REPORT OF THE
FTC FUEL COMBUSTION CATALYST TRIAL
M.V. NEPTUNE JASPER
NEPTUNE ORIENT LINE
SINGAPORE

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May 1988

REPORT OF THE FTC FUEL COMBUSTION CATALYST TRIAL,
M.V. NEPTUNE JASPER TO MARCH 1988

CONTENTS

INTRODUCTION

This report describes the results of a four month trial of a ferrous picrate combustion catalyst (FTC-3) metered into the bunker fuel of Neptune Orient Line, m.v. Neptune Jasper. The purpose of the trial was to confirm and better quantify improved fuel economy and engine cleanliness.

The report sections which follow first describe, with supporting technical evidence, the ferrous picrate catalyst, then the trial programme and the data retrieved therefrom and finally, the observed and measured changes in the ship's engine operations.

A section dealing with the economic implications of the trial results concludes the report.

CONCLUSIONS AND RECOMMENDATIONS

1. In spite of the comprehensive operating data available from the ship's engine log, the data variables make an accurate quantification of fuel savings from the fuel treatment difficult, even with advanced statistical means. However, the analyses clearly indicate the fuel treatment resulted in fuel savings.

2. The conclusions to be drawn from this report are that observable and measured improvements have been demonstrated in fuel combustion during the trial.

3. These improvements in combustion translate into financial benefits; first through fuel savings and secondly, and perhaps even more significant, important maintenance benefits which will reduce costs and increase the efficiency and service life.

ACKNOWLEDGEMENTS

This study is a product of interest and support given by the Neptune Ship Management Services (Pte) Ltd organization and the ship's officers all of whom have given generously and courteously of their experience, knowledge and time.

FUEL TECHNOLOGY PTY LTD
May 1988

SECTION 1

SECTION 1: THE FUEL CATALYST

The active ingredient added to the Neptune Jasper fuel is ferrous picrate carried in an aromatic solvent vehicle. The product was first developed at the University of British Columbia and the earliest patents were applied for in 1944 and granted in 1950.

FTC=3 is added to the fuel at a 1:3000 ratio, e.g. one litre of FTC-3 treats approximately three tonnes of fuel. The initial dosing procedure involved pouring FTC-3 directly into the bunkers during fuelling operations, was not successful and bunker samples showed no evidence of ferrous picrate in solution. The ongoing trial from December 1987 involved installation of a metering pump and injecting FTC at the main engine fuel oil mixing tube.

Studies by the manufacturer and independent researchers (2), (3) describe three actions by which the product containing ferrous picrate improves combustion:

a. The aromatic solvent improves misting of fuel upon injection.

b. The heat in the combustion chamber vaporizes the small amount of alcohol in each fuel droplet, precipitating for an instant microcrystals of ferrous picrate. These ignite before and during the fuel burn, generating multiple flame centres.

c. The free FE++ ions released by the action in step 2 act catalytically to promote oxidation by breaking hydrocarbon molecular bonds in fuel droplets and in any complex carbon deposits found in the combustion zone.

(2) Albert F. Bush, Professor of Engineering, U.C.L.A., School of Engineering, Report CPR 7, December 1971.

(3) Robert B. Sterns, Ferrous Corporation, U.S.A., The Motor Ship, December 1981.

If the process described in steps 1-3 is correct, the result of treating fuel with FTC should be:

- a shorter ignition lag, reducing the time of the first phase of combustion,
- acceleration of the second and third phases of combustion,
- increased power from a set amount of fuel,
- reduced fuel consumption at a given load,
- reduced emissions of HC, CO and CO_2 in a given mass of engine exhaust, and
- a gradual elimination of combustion-zone carbon deposits.

As demonstrated by the curves, tables and photographs in Appendix 1, this is exactly what happens.

Appendix 1A: Curves 1-3 were developed by Mr John Gould using a 7.5 kW dynamometer in the Thermodynamics Laboratory at the West Australian Institute of Technology (W.A.I.T.).

Graph 1: "Power vs Injection Timing" shows that as the concentration of active ingredient in fuel treated with FTC increases from zero to a 1:1200 mixture, the maximum power value achieved from pure diesel fuel injected at 35 degrees before TDC is matched by treated fuel at around 32 degrees because of reduced ignition lag. Power throughout the injection range is higher with treated fuel indicating more complete combustion in phases two and three.

Graph 2: "Power Comparisons" shows that power increases with increasing concentration of FTC catalyst.

Graph 3: "Fuel Consumption Comparisons" shows a decrease in fuel consumption with increasing concentration of the active ingredient. Consumption is measured in kilograms fuel per horsepower hour. Since the data for graphs 2 and 3 are taken from the same test, the power increase shown in graph 2 is actually developed at a decreased fuel consumption.

Graph 4: "Specific Fuel Consumption Trial" in a mining company's 650 kW engine shows two features

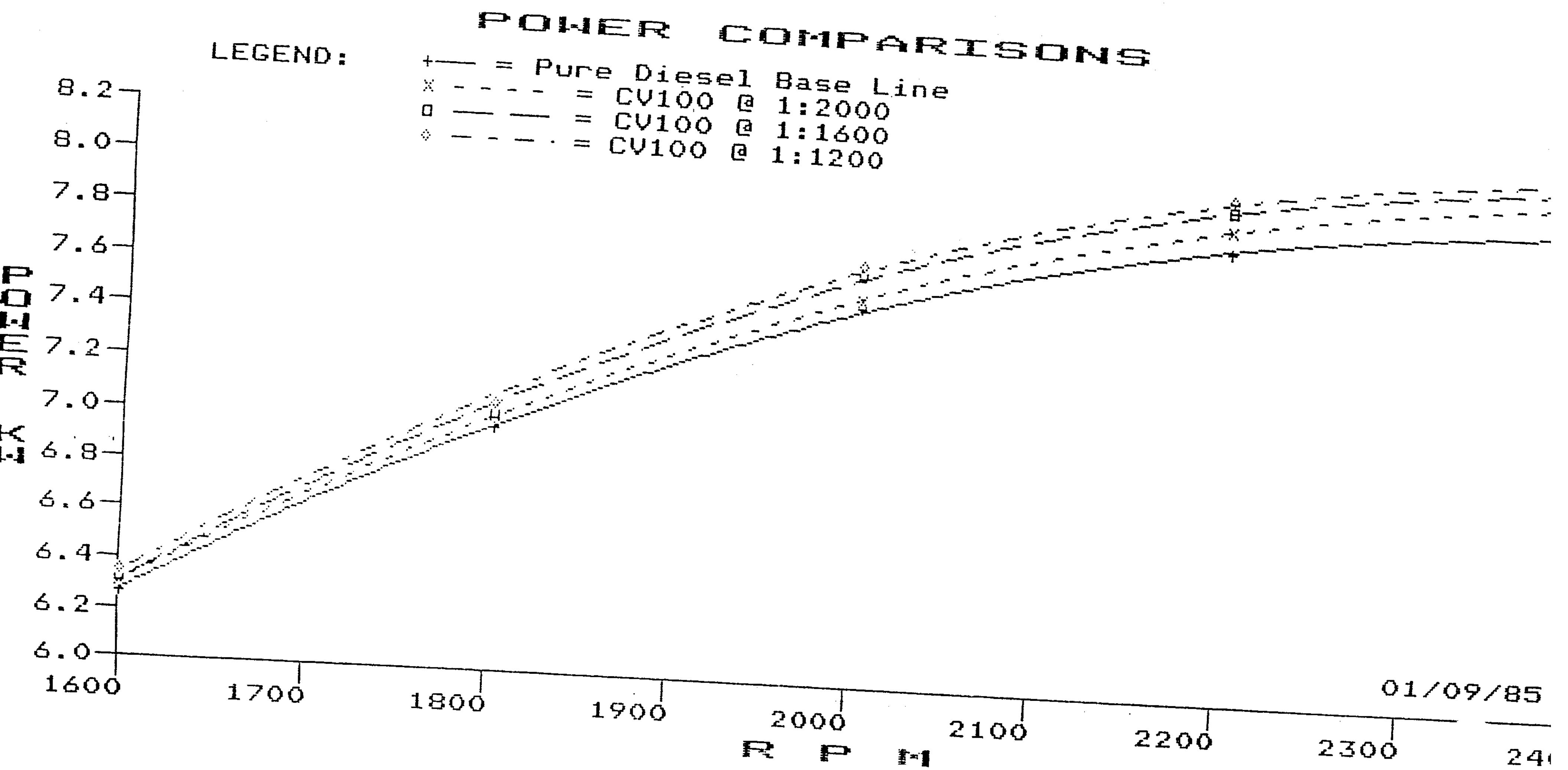
- an increase in untreated diesel fuel consumption over a three month period as a result of engine "ageing",
- a decrease in fuel consumption (approximately 4%) as a result of treating fuel with FTC.

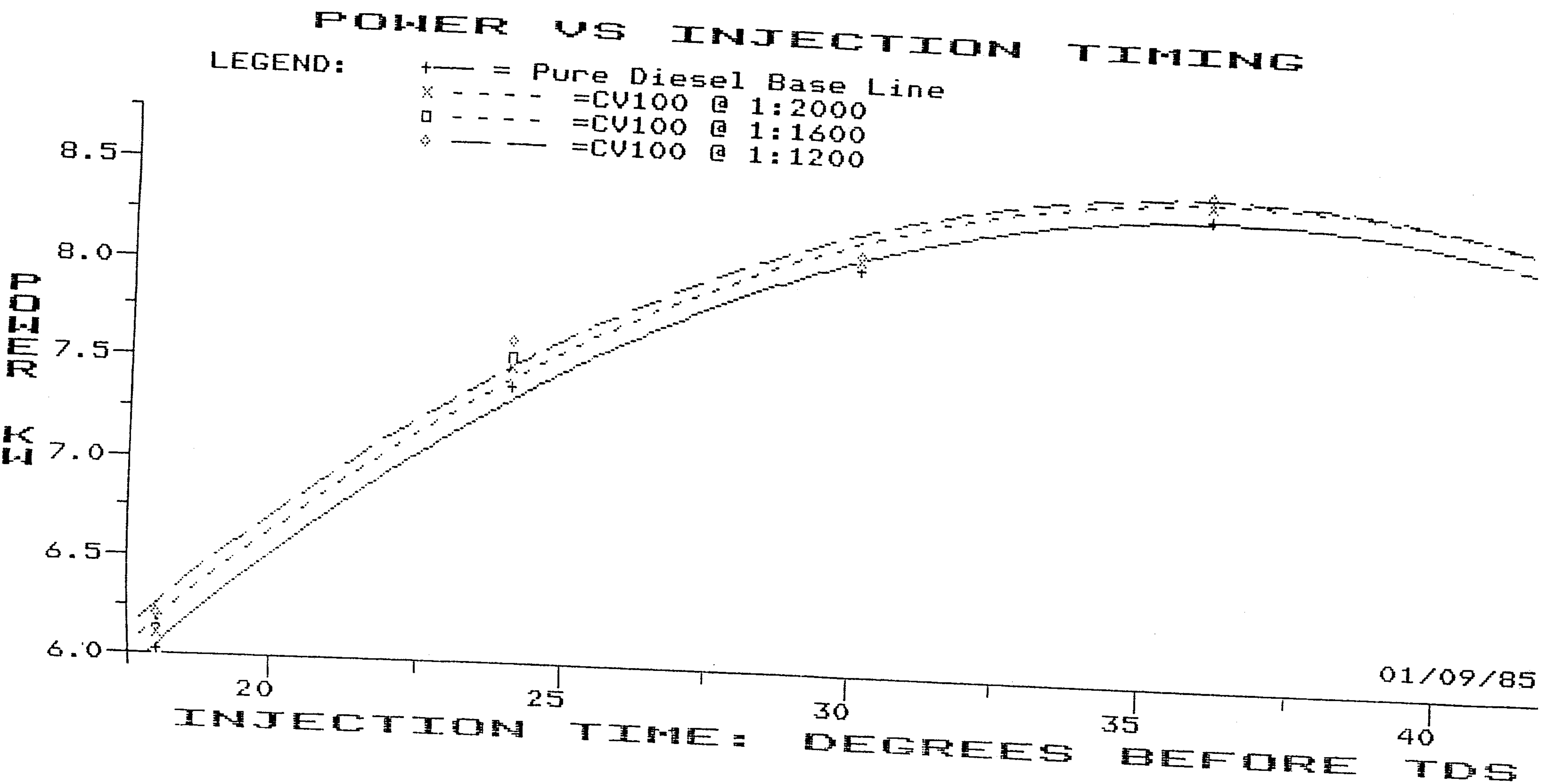
These consumption tests were run under the owner's supervision using the gravimetric fuel consumption method.

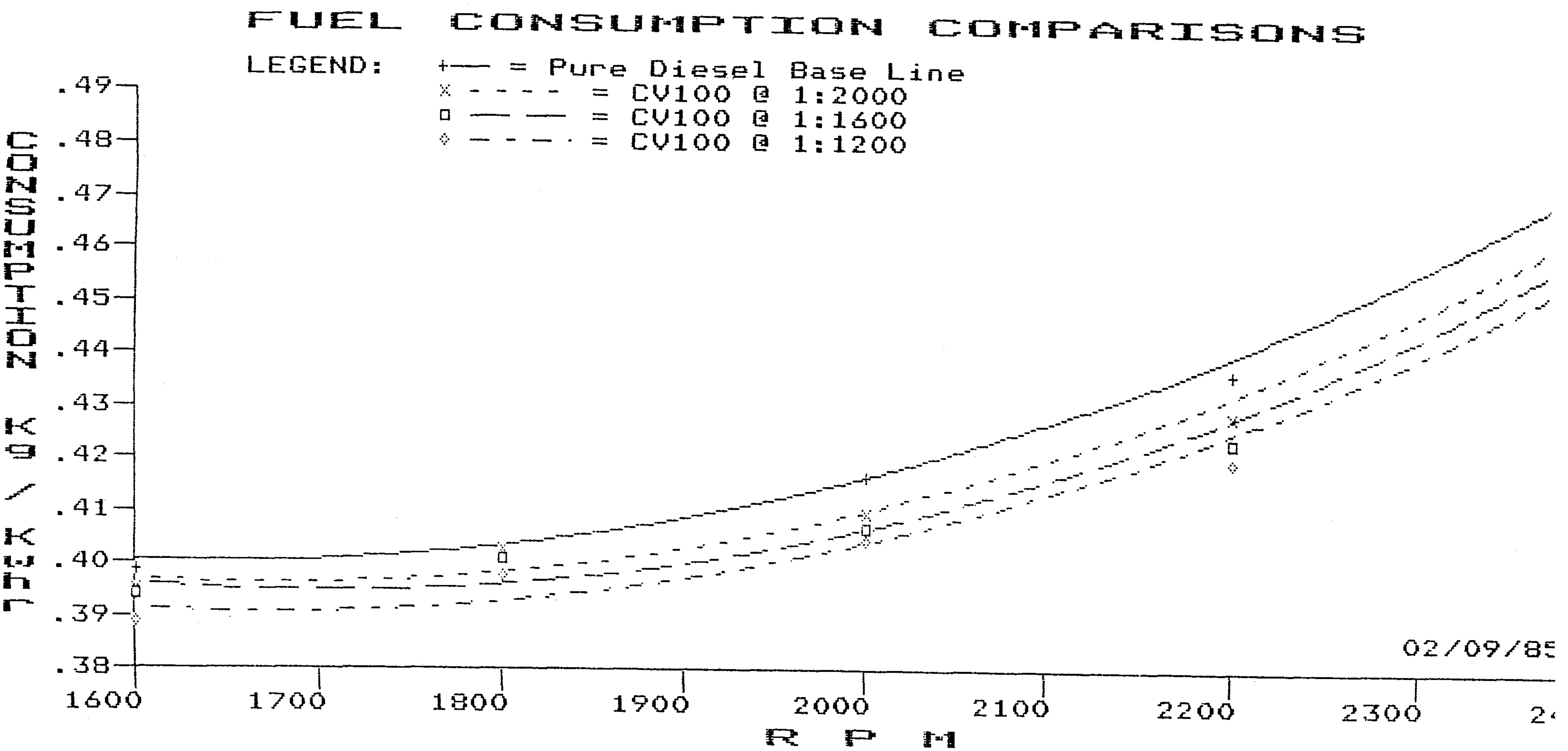
Appendix 1B: A 1978 report showing reduced CO and HC emissions from treated fuel by the testing laboratory of the New South Wales Department of Mines. The test measured emissions from a Perkins 3 cylinder diesel engine burning treated and untreated fuel. Since this report, Carbon Balance equipment has been used on numerous occasions measuring with similar results exhaust composition versus mass flow on a range of engines up to 15,000 kW capacity.

Appendix 1C: shows photographically the reduction of carbon deposits in two marine power plants.

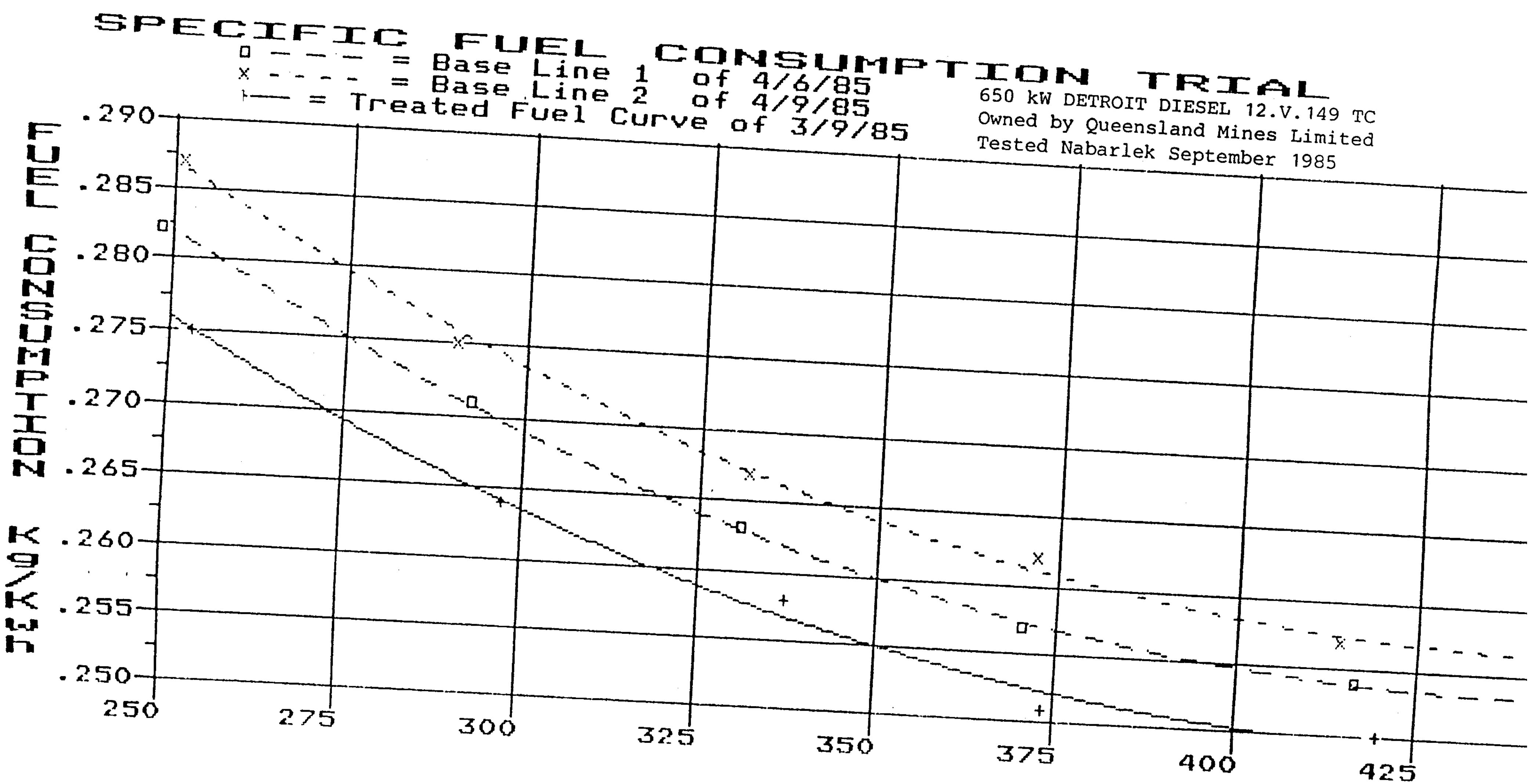
The Sections which follow demonstrate that FTC-3 treatment of m.v. Neptune Jasper fuel oil resulted in similar improvements to combustion.


POWER COMPARISONS
LEGEND:
+—— = Pure Diesel Base Line
x - - - - = CV100 @ 1:2000
□ —— —— = CV100 @ 1:1600
◇ — - — - = CV100 @ 1:1200
POWER KW
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
1600
1700
1800
1900
2000
2100
2200
2300
R P M
01/09/85


POWER VS INJECTION TIMING
LEGEND:
+—— = Pure Diesel Base Line
x - - - - =CV100 @ 1:2000
□ - - - - =CV100 @ 1:1600
◊ —— —— =CV100 @ 1:1200
8.5
8.0
7.5
7.0
6.5
6.0
POWER KW
20
25
30
35
40
INJECTION TIME: DEGREES BEFORE TDS
01/09/85



FUEL CONSUMPTION COMPARISONS
LEGEND:
+—— = Pure Diesel Base Line
x - - - - = CV100 @ 1:2000
□ —— —— = CV100 @ 1:1600
◇ - - - · = CV100 @ 1:1200
CONSUMPTION Kg / Kwhr
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
.39
.38
1600
1700
1800
1900
2000
2100
2200
2300
R P M
02/09/85


SPECIFIC FUEL CONSUMPTION TRIAL
□ - - - - = Base Line 1 of 4/6/85
x - - - - = Base Line 2 of 4/9/85
+—— = Treated Fuel Curve of 3/9/85
650 kW DETROIT DIESEL 12.V.149 TC
Owned by Queensland Mines Limited
Tested Nabarlek September 1985
FUEL CONSUMPTION
kg/kWh
.290
.285
.280
.275
.270
.265
.260
.255
.250
250
275
300
325
350
375
400
425

Department of Mines
CHEMICAL LABORATORY
Joseph Street,
Lidcombe, N.S.W.
P.O. Box 76
Lidcombe. 2141.

Mr D. Campbell,
Golden Fleece Petroleum,
P.O. Box 915,
NORTH SYDNEY. 2060

Our reference:

Your reference:

For further information
Telephone: 646 1644

Ring C. Ellis
Extension: 13

3rd October, 1978

Dear Sir,

Tests of Diesel Fuel Additive CV100

On 11th September and 15th September 1978, tests were carried out at the Londonderry Testing Station of this Department, to determine the effects of diesel fuel additive CV100 on exhaust gas composition.

A Perkins 3 cylinder diesel engine, of 152 cubic inches displacement, was operated on the dynamometer for about six hours, using standard diesel fuel. At the end of this period the exhaust gases were analysed.

The engine was then run for about 38 hours over the next four days, using the same fuel treated with additive CV100 in the proportion 1 to 1600. At the end of this period, the exhaust gas analyses were repeated.

The instruments used for analysis, and the results obtained, form a certificate attached to this report.

The tests after operation with the treated fuel showed the following:

1. A reduction in carbon monoxide emissions, of the order of 10% under the test conditions.

2. No significant change in oxides of nitrogen (or of nitric oxide).

3. A reduction in hydrocarbon emissions of 25% or more, under the test conditions.

I would draw your attention to the accuracies quoted in the dertificate, and to the additional comments at the end. These comments should explain the guarded manner in which I have expressed the results above.

"John McGlynn
for UNDER-SECRETARY"

...munications To Be Addressed To

The Under Secretary,
Department of Mines,
State Office Block,
Phillip Street,
Sydney. 2000

All Samples To Be Forwarded To

Department of Mines
Chemical Laboratory
Joseph Street
LIDCOMBE NSW 2141

PO Box 76
LIDCOMBE NSW 2141

Telephone: 646 1644

3rd October ,1978

Dear Sir,

The sample(s) ~~submitted by you on~~ of exhaust gas taken by C. Ellis on 11.9.78 & 15.9.78 ~~and stated to be~~ from the dynamometer - mounted Perkins 3-152 engine at the Department's Testing Station at Londonderry

have been ~~examined, assayed~~, analysed and results are shown on the Certificate below:

Mr D. Campbell
Golden Fleece Petroleum
P.O. Box 915
NORTH SYDNEY 2060

Yours faithfully,

G.M. MAXWELL
UNDER SECRETARY

CERTIFICATE No. CL 78920 Page 1 of 2

Analytical equipment used for assessment of fuel additive CV100

GAS	EQUIPMENT
Carbon dioxide	M.S.A. LIRA 202 carbon dioxide analyser, with linear output, digital display.
Carbon monoxide	Grubb Parsons model SB2 Infra Red Gas Analyser.
Oxides of nitrogen (NO & NO + NO_2)	A.M.I. Model 40R Chemiluminescence Analyser.
Oxygen	Taylor Servomex Type OA272 Oxygen Analyser
Hydrocarbons	M.S.A. FID Total Hydrocarbon Analyser.

N.B. Engine speed and power are included for identification of test conditions. These are not in accordance with the terms of this laboratory's N.A.T.A. registration.

NATA

Acting Director

Department of Mines
State Office Block
Phillip Street
SYDNEY NSW 2000

Joseph Street
LIDCOMBE NSW 2141

PO Box 76
LIDCOMBE NSW 2141

Telephone: 646 1644

3rd October ,1978

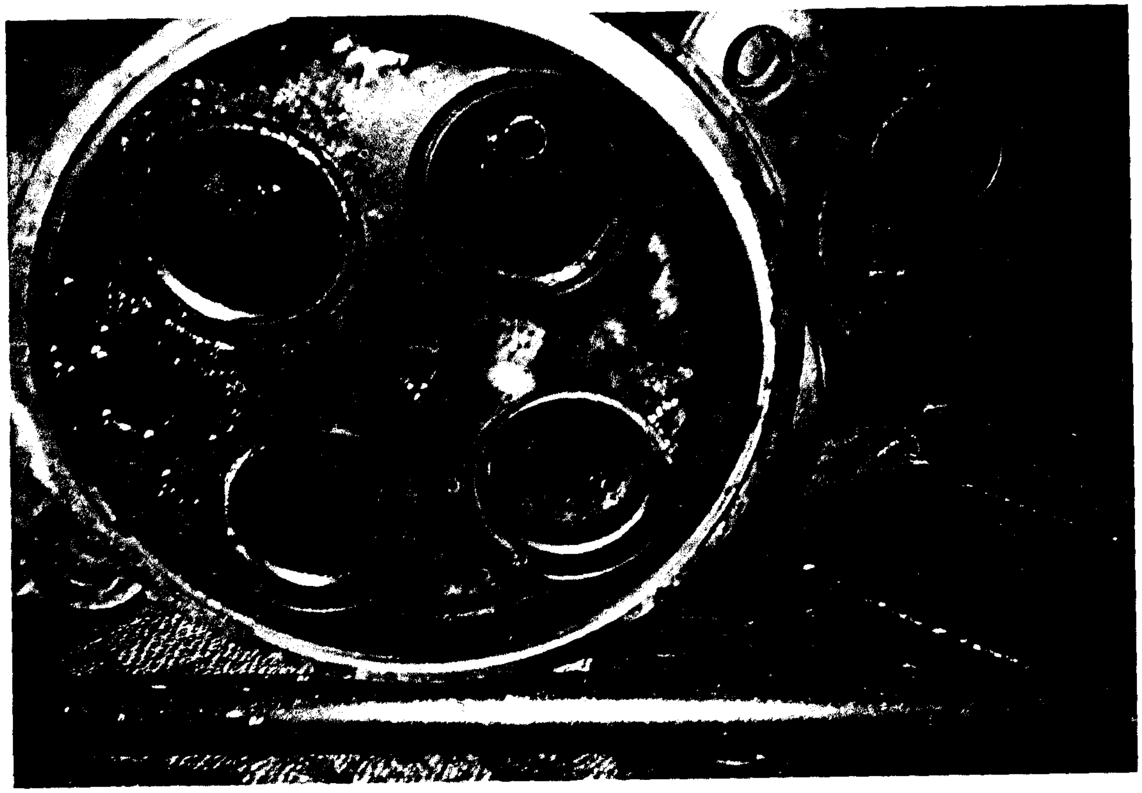
CERTIFICATE CL No. 78920

Fuel	Standard	Treated	Standard	Treated	Standard	Treated	Treated
Date	11.9.78	15.9.78	11.9.78	15.9.78	11.9.78	15.9.78	15.9.78
Engine Speed RPM	1200	1200	2000	2000	2000	2000	2000
Engine Power	22.5	22.5	36	36	37.5	37.5	38
Sample No.	3384	3385	3386	3387	3388	3389	3390
Carbon Dioxide (%)	8.7	8.3	9.5	9.2	9.8	9.5	9.7
Carbon Monoxide (ppm)	530 ± 20	420 ± 20	1140 ± 40	1040 ± 40	1380 ± 50	1260 ± 50	1310 ± 50
Difference (ppm)	110 ± 15		100 ± 35		120 ± 35		-
Nitric oxide + nitrogen dioxide (NO + NO_2; ppm NO)	1880 ± 40	1840 ± 40	1180 ± 40	1180 ± 40	1250 ± 40	1210 ± 40	1300 ± 40
Nitric oxide (ppm NO)	1750 ± 40	1700 ± 40	1130 ± 40	1140 ± 40	1180 ± 40	1140 ± 40	1230 ± 40
Oxygen (%)	8.7 ± 0.2	9.3 ± 0.2	7.7 ± 0.2	8.0 ± 0.2	7.1 ± 0.2	7.4 ± 0.2	7.2 ± 0.2
Total hydrocarbons (ppm equivalent methane)	60 ± 5	25 ± 5	145 ± 10	110 ± 10	165 ± 10	125 ± 10	125 ± 10
Difference (ppm)	35 ± 5		35 ± 10		40 ± 10		-

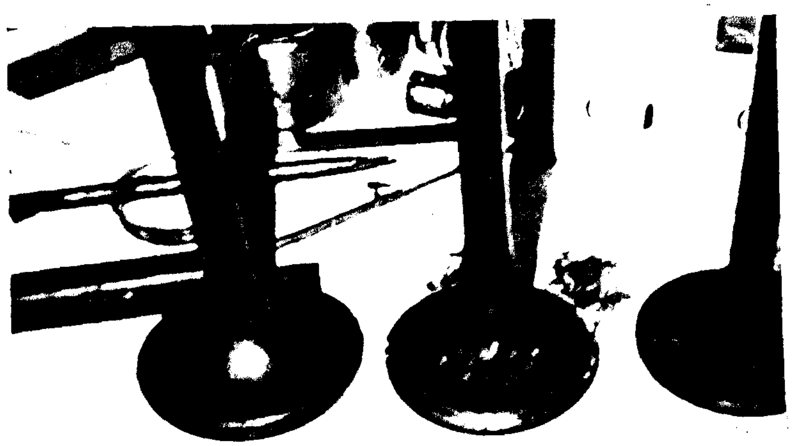
Additional comments concerning accuracy.

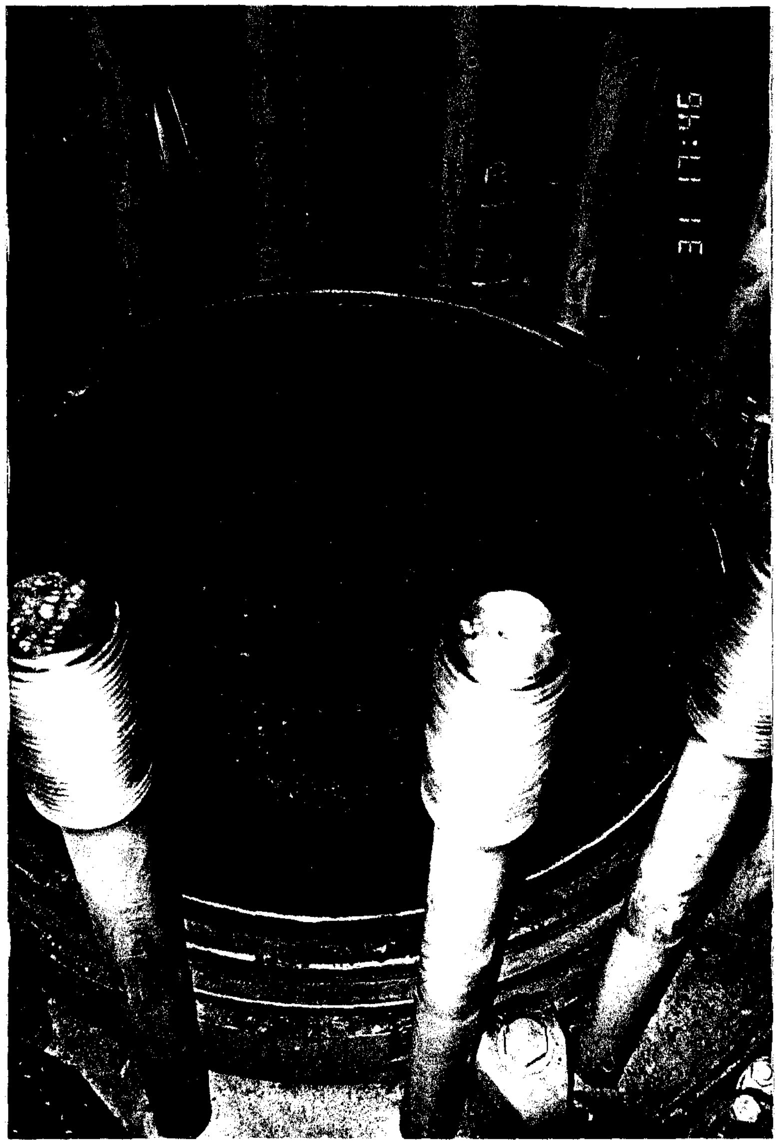
The accuracies quoted in the results are those which would apply in the analysis of a gas mixture of unchanging and homogeneous composition. This is not the situation with an operating engine, even under constant load on a dynamometer. Caution must therefore be exercised in drawing conclusions, where there are small apparent changes in exhaust gas composition. Care was taken during the analyses to obtain an 'average' reading over about 30 seconds, thus reducing the effect of the more rapid changes in composition; however the possibility of slower changes remains.

Director
Chemical Laboratory



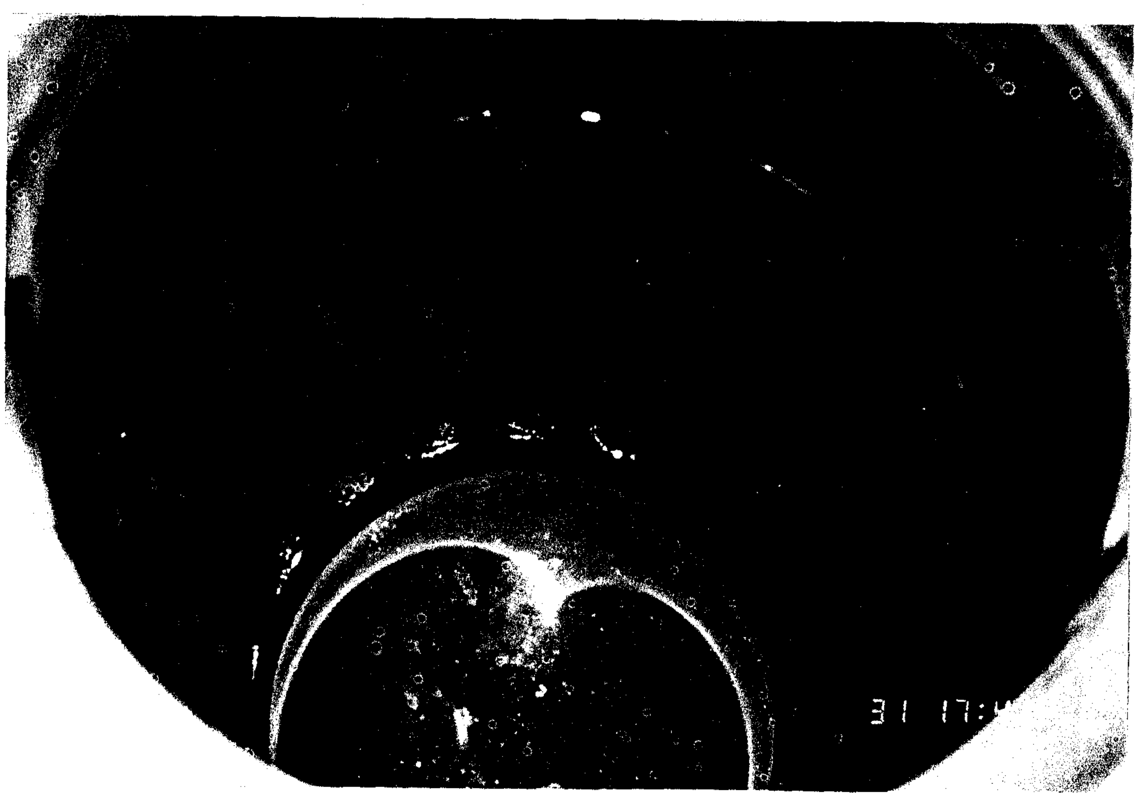
Cylinder head and valves from B&W Alpha engine operating on Heavy Fuel Oil treated with FTC Combustion Catalyst

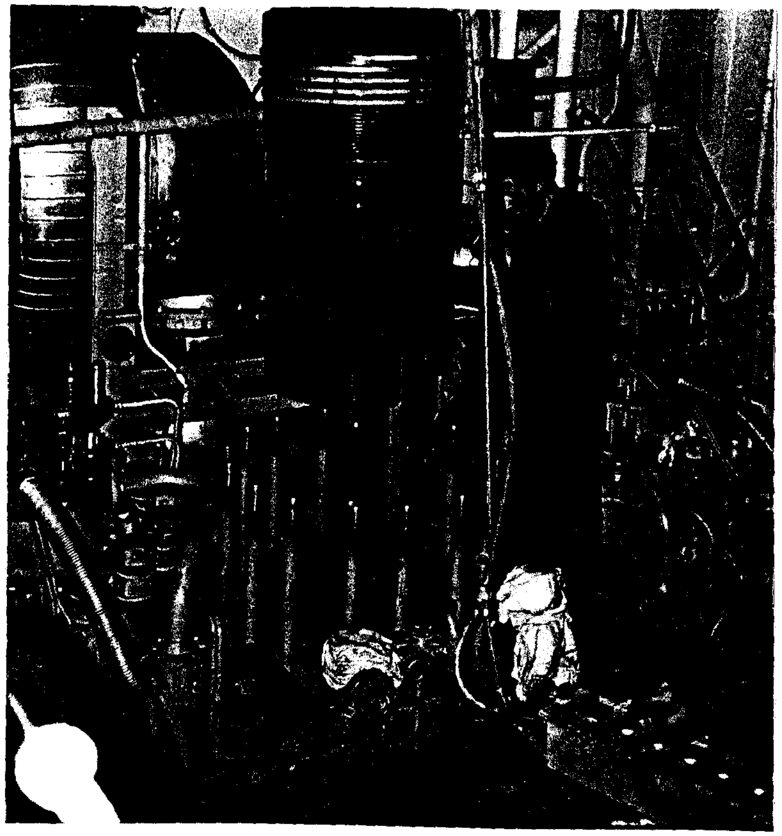




Piston crown and cylinder of Sulzer RD700 main engine burning Heavy Fuel Oil and treated with FTC Combustion Catalyst for 4000 hours.

Note that lower section of piston crown has been wiped with a cloth to expose clean metal surface. Dark marks in centre are foot marks.





Piston assembly drawn from Sulzer RD700 main engine after 4000 hours running with FTC Combustion Catalyst treated heavy fuel oil. Piston rings free in grooves and no visible hard carbon deposits.

SECTION 2

SECTION 2: THE TRIAL

The specification for the trial was set out in our letter dated September 12, 1986. Accurate dosing of the ship's fuel oil commenced on December 9, 1987.

2.1 SHIP OPERATING DATA

Background operating data from the ship's main engine log were extracted for the period commencing May 1986.

Similar operating data was extracted during the treatment period from December 9, 1987.

All of the data extracted from the log is reproduced in the attached tabulation in Appendix 2A.

Fuel Technology has been able to quantify a major variable affecting fuel efficiency, namely the relationship between engine RPM and daily fuel consumption. A computer model was developed which provides an accurate linear relationship between the two factors enabling a mathematical correction formula to be employed. Data included in Appendix 2B.

Fuel consumption and RPM values listed are those extracted from the ship's engine log. Analysis of performance is made using two different bases:

1. Average monthly adjusted fuel consumption from engine log

2. Daily fuel consumption since drydocking October 1986 based on 20 hours + per day steaming.

The "ageing" effect of an engine introduces another time-related variable. All engines age, even those under constant and programmed servicing. They are less efficient after one year, two years, five years than when new. This is a variable that is difficult to recognize over a short period because it is incrementally small, persistent and not necessarily linear. Added to this is a transition period between the efficiency of untreated and treated fuel. This change can take over 1,000 hours of operation depending on the engine condition and service.

A further factor affecting performance is the deterioration of hull underwater surfaces and the increased friction resulting in increased fuel consumption over time.

All of these variables make it difficult to directly compare fuel efficiency as calculated in FS during the Background with that calculated during the Treatment period.

NOL EVALUATION - NEPTUNE JASPER

Adj FS = FS + (107 - rpm) x 0.784

Month	AvFS/Day	RPM	Engine Knots	Ships Knots	Adj FS	Adj FS (1)	
M(1986)	23.76	101.74	16.45	14.61	27.88	27.81	
J	24.96	102.54	16.58	14.65	28.45	28.41	
J	25.44	103.74	16.77	15.02	28.00	28.38	
A	24.13	100.90	16.31	14.76	28.91	29.07	
S	29.08	107.90	17.45	15.70	28.37	28.66	25.44
O Dry Dock	28.60	107.00	17.30	15.72	28.60	28.62	
N	31.10	110.80	17.91	15.89	28.12	28.17	
D (1987)	26.74	109.10	17.64	15.85	25.10	29.06	
J	30.70	108.60	17.56	15.56	29.44	28.70	
F	28.60	105.60	17.07	15.03	29.70	29.55	
M	28.50	107.30	17.36	15.76	28.26	28.18	
A	30.15	111.50	18.03	16.52	26.62	26.45	27.7
M	28.53	110.46	17.85	16.60	25.86	25.79	
J	26.27	104.00	16.80	15.71	28.62	27.53	
J	31.60	106.55	17.23	15.77	31.95	31.34	
A	29.55	103.3	16.76	15.29	32.45	30.80	
S	28.33	107.6	17.40	16.30	27.86	27.60	
O	24.27	102.7	16.60	15.39	27.72	27.73	
N	27.12	103.6	16.75	14.14	29.78	27.79	

FTC TREATMENT COMMENCED 9 DEC 1987

Month	AvFS/Day	RPM	Engine Knots	Ships Knots	Adj FS	Adj FS (1)
D	31.30	110.2	17.82	15.99	28.79	27.86
J (1988)	27.14	105.0	16.98	15.00	28.71	28.09
F	26.93	105.1	17.00	15.38	28.42	28.36
M	28.99	108.6	17.56	16.05	27.73	26.94
A	30.54	110.3	17.84	16.23	27.95	27.84

NOTE (1)

Based on monthly average of daily fuel consumption exceeding 20 hours per day operation

NO.	DATE	HOURS	RPM	ME FS	ADJ. FS
1	1 MAY 86	22.3	101.83	22.3	28.36
2	6 MAY 86	24.0	98.20	20.3	27.20
3	7 MAY 86	24.0	100.96	23.6	28.34
4	8 MAY 86	23.5	94.37	19.9	30.44
5	9 MAY 86	24.0	98.56	20.5	27.12
6	12 MAY 86	23.5	104.82	25.6	27.89
7	13 MAY 86	23.0	101.37	22.8	28.40
8	14 MAY 86	23.0	98.79	20.4	28.00
9	18 MAY 86	24.0	105.69	23.8	24.83
10	19 MAY 86	24.0	103.28	24.8	27.72
11	20 MAY 86	24.0	107.97	29.0	28.24
12	21 MAY 86	24.0	108.54	29.8	28.59
13	22 MAY 86	24.0	107.55	27.7	27.27
14	23 MAY 86	24.0	105.64	25.9	26.97
	MAY 86 AVERAGE FUEL CONSUMPTION				27.81
1	2 JUNE 86	20.5	95.65	16.9	30.20
2	3 JUNE 86	24.0	98.51	20.9	27.56
3	4 JUNE 86	23.5	98.33	20.6	27.98
4	5 JUNE 86	24.0	101.96	23.1	27.05
5	6 JUNE 86	21.0	102.17	20.7	27.98
6	9 JUNE 86	23.5	102.09	23.2	27.62
7	10 JUNE 86	23.0	100.50	22.1	28.38
8	11 JUNE 86	23.0	97.04	21.0	30.06
9	12 JUNE 86	22.5	103.20	22.2	26.86
10	14 JUNE 86	24.0	101.68	23.1	27.27
11	15 JUNE 86	24.0	102.22	25.6	29.35
12	16 JUNE 86	24.0	103.78	27.0	29.52
13	17 JUNE 86	24.0	107.72	29.4	28.84
14	18 JUNE 86	24.0	109.53	30.7	28.72
15	19 JUNE 86	24.0	109.68	30.9	28.80
	JUNE 86 AVERAGE FUEL CONSUMPTION				28.41
1	2 JULY 86	22.0	100.59	21.2	28.61
2	3 JULY 86	24.0	101.39	22.7	27.10
3	4 JULY 86	23.6	99.32	21.6	28.09
4	5 JULY 86	24.0	106.43	26.7	27.15
5	6 JULY 86	24.0	113.92	32.1	26.67
6	10 JULY 86	23.5	101.57	24.0	28.86
7	11 JULY 86	23.0	105.27	24.8	27.29
8	12 JULY 86	23.0	102.02	22.7	27.76
9	13 JULY 86	24.0	106.23	26.1	26.70
10	15 JULY 86	20.3	102.68	20.1	27.77
11	16 JULY 86	24.0	106.16	28.0	28.66
12	17 JULY 86	24.0	108.94	29.6	28.08
13	18 JULY 86	24.0	111.84	32.7	28.91
14	19 JULY 86	24.0	111.50	32.1	28.57
15	20 JULY 86	24.0	93.84	20.2	30.52
16	21 JULY 86	24.0	93.84	31.1	41.42
17	26 JULY 86	24.0	110.22	22.8	20.28
18	30 JULY 86	24.0	99.25	22.2	28.28
19	31 JULY 86	24.0	95.53	19.6	28.59
	JULY 86 AVERAGE FUEL CONSUMPTION				28.38

1	1 AUG	86	23.5	95.34	15.8	25.47
2	2 AUG	86	24.0	100.00	22.2	27.69
3	5 AUG	86	23.5	99.02	21.6	28.45
4	6 AUG	86	23.0	87.03	16.1	33.14
5	7 AUG	86	23.5	91.45	17.9	30.73
6	8 AUG	86	23.5	89.06	17.1	31.83
7	11 AUG	86	24.0	102.40	25.6	29.21
8	12 AUG	86	24.0	103.93	28.3	30.71
9	13 AUG	86	24.0	103.81	26.9	29.40
10	14 AUG	86	24.0	107.57	29.7	29.25
11	15 AUG	86	24.0	108.22	29.3	28.34
12	16 AUG	86	24.0	108.51	29.4	28.22
13	24 AUG	86	24.5	107.16	28.9	28.19
14	27 AUG	86	21.2	99.75	20.8	29.98
15	28 AUG	86	24.0	102.68	24.4	27.79
16	29 AUG	86	22.0	100.24	21.2	28.91
17	30 AUG	86	24.0	100.37	23.9	29.10
18	31 AUG	86	24.0	104.02	24.6	26.94
	AUG	86	AVERAGE FUEL CONSUMPTION			29.07
1	3 SEPT	86	23.5	116.10	33.5	26.93
2	4 SEPT	86	23.0	113.08	34.0	30.50
3	5 SEPT	86	23.0	108.00	27.9	28.29
4	8 SEPT	86	24.0	104.40	25.3	27.34
5	9 SEPT	86	24.0	102.30	28.0	31.68
6	10 SEPT	86	24.0	106.20	29.7	30.33
7	11 SEPT	86	24.0	107.70	29.7	29.15
8	12 SEPT	86	24.0	111.60	30.9	27.29
9	13 SEPT	86	24.0	105.50	27.0	28.18
10	22 SEPT	86	21.0	103.10	22.9	29.67
11	25 SEPT	86	24.0	107.40	28.1	27.79
12	26 SEPT	86	23.5	114.80	33.0	27.46
13	27 SEPT	86	24.0	114.20	34.1	28.46
14	28 SEPT	86	24.0	111.20	31.5	28.21
	SEPT	86	AVERAGE FUEL CONSUMPTION			28.66
1	1 OCT	86	23.0	118.70	37.0	29.04
2	2 OCT	86	23.0	119.50	36.8	28.17
3	3 OCT	86	23.5	118.50	36.7	28.27
4	15 OCT	86	24.0	111.70	33.6	29.92
5	16 OCT	86	24.0	101.90	25.2	29.20
6	17 OCT	86	24.0	105.30	27.3	28.63
7	18 OCT	86	24.5	108.60	29.3	27.47
8	19 OCT	86	24.0	105.00	26.5	28.07
9	20 OCT	86	21.3	99.90	20.8	29.71
10	28 OCT	86	22.2	104.90	24.5	28.27
11	29 OCT	86	23.5	103.80	25.9	29.01
12	30 OCT	86	24.0	107.00	28.2	28.20
13	31 OCT	86	24.0	108.00	28.9	28.12
	OCT	86	AVERAGE FUEL CONSUMPTION			28.62

1	1	NOV	86	24.0	107.90	28.6	27.89
2	6	NOV	86	23.0	119.90	37.6	28.68
3	7	NOV	86	23.0	119.80	37.2	28.35
4	8	NOV	86	23.5	117.50	35.2	27.54
5	10	NOV	86	23.8	108.40	28.9	28.04
6	11	NOV	86	24.0	104.80	27.6	29.32
7	12	NOV	86	24.0	105.80	29.1	30.04
8	13	NOV	86	24.0	105.00	27.5	29.07
9	14	NOV	86	24.0	109.00	28.9	27.33
10	15	NOV	86	24.0	110.10	30.3	27.87
11	25	NOV	86	24.0	109.80	29.2	27.00
12	26	NOV	86	23.5	108.80	28.2	27.36
13	27	NOV	86	24.0	112.10	32.0	28.00
14	28	NOV	86	24.0	114.60	33.9	27.94
		NOV	86	AVERAGE FUEL CONSUMPTION			28.17
1	1	DEC	86	22.2	114.10	30.8	27.28
2	2	DEC	86	24.0	114.50	33.9	28.02
3	3	DEC	86	23.0	118.50	35.7	27.84
4	4	DEC	86	23.5	119.50	36.7	27.47
5	6	DEC	86	20.7	105.10	28.4	34.65
6	7	DEC	86	24.5	100.40	21.9	26.52
7	8	DEC	86	24.0	93.50	20.4	30.98
8	9	DEC	86	25.0	94.00	20.0	28.98
9	10	DEC	86	24.0	94.50	20.9	30.70
10	11	DEC	86	24.0	100.10	25.0	30.41
11	20	DEC	86	24.5	106.50	28.0	27.81
12	23	DEC	86	24.0	105.10	25.6	27.09
13	25	DEC	86	24.0	101.70	24.1	28.26
14	26	DEC	86	24.0	103.10	25.5	28.56
15	27	DEC	86	24.0	93.80	21.0	31.35
		DEC	86	AVERAGE FUEL CONSUMPTION			29.06
1	1	JAN	87	23.5	116.50	34.1	27.22
2	2	JAN	87	23.0	112.20	30.5	27.57
3	3	JAN	87	23.0	112.10	30.6	27.76
4	6	JAN	87	24.0	118.20	37.0	28.22
5	7	JAN	87	24.0	114.50	37.9	32.02
6	8	JAN	87	24.0	116.10	38.1	30.97
7	9	JAN	87	24.0	108.00	23.0	22.22
8	15	JAN	87	24.0	102.00	23.5	27.42
9	16	JAN	87	24.0	102.10	24.1	27.94
10	17	JAN	87	24.0	101.80	24.2	28.28
11	20	JAN	87	24.0	106.00	30.7	31.48
12	21	JAN	87	24.0	117.50	39.1	30.87
13	22	JAN	87	24.0	105.60	30.1	31.20
		JAN	87	AVERAGE FUEL CONSUMPTION			28.70

1	3 FEB	87	24.0	112.10	36.0	32.00
2	4 FEB	87	24.0	89.30	20.1	33.98
3	5 FEB	87	24.0	104.40	31.6	33.64
4	6 FEB	87	24.0	109.60	35.1	33.06
5	12 FEB	87	24.0	102.50	24.5	28.03
6	13 FEB	87	24.0	99.00	27.2	33.47
7	14 FEB	87	23.7	101.10	20.8	25.75
8	17 FEB	87	24.0	114.00	33.2	27.71
9	18 FEB	87	24.0	112.60	33.1	28.71
10	19 FEB	87	24.0	108.40	29.9	28.80
11	23 FEB	87	20.9	101.80	19.9	27.53
12	26 FEB	87	24.0	105.10	25.2	26.69
13	27 FEB	87	24.0	102.30	23.7	27.38
14	28 FEB	87	24.0	106.00	26.2	26.98
	FEB	87 AVERAGE FUEL CONSUMPTION				29.55
1	3 MAR	87	21.3	114.00	31.9	29.76
2	4 MAR	87	24.0	115.00	36.3	30.03
3	5 MAR	87	24.0	115.20	35.9	29.47
4	6 MAR	87	24.0	116.10	35.8	28.67
5	10 MAR	87	24.0	102.10	24.3	28.14
6	12 MAR	87	24.0	108.80	28.2	26.79
7	13 MAR	87	24.0	112.60	30.8	26.41
8	14 MAR	87	24.0	108.00	27.4	26.62
9	17 MAR	87	24.0	114.80	32.7	26.58
10	18 MAR	87	24.0	109.20	29.2	27.48
11	19 MAR	87	24.0	107.40	27.8	27.49
12	24 MAR	87	23.4	109.00	28.7	27.83
13	27 MAR	87	24.0	107.10	28.1	28.02
14	28 MAR	87	24.0	102.10	25.1	28.94
15	29 MAR	87	24.0	100.00	23.9	29.39
16	31 MAR	87	21.2	109.90	28.2	29.35
	MAR	87 AVERAGE FUEL CONSUMPTION				28.18
1	1 APL	87	21.8	109.90	29.5	29.97
2	2 APL	87	24.0	111.50	32.5	28.97
3	3 APL	87	24.0	116.30	34.6	27.31
4	10 APL	87	20.0	114.40	26.9	25.32
5	11 APL	87	24.0	115.70	31.9	25.08
6	12 APL	87	24.0	114.80	30.9	24.78
7	15 APL	87	24.0	112.40	30.3	26.07
8	16 APL	87	24.0	112.30	31.8	27.64
9	17 APL	87	24.0	112.00	31.9	27.98
10	22 APL	87	20.3	114.40	26.2	24.12
11	24 APL	87	24.0	112.20	28.6	24.52
12	25 APL	87	24.0	106.30	24.6	25.15
13	26 APL	87	24.0	103.40	23.1	25.92
14	28 APL	87	24.0	112.70	30.8	26.33
15	29 APL	87	24.0	112.50	31.5	27.19
16	30 APL	87	24.0	112.90	31.4	26.77
	APL	87 AVERAGE FUEL CONSUMPTION				26.45

1	1 MAY 87	22.6	112.70	28.3	25.31
2	8 MAY 87	24.0	114.40	31.4	25.60
3	9 MAY 87	24.0	111.70	28.9	25.22
4	10 MAY 87	24.0	103.40	23.4	26.22
5	12 MAY 87	22.0	113.70	29.2	26.12
6	13 MAY 87	24.0	116.10	33.6	26.47
7	14 MAY 87	24.0	115.60	32.8	26.06
8	15 MAY 87	24.0	114.80	32.6	26.48
9	19 MAY 87	24.0	109.00	26.4	24.83
10	22 MAY 87	24.0	108.50	27.8	26.62
11	23 MAY 87	24.0	105.30	24.4	25.73
12	24 MAY 87	24.0	103.80	23.7	26.21
13	26 MAY 87	24.0	107.70	26.4	25.85
14	27 MAY 87	24.0	111.00	28.2	25.06
15	28 MAY 87	24.0	111.20	28.2	24.91
16	29 MAY 87	22.5	110.00	26.6	25.86
	MAY 87 AVERAGE FUEL CONSUMPTION				25.79

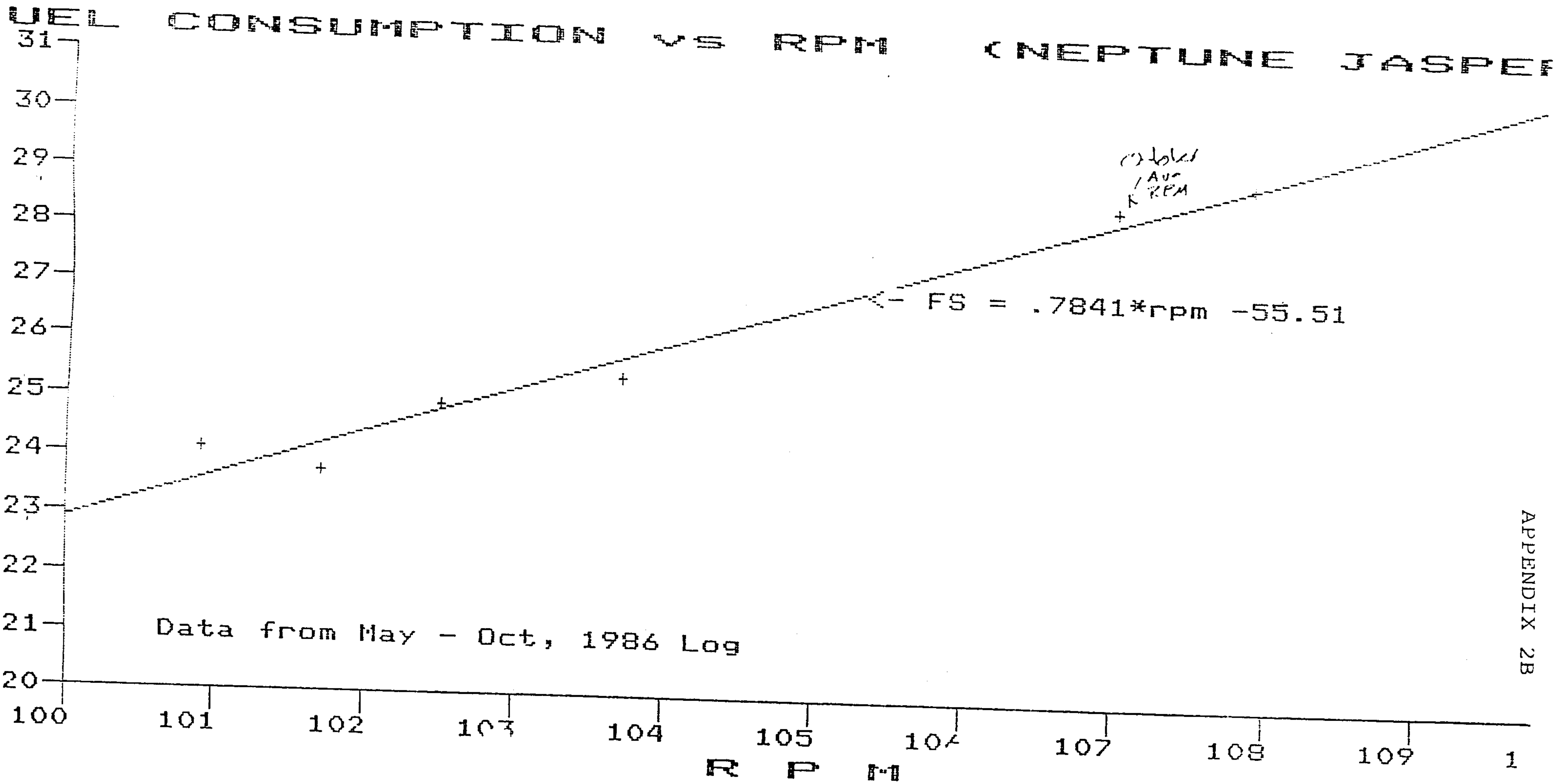
1	2 JUNE 87	24.0	106.20	25.2	25.83
2	4 JUNE 87	24.0	99.30	23.1	29.14
3	5 JUNE 87	24.0	104.30	23.9	26.02
4	6 JUNE 87	24.0	104.70	24.6	26.40
5	9 JUNE 87	24.0	108.80	28.4	26.99
6	10 JUNE 87	24.0	108.70	28.0	26.67
7	11 JUNE 87	24.0	109.70	29.5	27.38
8	12 JUNE 87	24.0	110.40	31.4	28.73
9	19 JUNE 87	24.0	107.60	28.2	27.73
10	20 JUNE 87	24.0	98.30	24.7	31.52
11	21 JUNE 87	24.0	103.30	25.2	28.10
12	23 JUNE 87	24.0	104.40	25.0	27.04
13	24 JUNE 87	24.0	103.40	24.2	27.02
14	25 JUNE 87	24.0	103.50	24.5	27.24
15	25 JUNE 87	20.5	103.60	21.0	27.71
16	30 JUNE 87	24.0	111.90	30.8	26.96
	JUNE 87 AVERAGE FUEL CONSUMPTION				27.53

1	2 JULY 87	24.0	110.00	30.4	28.05
2	3 JULY 87	24.0	111.30	33.0	29.63
3	4 JULY 87	24.0	110.80	31.9	28.92
4	7 JULY 87	24.0	107.90	27.6	26.89
5	8 JULY 87	24.0	102.80	24.0	27.29
6	9 JULY 87	24.0	103.40	24.7	27.52
7	9 JULY 87	22.3	104.70	23.8	27.56
8	14 JULY 87	24.0	112.00	33.7	29.78
9	16 JULY 87	24.0	104.20	34.2	36.40
10	17 JULY 87	24.0	104.40	33.5	35.54
11	18 JULY 87	24.0	103.60	27.7	30.37
12	18 JULY 87	20.0	105.00	26.3	33.44
13	21 JULY 87	24.0	110.70	38.9	36.00
14	22 JULY 87	24.0	105.90	37.8	38.66
15	23 JULY 87	24.0	108.20	36.7	35.76
16	30 JULY 87	24.0	104.20	28.7	30.90
17	31 JULY 87	24.0	104.30	28.0	30.12
	JULY 87 AVERAGE FUEL CONSUMPTION				31.34

DATE	HOURS	RPM	ME FS	ADJ FS
1/8	24	103.8	30.0	32.5
4/8	24	111.5	38.7	35.2
5/8	24	105.3	38.5	39.8
6/8	24	105.1	36.9	38.4
10/8	20	107.9	30.3	29.6
13/8	24	102.3	28.8	32.5
14/8	24	89.8	16.6	30.1
15/8	22.2	97.6	14.4	21.8
18/8	24.0	111.0	30.5	27.4
19/8	24	112.6	30.0	25.6
27/8	24	102.1	25.0	28.8
28/8	24	102.7	26.0	29.4
29/8	24	102.7	25.8	29.2
AUGUST AVERAGE FUEL CONSUMPTION				30.8
1/9	24	108.8	30.0	28.6
2/9	24	110.1	29.6	27.2
3/9	24	106.9	28.0	28.1
11/9	24	114.2	33.3	27.6
12/9	24	115.0	35.2	28.9
13/9	23.5	114.8	33.4	27.3
15/9	24	110.3	29.4	26.8
16/9	24	108.3	28.0	27.0
17/9	24	105.5	26.9	28.1
	23.3	112.0	31.6	27.7
21/9	21.7	104.2	22.5	24.7
24/9	24	100.5	23.0	28.1
25/9	24	100.8	23.5	28.4
26/9	24	100.0	22.5	28.0
29/9	24	114.3	33.0	27.3
30/9	24	114.2	34.0	28.3
SEPTEMBER AVERAGE FUEL CONSUMPTION				27.6

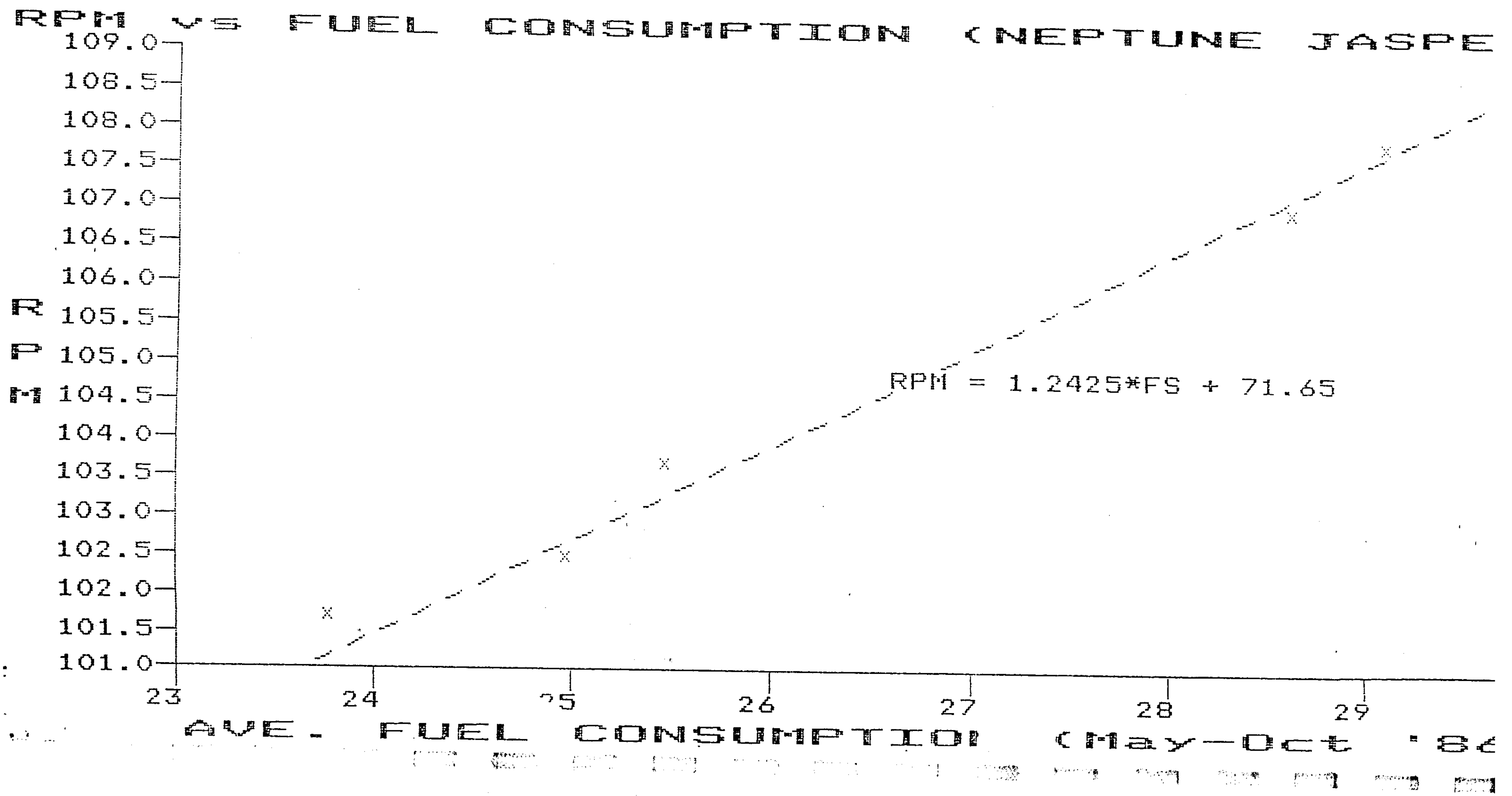
1	1 OCT 1987	24.0	112.8	32.0	27.45
2	5 OCT 1987	24.0	103.0	23.0	26.12
3	8 OCT 1987	24.0	101.7	23.0	27.15
4	9 OCT 1987	24.0	101.7	23.0	27.15
5	10 OCT 1987	24.0	101.0	23.0	27.70
6	13 OCT 1987	24.0	100.8	22.0	26.86
7	14 OCT 1987	24.0	100.9	23.0	27.78
8	15 OCT 1987	24.0	103.0	25.0	29.78
9	16 OCT 1987	24.0	101.4	24.0	28.39
10	19 OCT 1987	23.8	101.4	23.0	27.39
11	22 OCT 1987	24.0	101.7	23.0	27.15
12	23 OCT 1987	24.0	101.9	23.0	27.00
13	24 OCT 1987	24.0	100.4	22.0	27.17
14	27 OCT 1987	24.0	103.6	26.0	28.66
15	28 OCT 1987	24.0	106.4	28.0	28.47
16	29 OCT 1987	24.0	106.1	28.0	28.71
17	30 OCT 1987	24.0	105.0	27.0	28.57
	OCTOBER AVERAGE FUEL CONSUMPTION				27.73
1	3 NOV 1987	22.7	109.9	27.0	24.72
2	5 NOV 1987	24.0	103.8	25.0	27.51
3	6 NOV 1987	24.0	104.8	26.0	27.72
4	7 NOV 1987	24.0	108.1	28.0	27.14
5	8 NOV 1987	22.0	100.6	22.0	27.02
6	10 NOV 1987	24.0	112.8	32.0	27.45
7	11 NOV 1987	24.0	115.4	36.0	29.41
8	12 NOV 1987	24.0	115.2	35.0	28.57
9	13 NOV 1987	24.0	115.2	35.0	28.57
10	16 NOV 1987	24.0	107.7	27.0	26.45
11	19 NOV 1987	24.0	108.5	28.0	26.82
12	20 NOV 1987	24.0	107.6	28.0	27.53
13	21 NOV 1987	24.0	103.7	25.0	27.59
14	24 NOV 1987	24.0	102.7	24.5	27.87
15	25 NOV 1987	24.0	102.6	24.5	27.95
16	26 NOV 1987	24.0	101.5	25.0	29.31
17	29 NOV 1987	24.0	72.1	18.5	45.86
18	30 NOV 1987	24.0	83.6	24.0	42.35
	NOVEMBER AVERAGE FUEL CONSUMPTION				27.79
1	9 DEC 1987	24.0	105.7	33.5	34.52
2	10 DEC 1987	24.0	113.6	37.5	32.32
3	11 DEC 1987	24.0	115.5	36.5	29.84
4	15 DEC 1987	19.3	113.7	25.5	20.25
5	17 DEC 1987	20.6	113.5	26.0	20.90
6	18 DEC 1987	24.0	114.5	32.0	26.12
7	19 DEC 1987	24.0	114.8	32.0	25.88
8	23 DEC 1987	24.0	112.6	37.0	32.61
9	24 DEC 1987	24.0	110.8	36.0	33.02
10	25 DEC 1987	24.0	112.0	34.0	30.08
11	26 DEC 1987	20.3	112.0	28.0	24.08
12	29 DEC 1987	24.0	98.9	21.0	27.35
13	31 DEC 1987	24.0	109.2	27.0	25.27
	DECEMBER AVERAGE FUEL CONSUMPTION				27.86

1	1 JAN 1988	24.0	107.0	26.0	26.00
2	2 JAN 1988	24.0	100.6	22.0	27.02
3	5 JAN 1988	24.0	112.7	32.0	27.53
4	6 JAN 1988	24.0	105.8	35.0	35.94
5	7 JAN 1988	24.0	112.9	36.0	31.37
6	8 JAN 1988	24.0	112.0	32.0	28.08
7	12 JAN 1988	24.0	93.8	18.0	28.35
8	14 JAN 1988	24.0	108.0	27.0	26.22
9	15 JAN 1988	24.0	108.4	27.0	25.90
10	16 JAN 1988	24.0	103.2	24.0	26.98
11	19 JAN 1988	24.0	107.2	33.0	32.84
12	20 JAN 1988	24.0	105.0	32.0	33.57
13	21 JAN 1988	24.0	112.9	34.0	29.37
14	22 JAN 1988	24.0	112.6	31.0	26.61
15	28 JAN 1988	24.0	106.3	25.0	25.55
16	29 JAN 1988	24.0	104.7	24.0	25.80
17	30 JAN 1988	24.0	104.2	24.0	26.19
18	31 JAN 1988	19.0	100.1	17.0	22.41
	JANUARY AVERAGE FUEL CONSUMPTION				28.09
1	2 FEB 1988	24.0	113.0	32.0	27.30
2	3 FEB 1988	24.0	112.6	32.0	27.61
3	4 FEB 1988	24.0	99.0	29.0	35.27
4	5 FEB 1988	24.0	111.1	24.0	20.78
5	11 FEB 1988	21.0	100.5	22.0	27.10
6	12 FEB 1988	24.0	99.2	21.0	27.11
7	13 FEB 1988	24.0	93.5	17.0	27.58
8	16 FEB 1988	24.0	111.7	32.0	28.31
9	17 FEB 1988	24.0	111.7	33.0	29.31
10	18 FEB 1988	24.0	110.3	36.0	33.41
11	19 FEB 1988	23.5	108.6	34.0	32.74
12	24 FEB 1988	23.2	103.6	23.0	25.66
13	25 FEB 1988	24.0	100.3	22.0	27.25
14	26 FEB 1988	24.0	100.3	22.0	27.25
	FEBRUARY AVERAGE FUEL CONSUMPTION				28.36
1	1 MAR 1988	24.0	112.4	32.0	27.77
2	2 MAR 1988	24.0	112.3	32.0	27.84
3	3 MAR 1988	24.0	110.8	31.5	28.52
4	4 MAR 1988	23.0	109.2	30.0	28.27
5	11 MAR 1988	24.0	111.7	31.0	27.31
6	12 MAR 1988	24.0	109.8	29.0	26.80
7	15 MAR 1988	24.0	111.0	31.0	27.86
8	16 MAR 1988	24.0	111.3	31.0	27.63
9	17 MAR 1988	24.0	110.4	30.0	27.33
10	18 MAR 1988	18.0	110.3	24.0	21.41
11	21 MAR 1988	20.8	111.9	26.0	22.16
12	24 MAR 1988	24.0	101.3	23.0	27.47
13	25 MAR 1988	24.0	101.0	22.0	26.70
14	26 MAR 1988	24.0	98.7	21.0	27.51
15	29 MAR 1988	24.0	111.3	31.0	27.63
16	30 MAR 1988	24.0	111.5	31.0	27.47
17	31 MAR 1988	24.0	111.6	32.0	28.39
	MARCH AVERAGE FUEL CONSUMPTION				26.94

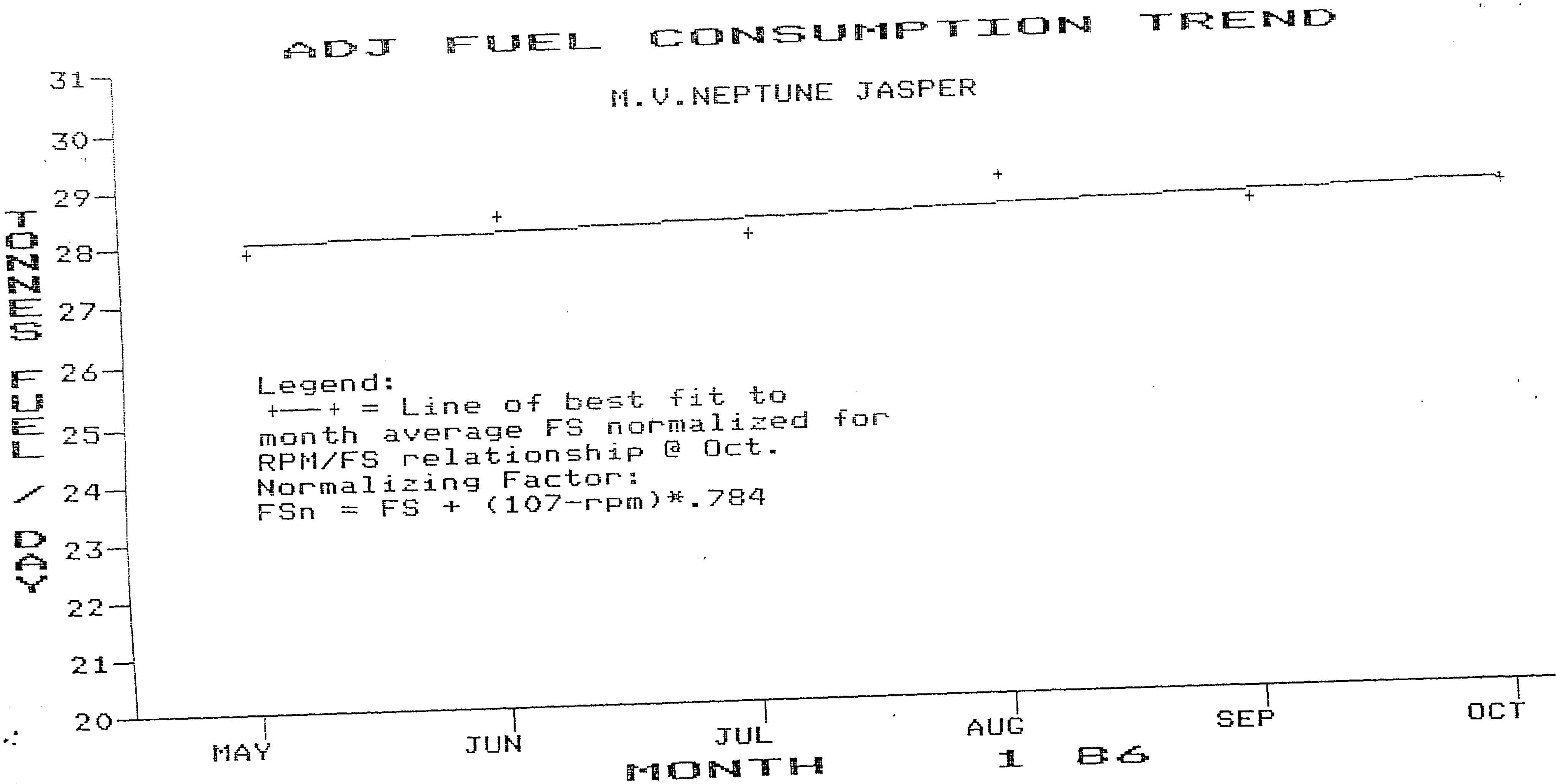

UEL CONSUMPTION VS RPM (NEPTUNE JASPEI
31
30
29
28
27
26
25
24
23
22
21
20
Avg RPM
<- FS = .7841*rpm -55.51
Data from May - Oct, 1986 Log
100
101
102
103
104
105
107
108
109
1
R P M

APPENDIX 2B

D


RPM vs FUEL CONSUMPTION (NEPTUNE JASPE
109.0
108.5
108.0
107.5
107.0
106.5
106.0
105.5
105.0
104.5
104.0
103.5
103.0
102.5
102.0
101.5
101.0
RPM
RPM = 1.2425*FS + 71.65
23
24
25
26
27
28
29
AVE. FUEL CONSUMPTIOI (May-Oct '8

E


ADJ FUEL CONSUMPTION TREND
M.V.NEPTUNE JASPER
TONNES FUEL / DAY
31
30
29
28
27
26
25
24
23
22
21
20
Legend:
+—+ = Line of best fit to
month average FS normalized for
RPM/FS relationship @ Oct.
Normalizing Factor:
FSn = FS + (107-rpm)*.784
MAY
JUN
JUL
AUG
SEP
OCT
MONTH
1 86

SECTION 3

SECTION 3: THE TRIAL RESULTS

As suggested in Section 2, the results of the trial can be taken in two parts.

1. Engineering or operating observations.
2. Statistical analysis of the engine performance data.

3.1 OBSERVATIONS

At time of compiling this report no knowledge of variation in engine combustion chamber condition is available. However, experience over a long period of time with a similar class of vessel indicates a substantial reduction in carbon deposits and extended time between piston and unit overhaul.

3.2 STATISTICAL ANALYSIS

This subsection provides the results of the Fuel Technology plot of statistical trends.

3.2.1 Using the data edit procedures indicated in the margin of the daily Engine Log Data Listing (Appendix 2A), Fuel Technology plotted the trend-lines, Appendix 3A. These lines represent the best statistical fit by regression of the two methods of analysis.

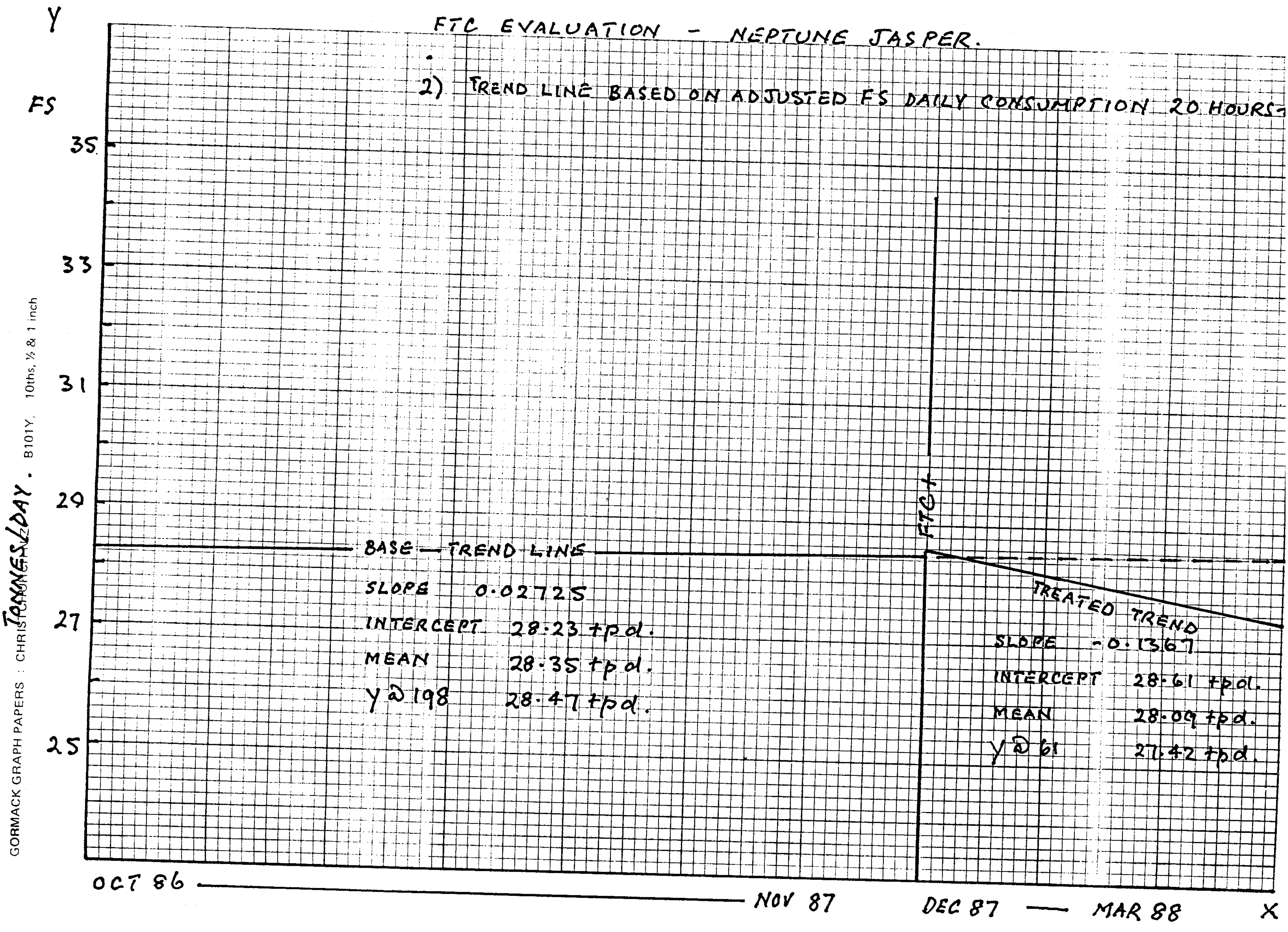
a) Average monthly adjusted fuel consumption for baseline and treated periods ex engine log.

b) Daily adjusted fuel consumption for baseline since October 1986, drydocking and treated period from December 9, 1987. Data based only on 20+ hours per day running.

The extension line of the background trend shown in Appendix 3A forms the line of prediction, that is the trend-line of fuel consumption the ship's main engine would follow if nothing had been changed.

Within a reasonable period of time, and at any selected moment, the difference between the background trend and the treatment trend should be a reasonable measure of the change in fuel consumption resulting from the change in combustion efficiency and of course from any changes in the operation of the ship.

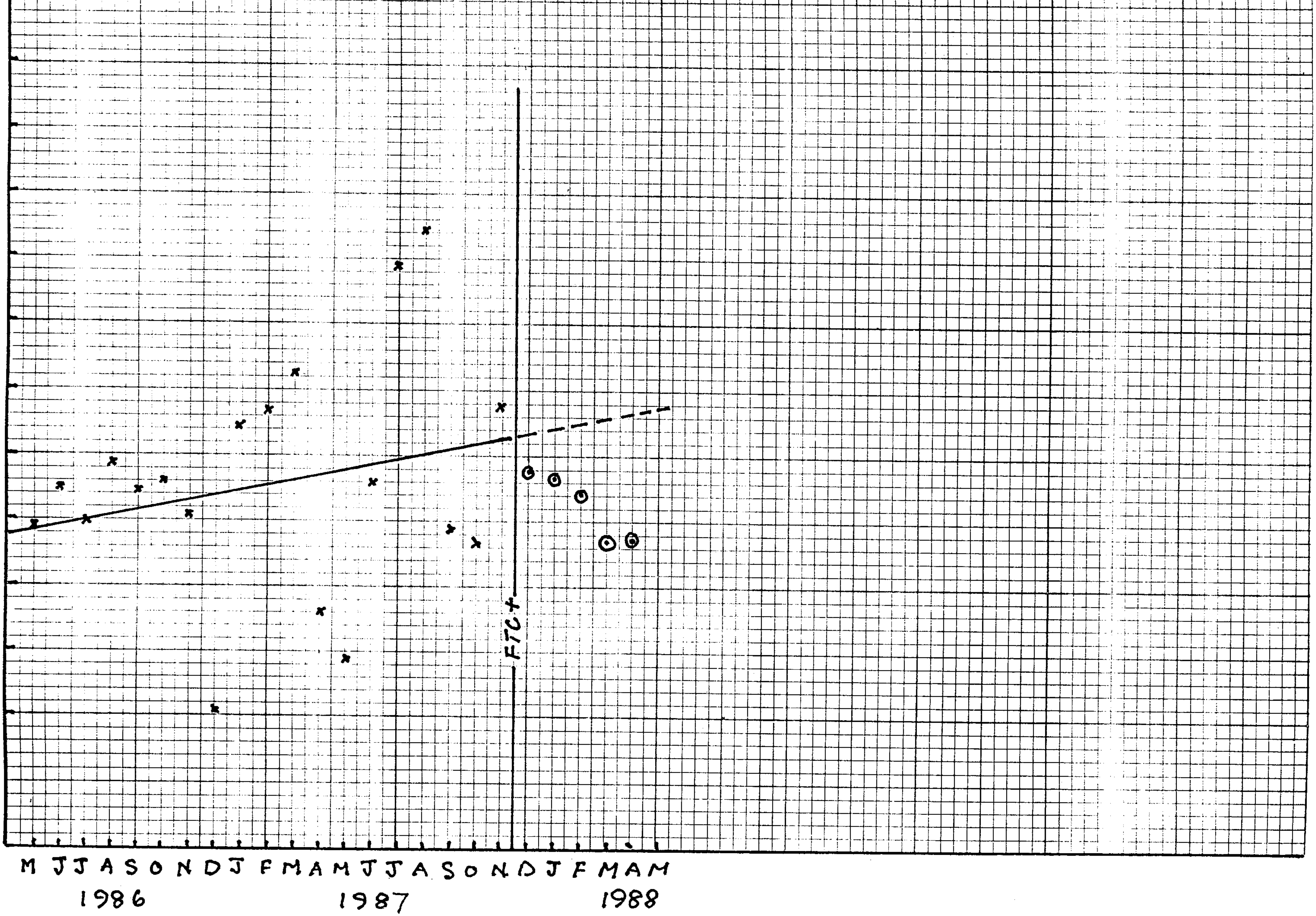
The two methods of analysis indicate a reduction in fuel consumption ranging from 4.0% to 4.3% suggesting a probable 4% gross efficiency gain by application of FTC Combustion Catalyst.



FTC EVALUATION - NEPTUNE JASPER.
2) TREND LINE BASED ON ADJUSTED FS DAILY CONSUMPTION 20 HOURS
Y
FS
35
33
31
29
27
25
TONNES/DAY.
BASE TREND LINE
SLOPE 0·02725
INTERCEPT 28·23 tpd.
MEAN 28·35 tpd.
Y @ 198 28·47 tpd.
FTC+
TREATED TREND
SLOPE -0·1367
INTERCEPT 28·61 tpd.
MEAN 28·09 tpd.
Y @ 61 27·42 tpd.
OCT 86
NOV 87
DEC 87
MAR 88
X
GORMACK GRAPH PAPERS : CHRISTCHURCH B101Y, 10ths, ½ & 1 inch

FTC EVALUATION — NEPTUNE JASPER

1) TREND LINE ADJUSTED FS BASED ON ENGINE ROOM LOG



APPENDIX 3A

SECTION 4

SECTION 4: ECONOMIC IMPACT

4.1 FUEL SAVINGS

FTC Combustion Catalyst is priced at USD 5.00 per litre and therefore the cost of treating a tonne of fuel is USD 1.77.

Current bunker prices in Singapore are USD 80 per tonne.

The USD 1.77 per tonne treatment cost would be 2.2% of the fuel cost. Thus if fuel saved from treatment is:

2.2%	There would not be a net* fuel saving.
4%	The annual net saving in fuel will be 288 tonnes or a net saving of about $10400.
4.3%	The annual net saving in fuel will be 310 tonnes or a net saving of about $12100.

* net saving means saving, net of treatment costs.

Translating the benefits achieved on "Neptune Jasper" to the Neptune Orient Line fleet fuel consumption the net economic benefit will be in the region of USD 388800 based on the following assumptions.

Average annual fuel consumption	270,000 tonnes
Average fuel cost per tonne	USD 80
Gross efficiency gain by use of FTC-3	4%
Estimated cost FTC-3 per litre	USD 5.00
Litres/tonne conversion rate	1065
FTC treatment ratio	1:3000