~~INDEX 5 A(i)~~ DIPETANE TREATED FUELS

BOILERS

FUEL SAVING TESTS

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REPORT NO 3.

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REPORT 3

Further investigation of the characteristics of gas oil treated with Dipetane Fuel Treatment by means of a controlled test using a domestic oil fired boiler

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SUMMARY

A domestic oil fired boiler operating on Gas Oil was setup on test to determine the effect of using an additive on the characteristics of the fuel. From the data measured over a period of 1036 hours an energy balance was established using information contained in BS 7190, from which it was possible to ascertain the energy release from the combustion of the fuel.

1. REVIEW OF PROCEDURE:

1.1 From previous experience of investigating the characteristics of gas oil treated with additive, it was felt that the energy transfer rate across the boiler should be monitored at regular intervals throughout the test.

In order to do this a Thermal Energy Meter was used to determine the energy transferred to the system, with the accuracy of the meter confirmed by applying the test procedure laid down in BS7190 to determine boiler Thermal Efficiency. [APPENDIX I]

1.2 One of the claims made for this additive was that it would reduce the amount of fuel required to produce a given quantity of energy. In order to achieve this aim it follows that there must be an 'Enhanced Energy Release' above the Calorific Value for the fuel.

If this is so, then Thermal Efficiency of the boiler is no longer a useable parameter, as it is calculated using the assumption that 'Energy Release' from the fuel, ie Calorific Value, remains constant.

A more useful unit of measurement is the Specific Fuel Consumption (SFC) for the boiler measured in units of grammes of fuel per kWh of energy produced (g/kWh).

1.3 As well as determining the energy transfer across the boiler, flue gas analyzing equipment was used to monitor the O_2, CO, SO_2, NO, NO_2 and boiler smoke number, at intervals throughout the test period.

2. EQUIPMENT USED

2.1	Boiler Type:	Warmflow 50,000/90,000 BTU output, fitted with a pressure jet oil burner:- Riello 40 Type 437T50 Nozzle size: 0.6 galls/hr Nozzle spray angle: 80°
2.2	Thermal Energy Meter:	Aquametro PMG-IH Test Certificate No 2805 Accuracy - Integrator ± 0% Flowmeter ± 2%
2.3	Gas Analyzer:	Testo 33 TÜV TestReport BI 147/148 O_2: tolerance ± 0.2% CO, NO, NO_2, SO_2: tolerance ± 20 ppm Flue gas temp: tolerance ± 0.5°C
2.4	Smoke Number:	True Spot Smoke Tester Type RCC-B Bacharach Instrument Co
2.5	Chart Recorder:	Chessell 320 3-channel. Measuring performance 0.5%. K-type thermocouples.
2.6	Weighing Balance:	Mettler Electronic Scales PM 30000-K Reproducibility - 0.1 grams

3. SET-UP PROCEDURE

3.1 Boiler installed on test hearth and the combustion operating conditions optimised as follows:

Excess O_2 -	3.0%
CO -	6 ppm
Flue gas Temp -	260°C
Smoke No -	3

3.2 It was decided that the boiler operating conditions should be such that it would operate with a smoke number in the upper range of the acceptable limit, in order that a carbon build-up should take place on the internal surfaces during operation.

3.3 The boiler and test rig were then commissioned using procedures laid down in BS7190 to determine 'Thermal Efficiency' of boiler and accuracy of Thermal Energy Meter. [APPENDIX I]

4. TEST PROCEDURE - GAS OIL:

4.1 Boiler operated on test rig over a period of 275 hours burning Gas Oil Class D to BS 2869 - 1988.

4.2 During this period boiler energy transfer rates were determined at regular intervals (Graph 1). Each test consisted of a test run over a period of approximately 3 hours, where the boiler was operated on a continuous load, during which a fixed quantity of fuel was burnt.

From the values of the (1) time taken, measured by an electronic counter, (2) quantity of fuel consumed, measured on electronic scales, (3) energy supplied to system, measured from thermal energy meter, the following data was calculated:-

SFC (g/kWh)	(Graph 1)
Fuel flow rate (kg/h)	
Boiler efficiency (calculated)	(Graph 10)

4.3 During each test period, approximately 30 mins prior to the completion of the test period, gas analyzing equipment was used to monitor the flue gas conditions of O_2, CO, SO_2, NO, NO_2, flue gas temperature and Smoke No.

4.4 Over the period of 275 hours a total of 21 tests were performed where the parameters of 4.2 and 4.3 were recorded.

5. TEST PROCEDURE - GAS OIL TREATED WITH ADDITIVE:

5.1 The boiler was then operated on test rig over a period from 275 hours to 1,036 hours burning gas oil treated with additive, mixed in the ratio 200 : 1.

5.2 During this period boiler energy transfer rates were determined at regular intervals (Graph 1).

Each test consisted of a test run over a period of approximately 3 hours, where the boiler was operated on a continuous load during which a fixed quantity of fuel was burnt.

From the values of (1) time taken, measured by an electronic counter, (2) quantity of fuel consumed, measured on electronic scales, (3) energy supplied to system, measured from the thermal energy meter, the following data was calculated -

SFC (g/kWh)	(Graph 1)
Fuel Flow rate (kg/h)	
Boiler efficiency (calculated)	(Graph 10)

5.3 During each test period approximately 30 mins. prior to the completion of the test period, gas analyzing equipment was used to monitor the flue gas conditions of O_2, CO, SO_2, NO, NO_2, flue gas temperature and Smoke No.

5.4 Over the test period from 275 hours to 1,036 hours a total of 23 tests were performed where the parameters of 5.2 and 5.3 were recorded.

6. ANALYSIS OF RESULTS:

Because of the quantity of data recorded throughout the complete test programme, it was decided to display the results obtained - both from measured data and derived data - in the form of graphs of the relevant data plotted against the number of hours the boiler ran on test.

Graph 1 - Hours run v Specific Fuel Consumption
Graph 2 - Hours run v Excess O_2 in flue gas
Graph 3 - Hours run v Smoke Number
Graph 4 - Hours run v CO
Graph 5 - Hours run v SO_2 / Regression Analysis
Graph 6 - Hours run v NO / Regression Analysis
Graph 7 - Hours run v Flue Gas Temperature
Graph 8 - Hours run v Energy Balance
Graph 9 - Hours run v Efficiency (measured)
Graph 10 - Hours run v Efficiency (calculated)

It was assumed that the Calorific Value of Gas oil was 45.6 MJ/kg. This value was obtained from Shell Technical Services and was used throughout in any calculations requiring the Calorific Value.

However, analysis of two samples of gas oil - one untreated and the other treated by the additive - gave the calorific values to be 45.092 MJ/kg for untreated fuel and 45.176 MJ/kg for treated fuel. (See Report No 5871/92).

6.1 Graph 1 - Specific Fuel Consumption:

6.1.1 Prior to the changeover of fuels to treated gas oil, ie 275 hours, the SFC for the boiler averaged out at 96.53 g/kWh.

Assuming CV of 45.6 MJ/kg,

then energy produced by boiler/kWh	=	96.53 x 45.6
	=	4401.768 kJ/kWh
Thus - Boiler Thermal Efficiency	=	$\frac{3600}{4401}$
	=	81.79%

This value bears out with the results from 0 to 275 hrs in Graph 10, but also validates the use of SFC as a parameter to measure energy transfer across boiler.

6.1.2 After changing to Gas oil treated with the additive, the SFC remained unchanged for a period and then commenced to reduce to its lowest figure at 924 hour, of 85.13 g/kWh, whereby it remained within this vicinity to completion of test period.

The last three results were then averaged at 86.44 g/kWh and the percentage reduction in fuel to obtain 1 kWh of energy was calculated to be 10.45% over that period.

6.2 Graph 2 - Excess O_2:

6.2.1 Prior to additive being mixed with gas oil, ie at 275 hours, the excess oxygen in the flue gas remained around 3%.

6.2.2 However, it would appear that initially on changing to treated gas oil, the excess O_2 reduced to a lower value, perhaps as claimed by the additive manufacturer, due to the carbon deposits on the internal surfaces

of the boiler being 'burnt off' with further combustion taking place with this carbon.

Overall, during the period between 275 hours and 1,036 hours the excess O_2 readings remained lower.

6.2.3 Throughout the total test period, no attempt was made to regulate excess O_2 by making adjustments to the burner operating parameters.

6.3 Graph 3 - Smoke Number:

6.3.1 Prior to addition of additive the smoke number, as determined by the Bacharach Smoke tester, remained within the scale of 2/3.

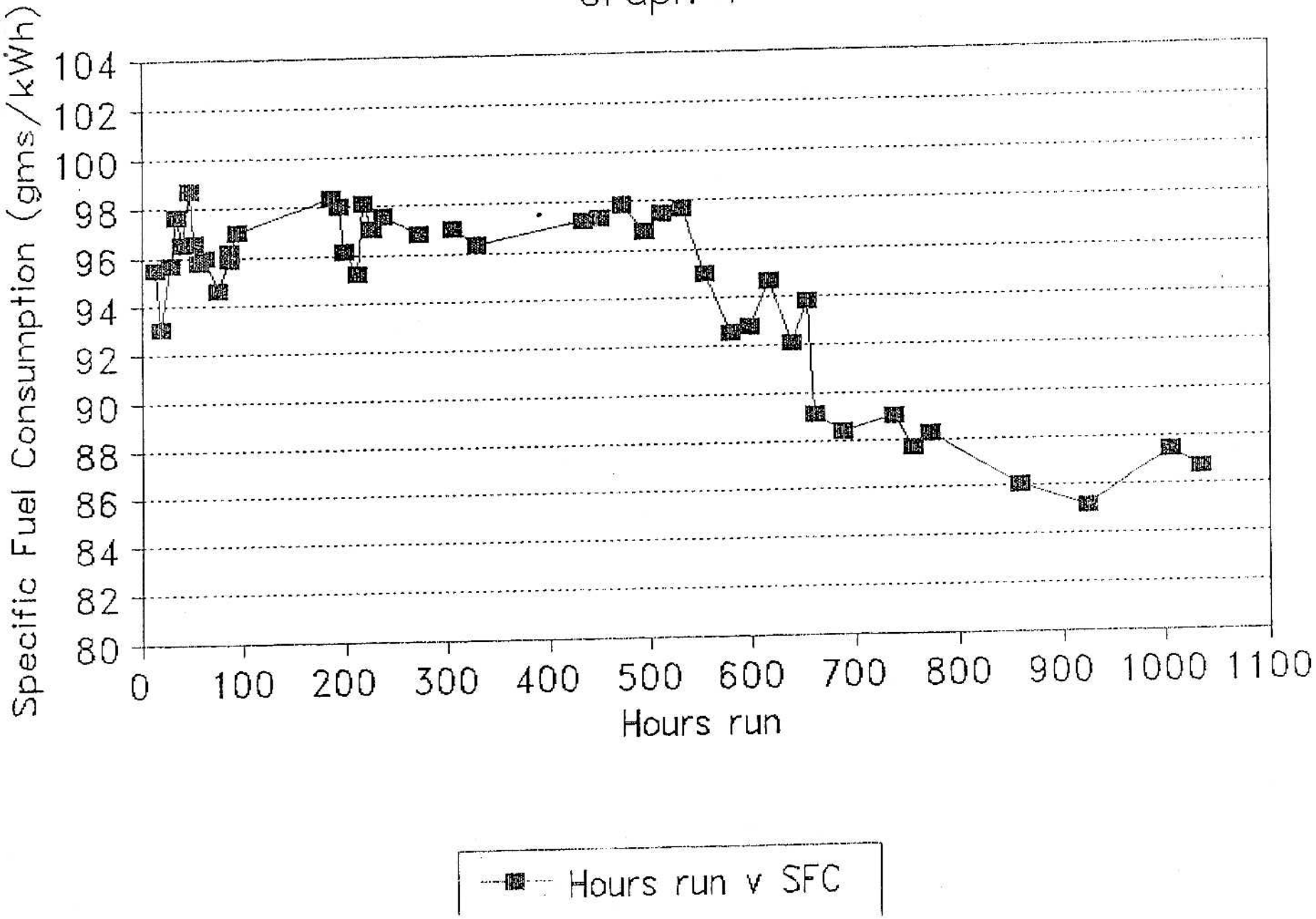
6.3.2 On operating boiler with additive in the fuel, the smoke number initially increased to a much higher value, whereby it stayed for a period. Then it dropped to a lower level again, although the excess O_2 in the flue gas (Graph 2) was at a lower value than prior to the addition of the additive.

6.3.3 Overall it would seem that the boiler smoke number was lower for the equivalent excess O_2 reading when using additive, and if smoke number is an indication of particulate matter in the flue gas, then it would indicate a slight reduction in particulate matter.

6.3.4 It could also be suggested that the initial high smoke reading between 275 hours and 450 hours was due to the 'Burn off' of the carbon deposits on the boiler internals.

Hours run v SFC

Graph 1



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CERTIFICATE NUMBER

2805

THIS IS TO CERTIFY

Volumetro Meter Type: ...PMG-IH.... Integrator Type: Mecal: CA2 .....

Meter Bore Size: ...1" [25mm]. Calec: C.E.H. .....

" C.E.F. .....

" M.C.L ..✓.....

" E. .....

" W. .....

Meter Number: ...2,946,912..... Integrator Number: ...3,034,362.....

was tested and/or re-calibrated within the accuracy tolerance stated on .30th January 1991

	High T	Low T
Integrator	±0 .....%	±0 .....%

Meter ±2 .....%
[Flow range]

Site and/or Location: University of Ulster

Remarks:

for THE RANGER INSTRUMENT COMPANY LIMITED