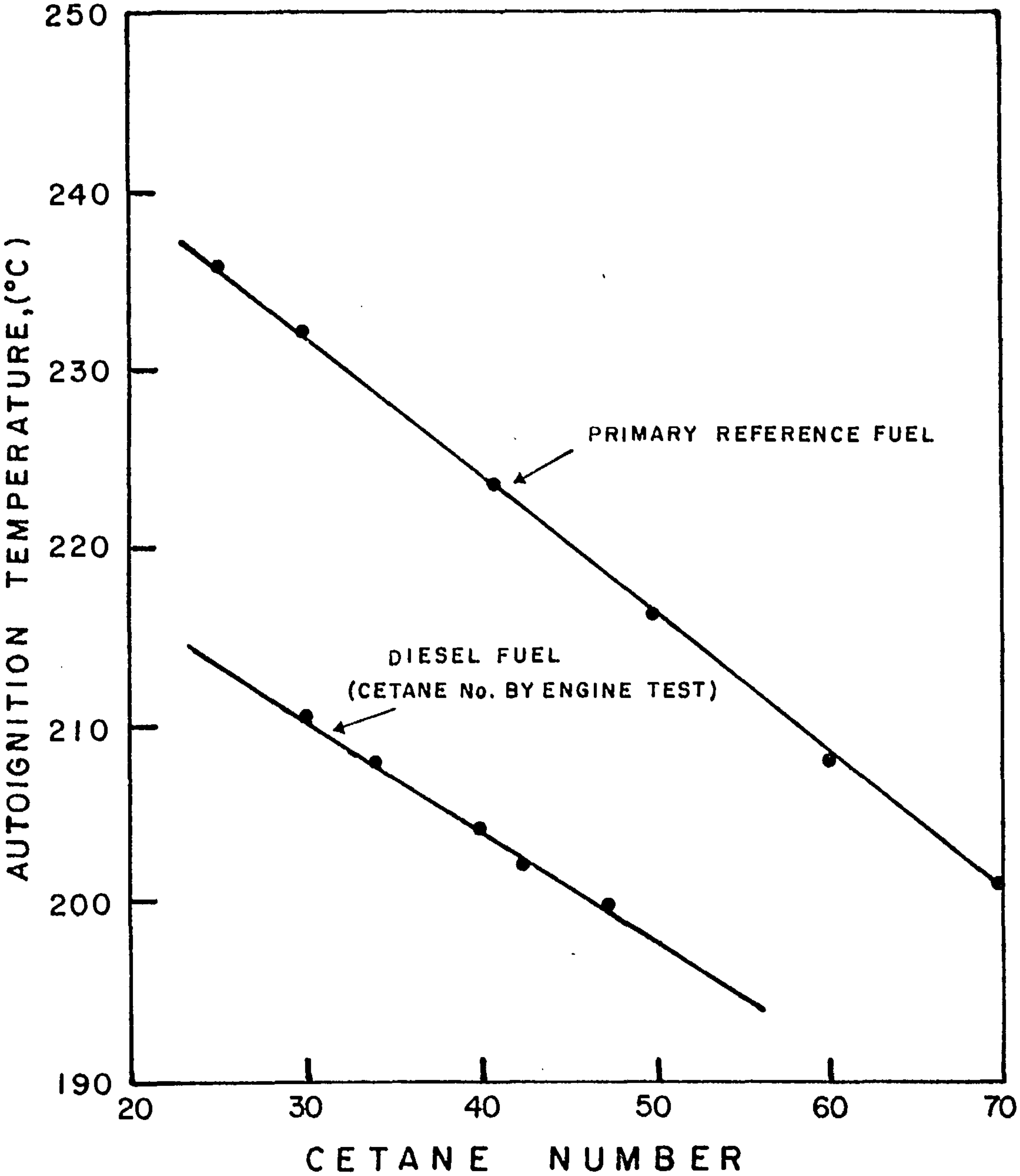

Fig. 3 - Comparison of autoignition temerature of primary reference fuel and diesel fuels using a modified Moore S.I.T. apparatus