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**Cominco Alaska, Inc., Red Dog Mine Powerhouse Trial
of
FPC-1 Fuel Performance Catalyst**

FINAL REPORT

Prepared by UHI Corporation
Provo, Utah
and
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Boise, Idaho

February 24, 1995

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I. Introduction

FPC-1 Fuel Performance Catalyst is a burn rate modifier (catalyst) proven to reduce fuel consumption and increase engine horsepower in several recognized, independent laboratory tests, and several hundred independent field trials. The catalyst speeds the rate of flame propagation, and therefore, is particularly beneficial to engines wherein engine design and/or operation type contribute to efficiency loss.

Although innately more efficient than high-speed engines in mobile equipment, dozens of genset trials have shown the use of FPC-1 creates fuel consumption reductions in the range of 3.0% to 4.5%. Some seventeen tests in medium-speed diesel engines running on light fuel oil (# 2 diesel) have demonstrated an average reduction in fuel consumption of 3.52% with FPC-1 fuel treatment. Further, a test of FPC-1 conducted Southwest Research Institute in a 2500 horsepower, medium-speed, turbocharged genset, showed the catalyst created a nearly 2% gain in efficiency. Combustion experts agree that a 2% gain in a test and engine of this type will translate to a 3.5% to 4.5% gain in a similar engine operating in the field.

The catalyst also has a positive impact upon the products of incomplete combustion, primarily soot (smoke) and carbon monoxide, a fact which further confirms the catalyst improves the rate of combustion.

The intent of the current trial at Cominco Alaska's Red Dog Mine is to determine the degree of fuel consumption reduction created by the addition of FPC-1 to the arctic diesel fuel supplied to the powerhouse. The test methodology for determining fuel consumption uses both the "carbon mass balance" (CMB) and powerhouse data from the control panel and in-line fuel flowmeters.

The CMB method measures the carbon containing products of the combustion process (CO₂, CO, HC) found in the exhaust, rather than directly measuring fuel flow into the engine. The CMB also makes possible the determination of FPC-1's effect upon regulated emissions, specifically smoke and carbon monoxide (CO).

This report summarizes and compares the baseline and FPC-1 treated fuel rates of consumption and emissions data for Units # 2 and # 5, both Wartsila 16V32s. Unit # 2 has a different camshaft and injection timing than Unit # 5, a design that sacrifices efficiency for reduced emissions of oxides of nitrogen (NO_x). Unit # 5 has proven to be more efficient (approximately 8%) than Unit # 2.

II. Discussion of Carbon Mass Balance Method

The CMB uses state-of-the-art, non-dispersive infrared analysis (NDIR) and the measurement of carbon containing exhaust gases to determine fuel consumption indirectly. The method has been central to the EPA Federal Test Procedures (FTP) and Highway Fuel Economy Test (HFET) since 1974, and is internationally recognized.

The exhaust gas data collected during the baseline and treated fuel carbon balance tests for Units # 2 and 5 are summarized on the attached computer printouts (Appendix 1). From these data, the volume fraction (VF) of each gas is determined and the average molecular weight (Mwt) of the exhaust gases computed. Next, the engine performance factor (pf) or the carbon mass in the exhaust is computed. The pf is finally corrected for exhaust temperature and exhaust pressure velocity (exhaust density), and intake air pressure (barometric) yielding a engine performance factor (PF) or carbon mass flow rate corrected for total exhaust mass flow. The PFs are shown on the bottom of the computer printouts found in Appendix 1. A positive change in PF equates to a reduction in fuel consumption.

The CMB calculations and legend are found on Figure 1 under Appendix 7. A sample calculation is found on Figure 2, also under Appendix 7.

Correction for Fuel Density

The treated fuel PF (PF2) must be corrected for any change in fuel density (measured as specific gravity), and therefore, energy content. The baseline fuel density is used as the reference. The correction factor (if applicable) for fuel density is shown on the treated fuel database computer printouts.

Correction for Barometric Pressure and Ambient (intake air) Temperature

The barometric pressure is used in the calculation of both the baseline and treated fuel PFs. These pressure readings were taken at the airport in Kotzebue and corrected for the altitude (970 feet elevation) at the powerhouse. This approach was discussed with and approved by Mr. Harmon Ranney, Environmental Coordinator. The correction is made as follows:

$$* \text{barometric pressure sea level} - (970/1000)(.11) = \text{atmospheric pressure corrected for altitude}$$

The corrected barometric pressure is shown on the treated fuel computer printouts.

Ambient temperature changes are corrected for in the calculation of the exhaust mass flowrate since changes in intake air temperature will be reflected in the exhaust temperature.

III. Accuracy of the Two Test Methods

The CMB data and test method have proven to be accurate to $\pm 1\%$. The accuracy of the powerhouse flowmeters is approximately $\pm 4\%$, although the accuracy of the method is improved by collecting a large body of data over multiple test runs. The CMB also collects considerable data. Therefore, the CMB is the more accurate of the two methods and is more likely to reveal the actual rate of fuel consumption.

For example, during baseline testing of Unit # 2, back-to-back baselines were conducted in an attempt to stabilize engine load. All factors influencing fuel consumption at a given power

output were measured. The powerhouse data indicated the load was reduced approximately 5% (see powerhouse data on Table 1, Appendix 2) during the second baseline, yet the flowmeters were unable to register a change in fuel consumption. The CMB, on the other hand, showed a fuel consumption reduction of 1.40% (see computer printouts, Appendix 3), a change that more closely reflects the reduction in power output of the engine.

Given the accuracy of the two methods, this would be expected. It is less likely that the flowmeter, having an accuracy of \pm 4%, would register a 1% change.

IV. Discussion of the Powerhouse Data for the Baseline and Treated Fuel Tests

Both engines were tested over a fifty (50) minute period for both the baseline and treated fuel runs. Data points were taken every two and one-half (2.5) minutes. Stop watches were used to synchronize the start of data acquisition and to ensure readings were taken at the same time and at the nominated interval (2.5 minutes).

While the engines were operating under a fixed load (in droop), the following powerhouse data were recorded:

- Exhaust temperature (stack A and B, after Turbo)
- Megawatts (MW)
- KVAR
- Amps
- Megavoltamps (MVA)
- Power factor (PF)
- Kilowatt hours per gallon of fuel (Kwh/G)
- Gallons of fuel consumed per five minute interval
- Gallons per minute (gpm)

These data from each test run are compiled on Table 2, Appendix 4.

Exhaust Stack Temperature

Typically, exhaust gas temperatures are taken at the same point as the exhaust pressure velocity and exhaust gas readings when using CMB. However, the heat recovery system made accurate measurement of engine exhaust temperature impossible. Therefore, exhaust gas temperature readings at the turbocharger and prior to the heat recovery system, were used in the CMB calculations to correct for changes in total exhaust mass.

V. Discussion of the Bacharach Smoke Spot Method

Smoke is a product of incomplete combustion, and as such, is a measure of engine efficiency. Smoke is simply unburned fuel droplets not consumed during the final phase or tail of combustion when combustion temperatures are significantly lower, and most of the oxygen in the combustion chamber has been expended. The FPC-1 catalyst improves the oxidation of these fuel droplets, extracting more useful energy and reducing smoke emissions.

Baseline smoke density was determined using the widely accepted Bacharach Smoke Spot method. The Bacharach method draws a specific volume of exhaust gas through a standard 5 micron filter medium. The particulate in the exhaust gas sample collects on the surface of the filter medium. The surface is darkened by the particulate according to the density of the particulate in the exhaust sample. The greater the particulate density, the darker the color. The Bacharach smoke scale ranges from 0 to 9, with 0 being a white, particulate free filter, and 9 being a completely black filter.

The smoke spot numbers are relative smoke density numbers for each engine tested and can be used to determine any change in smoke emissions when compared to FPC-1 treated fuel. A comparison of the baseline and treated Smoke Numbers (shown on Table 3, Appendix 5) indicate the use of FPC-1 created an approximate reduction in smoke density of 20%. Smoke reductions in other genset trials average 19.5%.

VI. Discussion of Fuel Consumption Results

Unit # 2

Unit # 2 was the only engine tested with fuel under full FPC-1 treatment (January 29 and 31 powerhouse data, and January 31 CMB data). The test runs for both engines on February 19th were done on partially treated fuel. This was due to a problem with the metering pump. As near as could be determined, the fuel treatment rate during the test runs was approximately one third of the 1:5000 mixing ratio recommended by the manufacturer (see Discussion of the Effect of Mixing Ratio under Section VII).

The uncorrected powerhouse data (not including the run on partially treated fuel) for Unit # 2 indicates an average fuel consumption reduction of 1.79% $\{(1.41\% + 1.65\% + 2.31\%)/3\}$ for the three treated fuel test runs (January 29 and 31). The test run of January 29th (1.65%) cannot be corrected for fuel density. Both test runs on the 31st have fuel density data. The average uncorrected percentage change in fuel consumption for the two treated fuel runs on the 31st is 1.86% $\{(1.41\% + 2.31\%)/2\}$.

Fuel density was 0.25% lower (correction factor for gallons consumed = 0.9975) and intake air temperature was 4.5 degrees C lower (correction factor = 0.9955, see explanation of correction factor on Figure 3, Appendix 7). The two factors combine to correct the powerhouse data collected on the 31st towards a greater reduction in fuel consumption. Therefore, the powerhouse data collected from tests run on Unit # 2 on the 31st of January indicate an average fuel consumption reduction with FPC-1 treated fuel of 2.53%.

The first treated test run on the 31st reproduced the baseline engine load more closely than the treated test of the 29th or the 2nd treated test of the 31st. The fuel consumption reduction was the greatest during this test (2.31% uncorrected). The reduction was 2.98% after correcting for fuel density and intake air temperature. Because of the precision of load reproduction during this test, the results obtained may be considered the most accurate, and therefore, the most

representative of the effect of FPC-1 upon fuel consumption in Unit #2.

The final treated test run on Unit # 2 (February 19th), as mentioned above, was done while running on grossly undertreated fuel. Therefore, the data and results from this test must be considered invalid, particularly the powerhouse data which is less sensitive to fuel consumption change (see discussion under section III. Accuracy of the Two Test Methods).

The CMB methodology corrects fuel consumption for changes in fuel density, intake air temperature, and pressure (barometric) from the baseline. The treated CMB test run on Unit # 2 (January 31) compared to the baseline CMB test run (January 18) shows a 4.75% reduction in fuel consumption.

Again, the final treated fuel CMB (February 19) was run on grossly undertreated fuel. The CMB showed a 3.69% fuel consumption reduction in fuel consumption over the baseline, but also a reduction of over 1.0% from the improvement seen under full fuel treatment. Although the improvement might be significant, due to the undertreatment, the results of this test run should not be weighted as heavily as results seen under full treatment (January 31).

Unit # 5

The powerhouse test runs of January 29 and 31 were under full treatment with FPC-1. None of the CMB test runs on Unit # 5 were under full treatment with FPC-1. The powerhouse data for the 29th indicates a fuel consumption reduction (uncorrected) with FPC-1 fuel treatment of 1.30%. The fuel density was unknown, but the intake air temperature was 6.4 degrees C. lower. Using the same formula as that used for Unit # 2 to correct for intake air temperature (see Figure 3, Appendix 7), the gallons consumed would be corrected 0.64% (correction factor = 0.9936) towards a reduction in fuel consumption (1.90% corrected). The powerhouse data from the 31st can be corrected for both fuel density and intake air temperature. Like Unit # 2, the fuel density was 0.25% lower. Intake air temperature was 6.4 degrees C. lower on the 31st, also. The powerhouse data indicates an increase in fuel consumption of 0.72% (uncorrected). After correcting for fuel density and intake temperature, the actual fuel consumption change was -0.20%. The average reduction in fuel consumption for the two powerhouse test runs on Unit #5 with FPC-1 treated fuel is 1.05%.

The only CMB test comparing baseline to treated fuel was that of February 19 when the fuel was grossly undertreated. Here the CMB data indicates a 3.76% reduction in fuel consumption. There was some difficulty in maintaining a constant load during this test run also, which led to slightly erratic exhaust gas pressure velocity readings. An inaccuracy in these readings could have led to a slightly greater change in fuel consumption than otherwise expected. However, the change closely reproduces the improvement seen in Unit # 2 for the same day.

The final test run on Unit # 5, like # 2, was done on grossly undertreated fuel.

As mentioned in the previous discussion of the accuracy of the two methods, the CMB

methodology has at least twice the accuracy of the powerhouse flowmeters. The 4.75%, 3.69%, and 3.76% change improvements are several times greater than the range of accuracy for the CMB methodology ($\pm 1\%$), whereas the 2.53% and 1.05% improvements in the powerhouse data fall well within the range of accuracy for the flowmeters ($\pm 4\%$). However, the powerhouse data has shown consistent changes in fuel consumption from run to run when under full treatment providing a large database that helps confirm the improvement seen in the CMB.

The NDIR analysis and Bacharach smoke density test also indicate reductions in CO and smoke of 40% and 20%, respectively, for Unit # 2 under full treatment. While undertreated, the Co emissions returned to baseline levels, while smoke remained at full treatment levels (-20%). These data agree with prior experience. CO has always been more readily effected by the addition or removal of FPC-1 from fuel.

Unit # 5 showed no change in CO with partially treated fuel, agreeing with Unit # 2. Also in agreement with Unit # 2, the smoke levels were reduced 20% while running on partial treatment.

These changes, created by FPC-1, further support the observed reductions in fuel consumption, as well as the mode of action of the catalyst. Results from seventeen previous genset tests in engines of 3,500 to 11,000 horsepower and 500 to 1000 rpm ranges reveal similar improvements.

VII. The Effect of Mixing Ratio

The tests runs on February 19th were done on fuel only partially treated with FPC-1. UHI determined the recommended mixing ratio by conducted several studies with FPC-1 fuel treatment at various mixing ratios and concentrations of the active ingredient. These studies show efficiency gain with the catalyst are not profoundly affected with fuel treat rates falling between 80% and 120% of recommendation, although higher concentrations trend toward greater gains. However, as might be expected, treat rates falling below 80% cause increasing losses until approximately 20% of treat rate. At this point, any improvement created by FPC-1 is so small it cannot be measured by typical instrumentation. Therefore, it is not surprising that improvements in Unit # 2 (wherein historical data exists) are lower during tests done on the 19th. It would also be expected that data from Unit # 5 would also show diminished improvements.

The effect of mixing ratio is also influenced by the engine conditioning, and deconditioning period observed in other laboratory and field tests. Once the fuel is treated with FPC-1, the engine starts into a gradual conditioning or preconditioning period. The engine begins to trend towards efficiency gain for several hundred hours. Along with the gains in engine efficiency, smoke and carbon monoxide emissions soon begin trending downward.

Once FPC-1 is removed from the fuel, the engine preconditioning period begins to reverse itself very gradually. The "return to baseline" engine efficiency and emissions output requires

approximately the same amount of time as did preconditioning. Therefore, although the effectiveness of the catalyst is certain to be reduced with partial treatment, the engines could still produce significant

VIII. Conclusions

(1) The data compiled during the Red Dog powerhouse trial on Units 2 and 5 confirm the mode of action of the FPC-1 catalyst. Fuel consumption and emissions are reduced at the same power settings, indicating improved flame speed. The more profound improvement seen in Unit # 2 would be expected since this engine is less efficient than Unit # 5 to begin with.

(2) The powerhouse flowmeters are less accurate than the CMB instruments, as demonstrated by the back-to-back baseline tests on Unit # 2. The consistency of both methods and the size of the database improve the accuracy of both methods.

(3) The loads for Unit # 2 and Unit # 5 were closely reproduced for all treated test runs on January 17, 18, 29, 31, and February 19. The first treated run on the 31st produced loads identical to the baseline and therefore, may be considered the most representative of the actual fuel consumption reduction created by the use of FPC-1. Fuel consumption was reduced 2.98% (corrected) during this particular run.

(4) Smoke density was reduced approximately 20%, which agrees with reductions in prior genset tests.

(5) Carbon monoxide (CO) was reduced approximately 40% in Unit # 2 under full treatment. Neither test engine saw CO reductions when only running on partially treated fuel.

(6) The powerhouse data that can be corrected for fuel density and ambient temperature shows an average fuel consumption reduction of 2.53% for Unit # 2 and 1.05% for Unit # 5 for all test runs under full treatment.

(7) The CMB method shows fuel consumption was reduced 4.75% in Unit # 2 when under full treatment, and 3.69% while undertreated. Unit # 5 showed a fuel consumption reduction of 3.76% using the CMB while undertreated.

Table 1. Powerhouse Data for Back-to-Back Baseline Runs of Unit # 2

<u>Unit No.</u>	<u>E. Temp.</u>	<u>MW</u>	<u>PF</u>	<u>KVAR</u>	<u>Amps</u>	<u>MVA</u>	<u>Kwh/G</u>	<u>gpm</u>
2	854.6 F	3.75	.879	2018	584	4.26	12.36	4.84
*2	863.6 F	3.77	.934	1438	555	4.04	12.42	4.84

* Re-test

Table 2. Powerhouse Data for Baseline and Treated Fuel Runs of Unit # 2 and Unit # 5

UNIT # 2									
<u>Test Date</u>	<u>E. Temp.</u>	<u>MW</u>	<u>PF</u>	<u>KVAR</u>	<u>Amps</u>	<u>MVA</u>	<u>Kwh/G</u>	<u>G/test</u>	<u>gpm</u>
*Jan 18	863.6 F	3.77	.934	1438	555	4.04	12.42	242.0	4.84
Jan 29	na	3.74	.942	1341	545	3.97	12.60	238.0	4.76
Jan 31	845.6 F	3.76	.933	1447	550	4.02	12.60	236.4	4.73
Jan 31	845.6 F	3.77	.948	1252	544	3.96	12.59	238.6	4.77
+Feb 19	876.2 F	3.80	.939	1398	554	4.03	12.19	247.0	4.94
UNIT # 5									
Jan 17	852.8 F	3.75	.927	1522	555	4.05	13.39	221.0	4.42
Jan 29		3.73	.908	1637	564	4.09	13.56	218.2	4.36
Jan 31		3.75	.932	1456	552	4.04	13.41	222.7	4.45
+Feb 19	860.9 F	3.76	.929	1485	555	4.06	13.35	223.0	4.46

* The Jan. 31st run that is bolded most closely matches the load during the baseline on Jan. 18th.

+ The Feb 19th run was done on partially treated fuel.

Table 3: Smoke Numbers

<u>Engine</u>	<u>Base Smoke No.</u>	<u>Treated Smoke No.</u>
No. 2	5.0	na
*No. 2	5.0	4.0
No. 2		4.0
No. 5	5.0	4.0

* 2nd test runs for both baseline and treated fuels.

WÄRTSILÄ DIESEL

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Annapolis, Maryland USA
Telephone: (410) 573-2100
Telecopier: (410) 573-2265

Technical Service

TELEFAX MESSAGE
Date: February 15, 1995

To: Greg Flenders
Company:
Phone:
Fax: (801)374-0345

From: Juha Vainio - Service Coordinator
Pages including this
cover page: 5

Re:

Red Dog Mine - 6 x 16V32 - Fuel Consumption

Sorry, we don't have kind of corrector factor what you asked, but
here by something regarding fuel / air relation.

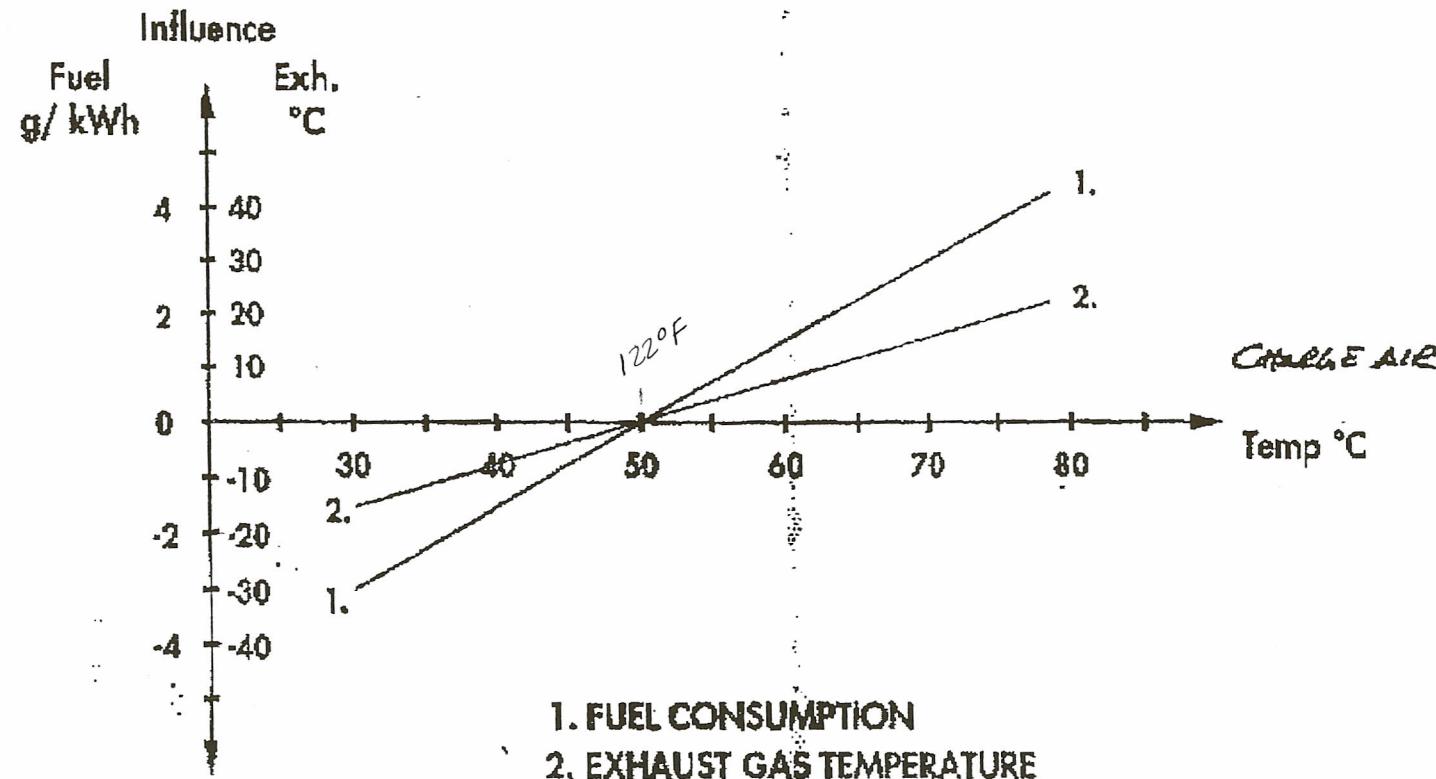
Sold maximum out put you can check with customer.

RGDS





THE INFLUENCE OF CHARGE AIR TEMPERATURE ON FUEL CONSUMPTION AND EXHAUST GAS TEMPERATURE



THE INFLUENCE OF CHARGE AIR TEMPERATURE ON FUEL CONSUMPTION AND EXHAUST GAS TEMPERATURE

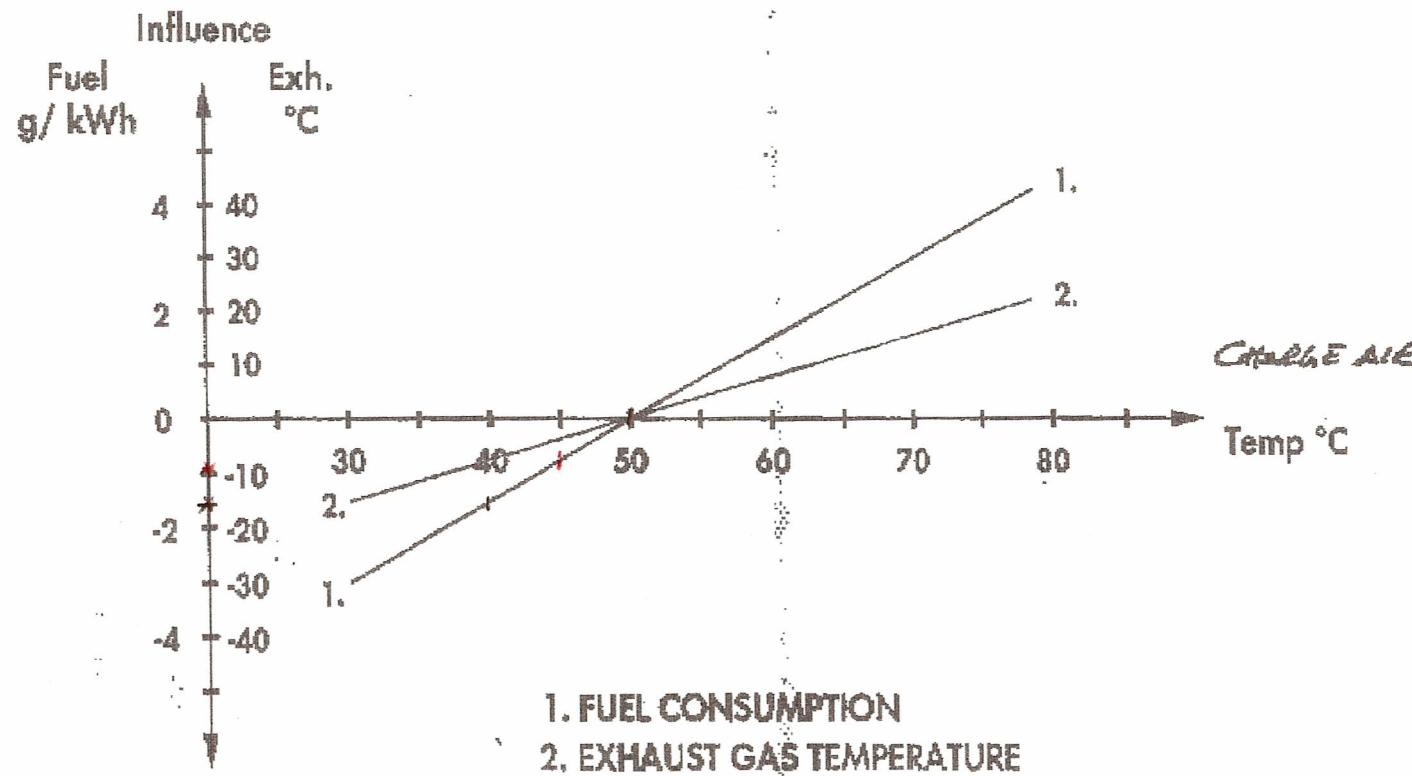


FIGURE 3

**THE INFLUENCE OF INTAKE AND CHARGE AIR TEMPERATURE ON
FUEL CONSUMPTION**

Based on mill experience and discussions with engine manufacturers, the impact of a change of 10 degrees Centigrade in intake air temperature on fuel consumption is approximately 1%, i.e., as intake air temperature is reduced fuel consumption increases, assuming load is held constant. Although Wartsila was unable to provide "correction factors", the attached charts for the VASA 32 show the relationships between charge air temperature, intake air temperature, fuel consumption, exhaust gas temperature, etc.

Calculation of Fuel Consumption correction factor based on Intake Air Temperature differences for Unit #2 Baseline (1/18/95) vs. Treated (1/31/95):

1/18/95 Intake Air Temperature 80 degrees F. = 26.7 degrees C.

1/31/95 " " " 72 degrees F. = 22.2 degrees C.
 4.5

$$\% \text{ Correction} = \frac{1\% (4.5 \text{ degrees C.})}{10 \text{ degrees C.}} = 0.45\%$$

$$\text{Correction Factor} = \frac{100\% - 0.45\%}{100} = .9955$$

WÄRTSILÄ DIESEL

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Technical Service

TELEFAX MESSAGE
Date: February 15, 1995

To: Greg Flenders

Company:

Phone:

Fax: (801)374-0345

From: Juha Vainio - Service Coordinator

Pages including this

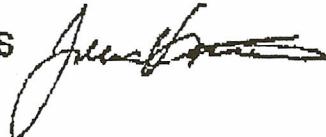
cover page: 5

Re:**Red Dog Mine - 6 x 16V32 - Fuel Consumption**

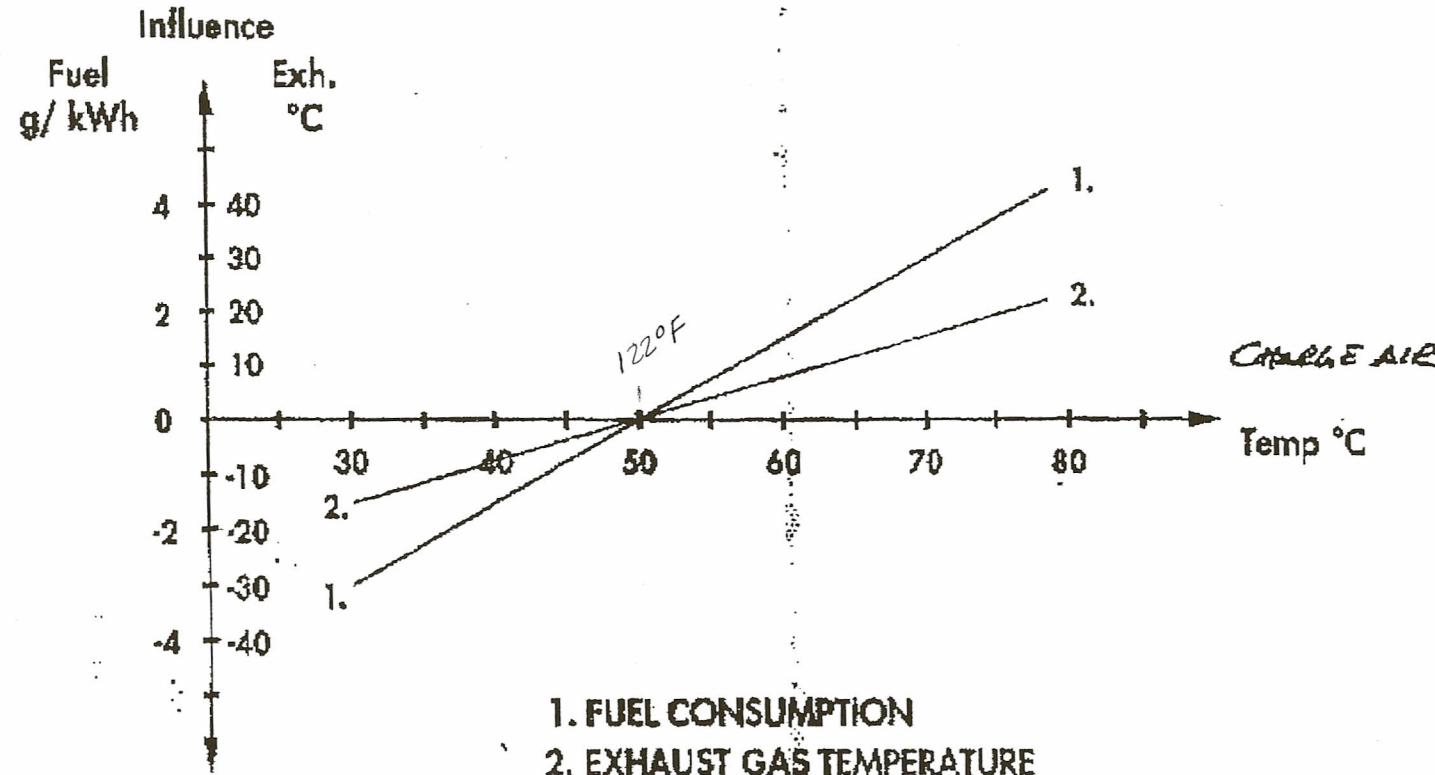
Sorry, we don't have kind of corrector factor what you asked, but
here by something regarding fuel / air relation.

Sold maximum out put you can check with customer.

RGDS

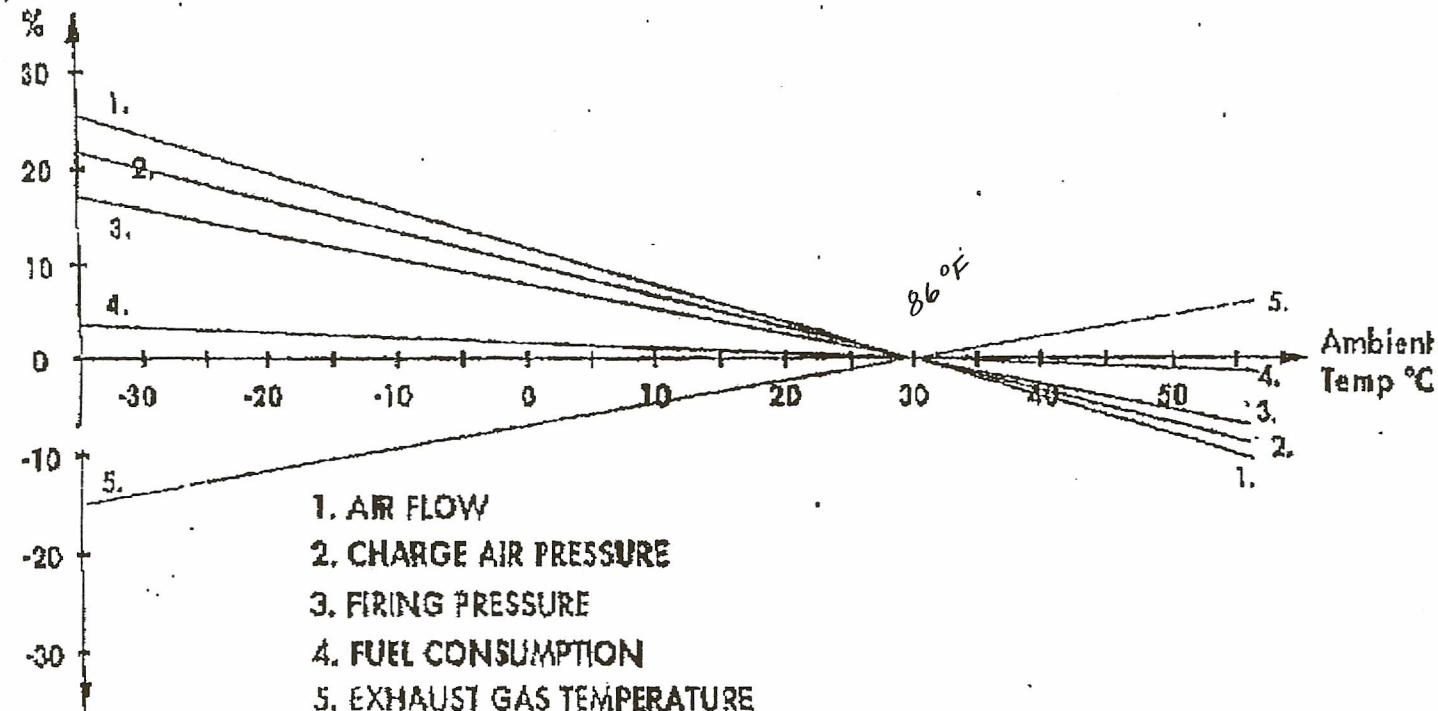


THE INFLUENCE OF CHARGE AIR TEMPERATURE ON FUEL CONSUMPTION AND EXHAUST GAS TEMPERATURE



THE INFLUENCE OF AMBIENT TEMPERATURE ON ENGINE PERFORMANCE

Influence on performance



FPC[®] TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Pg. 1

Smoke Spot Numbers

1. 5.0 2. _____

Company: Cominco / Red Dog

Test Date: 1-18-95

Test Portion: Baseline

Water Temp. _____

Treated

Oil Pressure _____

Equipment Tested:

Make Wartsila #2

Air Restriction _____

Miles _____ I.D. # _____

Engine Type _____

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: ~~29~~ Inches Hg @ 29.1 °F Ambient Temp: 920 am °F

Fuel: _____ SG @ _____ °F Start Time: 920 am

✓ ✓ - - X

	RPM Time	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
5.0 min	0			.02	8	5.42	12.3	
7 1/2	2.5 min			.02	10	5.41	12.3	
10	5.0 min			.02	13	5.38	12.4	
12 1/2	7.5 min			.02	13	5.34	12.4	
15				.01	13	5.33	12.4	Auto Cal
17 1/2				.01	10	5.32	12.1	
20				.02	10	5.30	12.1	.
22 1/2				.02	10	5.28	12.2	.
25				.02	12	5.28	12.1	-
27 1/2				.02	13	5.26	12.1	X cool
	Average							

Signature of Technicians: _____ Finish Time: _____

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

PAGE 2

Smoke Spot Numbers

1. 5.0 2. _____

Re-Test

Company: COMINCO RED DOG Test Date: 1-18-95

Test Portion: Baseline

Water Temp. _____

Oil Pressure _____

Treated

Air Restriction _____

Equipment Tested:

Make WARTSILLA #2 Miles _____ I.D. # _____

Engine Type _____ Hours _____ I.D. _____

Fuel Injection Naturally Aspirated

Mechanical Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: _____

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
30	1			.02	10	5.31	12.0	
37 1/2	2			.01	10	5.32	11.9	
35	3			.01	10	5.25	11.9	
37 1/2	4			.01	10	5.25	12.0	
40	5			.02	10	5.25	12.0	X CO ₂
42 1/2	6			.02	10	5.29	11.9	
45	7			.02	10	5.29	11.9	
47 1/2	8			.01	10	5.27	11.9	
50	9			.02	10	5.26	11.9	
	10							
	Average							

Signature of Technicians: _____ Finish Time: _____

BARROW 2000 22.2.93

PAGE 1 OF 2

Diesel Generator Specific Fuel Consumption Log

Customer: Cominco Alaska Inc Engine #: 2 Date: 18 JAN '95 Base: ✓ Treated: _____
 Location: Red Dog Operations Density: _____ Base: _____ Treated: _____
 Engine: Make: _____ Alternator: _____ Test Sequence #: 2 RETEST
 Model: _____ Make: _____
 Eng. Hrs: _____ Rating: _____

MVA

Temperature Degree F

TIME Start Finish	Elapsed Time	Nom Load kW	kWh Start Finish	kWh MW	PF Av	KVAR Volts	Amps	FUEL METER Start/Finish	Fuel Gallons	kWh/g g/kWh	STACK Exhaust Gas Temp	T, EX A Air In Dry/Wet	T ER B J.W. Out/In	Fuel In
2.5		<u>4.02</u>	<u>3.80</u>	<u>.943</u>	<u>1361</u>	<u>561</u>				<u>12.40</u>	<u>435.2</u>	<u>791</u>	<u>755</u>	
5		<u>4.09</u>	<u>3.83</u>	<u>.934</u>	<u>1420</u>	<u>559</u>				<u>12.60</u>	<u>435.7</u>	<u>791</u>	<u>755</u>	
7.5		<u>4.08</u>	<u>3.83</u>	<u>.937</u>	<u>1403</u>	<u>544</u>				<u>12.21</u>	<u>436.0</u>	<u>791</u>	<u>755</u>	
10		<u>4.10</u>	<u>3.83</u>	<u>.932</u>	<u>1462</u>	<u>561</u>				<u>12.58</u>	<u>436.3</u>	<u>791</u>	<u>755</u>	
12.5		<u>4.03</u>	<u>3.77</u>	<u>.938</u>	<u>1403</u>	<u>556</u>				<u>12.44</u>	<u>436.6</u>	<u>791</u>	<u>755</u>	
15		<u>4.05</u>	<u>3.80</u>	<u>.939</u>	<u>1418</u>	<u>555</u>				<u>12.26</u>	<u>436.7</u>	<u>791</u>	<u>755</u>	
17.5		<u>4.00</u>	<u>3.72</u>	<u>.935</u>	<u>1436</u>	<u>557</u>				<u>12.48</u>	<u>436.7</u>	<u>791</u>	<u>755</u>	
20		<u>4.09</u>	<u>3.83</u>	<u>.937</u>	<u>1425</u>	<u>557</u>				<u>12.40</u>	<u>436.8</u>	<u>791</u>	<u>756</u>	
22.5		<u>4.03</u>	<u>3.78</u>	<u>.934</u>	<u>1425</u>	<u>558</u>				<u>12.47</u>	<u>437.1</u>	<u>792</u>	<u>756</u>	
25		<u>3.93</u>	<u>3.66</u>	<u>.940</u>	<u>1493</u>	<u>547</u>				<u>12.39</u>	<u>437.2</u>	<u>792</u>	<u>756</u>	
27.5		<u>4.06</u>	<u>3.23</u>	<u>.931</u>	<u>1451</u>	<u>550</u>				<u>12.22</u>	<u>437.4</u>	<u>791</u>	<u>756</u>	
30		<u>4.01</u>	<u>3.24</u>	<u>.932</u>	<u>1417</u>	<u>548</u>				<u>12.36</u>	<u>437.5</u>	<u>791</u>	<u>755</u>	
32.5		<u>4.06</u>	<u>3.22</u>	<u>.938</u>	<u>1402</u>	<u>548</u>				<u>12.34</u>	<u>437.6</u>	<u>792</u>	<u>756</u>	

Diesel Generator Specific Fuel Consumption Log

Customer: Comisco Alaska Inc

Engine #: 2

Date: 18 Jan '95 Base: ✓ Treated:

Location: Red Dog Operations

Density: _____ Base: _____ Treated: _____

Engine: Make: _____
Model: _____
Eng. Hrs: _____

Alternator:
Make: _____
Rating: _____

Test Sequence #: 2 RETUSJ

MVA MW PF KVAR

Temperature Degree F

60	Surf:	88.87	82.81	20.56	31,648	12,203	583/381
	mean:	4.04	3.77	0.934	1,438.4	554.7	
	SD:	0.084	0.050	0.004	38.25	5.52	282/50

80 AMBIENT AIR IN POUHNUK

RWJ

Diesel Generator Specific Fuel Consumption Log

Customer: _____

Engine #: 2Date: 18-JAN

Base: _____

Treated: _____

Location: _____

Density: _____

Base: _____

Treated: _____

Engine: Make: _____
Model: _____
Eng. Hrs: _____Alternator: Make: _____
Rating: _____

Test Sequence #: _____

2495/1480

Temperature Degree F

TIME Start Finish	Elapsed Time	Nom Load kW	kWh Start Finish	kWh	kW Av	Kv Volts	Amps	FUEL METER Start/Finish	Fuel Gallons	g/kWh	Exhaust Gas Temp	Air In Dry/Wet	J.W. Out/In	Fuel In
				3048	1793			2548 1512	23				93°F	120°F
			-	2495 - 1482				2604 1543	25				" " "	" "
				553	311			2660 1543	24				" " "	" "
			-	311				2660 1575	24				" " "	" "
				(242 GAL)				2716 1606	25				" " "	" "
								2771 1637	24				" " "	" "
								2826 1668	24				" " "	" "
								553 - 311 = 242	2882 1200	24			" " "	" "
								2937 1731	24				" " "	" "
								2992 1762	24	217			" " "	" "
								3048 1793	25	(242 GAL)			" " "	" "

<u>2548</u> <u>2495</u> <u>53</u> <u>-30</u> <u>23 CAL</u>	<u>2604</u> <u>2548</u> <u>56</u> <u>31</u> <u>25 CAL</u>	<u>2660</u> <u>2604</u> <u>56</u> <u>32</u> <u>24 CAL</u>	<u>2716</u> <u>2660</u> <u>56</u> <u>31</u> <u>25 CAL</u>	<u>2771</u> <u>2716</u> <u>55</u> <u>31</u> <u>24 CAL</u>	<u>2826</u> <u>2771</u> <u>55</u> <u>31</u> <u>24 CAL</u>	<u>2882</u> <u>2826</u> <u>56</u> <u>32</u> <u>24 CAL</u>	<u>2937</u> <u>2882</u> <u>56</u> <u>31</u> <u>24 CAL</u>	<u>2992</u> <u>2937</u> <u>56</u> <u>31</u> <u>24 CAL</u>	<u>3048</u> <u>2992</u> <u>56</u> <u>31</u> <u>25</u>
--	---	---	---	---	---	---	---	---	---

Carbon Mass Balance Field Data Form

Company: _____ Location: _____ Test Date: 1-18-95

Test Portion: Baseline: _____ Treated: _____ Exhaust Stack Diameter: ____ Inches

Engine Make/Model: Wartsila #2 Miles/Hours: _____ I.D.#: _____
Type of Equipment: _____

Fuel Specific Gravity: _____ @: _____ (°F) *Re Test*

Barometric Pressure: _____ Inches of Mercury

Intake Air Temperature: _____ (°F) Start Time: _____

RPM	Exhaust Temp °F	P Inches of H ₂ O	% CO	HC ppm	% CO ₂	% O ₂	Smoke Number
1.	11	1.25	1.25				
2.	12	1.25	1.25				
3.	13	1.25	1.25				
4.	14	1.30	1.25				
5.	15	1.25	1.25				
6.	16	1.25	1.25				
7.	17	1.25	1.25				
8.	18	1.25	1.20				
9.	19	1.20	1.25				
10.	20	1.25	1.25				

End Time _____

Names of Customer Personnel Participating in Test:

Signature of Technicians:

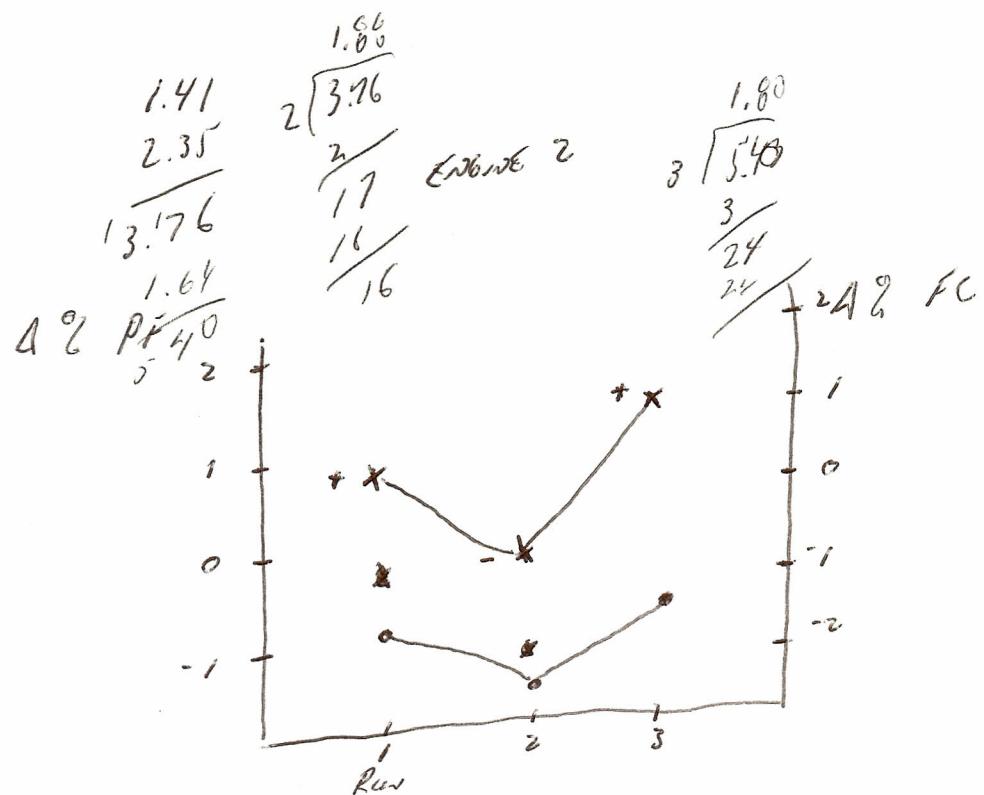
ENGINE 2 WARTSILA VASA 16U32 COMPUTED VALUES :

	CYLINDER	1	2	3	4	5	6	7	8
B CYL LINER 1		139	139	139	(157)	138	137	140	144
A CYL LINER 2		137	142	(154)	146	132	131	139	142
N CYL LINER 3		136	144	147	138	(143)	132	137	138
K EXH ULVE 1 WAVE		0	0	0	0	0	0	0	0
EXH ULVE 2 WAVE		0	0	0	0	0	0	0	0
A EXH TEMPERATURE		491	477	472	475	465	432	486	469
EXH VALUE DIFF		0	19	4	70	11	2	12	46
EXH TEMP DEU		29	15	10	13	3	- 30	24	7
MAIN BEAR	95	90	95	96	94	94	94	95	93
B CYL LINER 1		136	139	138	127	131	144	143	137
A CYL LINER 2		133	138	135	131	129	143	139	149
N CYL LINER 3		134	132	131	131	135	140	140	141
K EXH ULVE 1 WAVE		0	0	0	0	0	0	0	0
EXH ULVE 2 WAVE		1	0	0	0	0	0	0	0
B EXH TEMPERATURE		443	435	449	438	440	498	467	459
EXH VALUE DIFF		17	20	0	20	17	7	6	14
EXH TEMP DEU		- 19	- 27	- 10	- 24	- 22	36	5	- 3
MEAN TEMPERATURE 462									
1995-01-18 08:19									
RUN. HOURS 29567									

863.6

# 2 Engine under treatment with :	1063900	kwh generated					
Test # 2 of 2	306	hours of run time					
	FUEL	MW	PF	KVAR	AMP	MVA	KWH/G
#2 17 Jan	242.000	3.769	0.934	1438	555	4.039	12.418
#2 31 Jan	238.630	3.765	0.948	1252	544	3.960	12.587
	-3.370	-0.003	0.014	-185.9	-10.4	-0.080	0.168
	-1.41%	-0.09%	1.47%	-14.84%	-1.91%	-2.01%	1.34%

	# 2 Engine under treatment with :		1063900	kwh generated			
	FUEL	MW	PF	KVAR	AMP	MVA	KWH/G
#2 17 Jan	242.000	3.769	0.934	1438	555	4.039	12.418
#2 31 Jan	236.450	3.758	0.093	1447	550	4.024	12.597
			0.933				
	-5.550	-0.011	-0.841	8.2	-4.8	-0.015	0.179
			.001				
	-2.35%	-0.28%	-901.92%	0.57%	-0.87%	-0.37%	1.42%
			-0.1079				



$$\alpha = \text{PF}$$

$$\circ = \text{FC}$$

$$\#1 = 2.08$$

$$\#2 = 12.98$$

$$2.632$$

Sheet2

# 2 Engine under treatment with :	896900	kwh generated					
	253	hours of run time					
	FUEL	MW	PF	KVAR	AMP	MVA	KWH/G
#2 17 Jan 95	242.000	3.769	0.934	1438	555	4.039	12.418
#2 29 Jan 95	238.090	3.737	0.942	1341	545	3.967	12.601
	-3.910	-0.032	0.007	-97.5	-9.4	-0.072	0.183
	-1.64%	-0.86%	0.79%	-7.27%	-1.72%	-1.81%	1.45%

**UHI Corporation
2230 N. University Parkway, Suite 5B
Provo, Utah 84604
(801) 374-9010 FAX (801) 374-0345**

FAX Cover

TO: Wayne Armbrust, Electrical Super.

FROM: Craig Flinders

DATE: February 27, 1995

SUBJECT: Copy of Final Report

PAGES: 38

Dear Wayne:

Attached is a copy of the final report of findings from the FPC-1 trial. I have also put an original in the mail.

I will be traveling the next week. I have forwarded a copy to Lloyd Cox, who can answer your questions in my absence.

Thank you again for the opportunity to work with you and your staff at Red Dog. I have thoroughly enjoyed the experience.

Sincerely,



S. Craig Flinders
VP, Tech Services
UHI Corporation

cc. Lloyd Cox

**Cominco Alaska, Inc., Red Dog Mine Powerhouse Trial
of
FPC-1 Fuel Performance Catalyst**

FINAL REPORT

Prepared by UHI Corporation
Provo, Utah
and
FPC Technology
Boise, Idaho

February 24, 1995

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I. Introduction

FPC-1 Fuel Performance Catalyst is a burn rate modifier (catalyst) proven to reduce fuel consumption and increase engine horsepower in several recognized, independent laboratory tests, and several hundred independent field trials. The catalyst speeds the rate of flame propagation, and therefore, is particularly beneficial to engines wherein engine design and/or operation type contribute to efficiency loss.

Although innately more efficient than high-speed engines in mobile equipment, dozens of genset trials have shown the use of FPC-1 creates fuel consumption reductions in the range of 3.0% to 4.5%. Some seventeen tests in medium-speed diesel engines running on light fuel oil (# 2 diesel) have demonstrated an average reduction in fuel consumption of 3.52% with FPC-1 fuel treatment. Further, a test of FPC-1 conducted by Southwest Research Institute in a 2500 horsepower, medium-speed, turbocharged genset, showed the catalyst created a nearly 2% gain in efficiency. Combustion experts agree that a 2% gain in a test and engine of this type will translate to a 3.0% to 4.5% gain in a similar engine operating in the field.

The catalyst also has a positive impact upon the products of incomplete combustion, primarily soot (smoke) and carbon monoxide, a fact which further confirms the catalyst improves the rate of combustion.

The intent of the current trial at Cominco Alaska's Red Dog Mine is to determine the degree of fuel consumption reduction created by the addition of FPC-1 to the arctic diesel fuel supplied to the powerhouse. The test methodology for determining fuel consumption uses both the "carbon mass balance" (CMB) and powerhouse data from the control panel and in-line fuel flowmeters.

The CMB method measures the carbon containing products of the combustion process (CO₂, CO, HC) found in the exhaust, rather than directly measuring fuel flow into the engine. The CMB also makes possible the determination of FPC-1's effect upon regulated emissions, specifically smoke and carbon monoxide (CO).

This report summarizes and compares the baseline and FPC-1 treated fuel rates of consumption and emissions data for Units # 2 and # 5, both Wartsila 16V32s. Unit # 2 has a different camshaft and injection timing than Unit # 5, a design that sacrifices efficiency for reduced emissions of oxides of nitrogen (NO_x). Unit # 5 has historically proven to be more efficient (approximately 8%) than Unit # 2.

II. Discussion of Carbon Mass Balance Method

The CMB uses state-of-the-art, non-dispersive infrared analysis (NDIR) and the measurement of carbon containing exhaust gases to determine fuel consumption indirectly. The method has been central to the EPA Federal Test Procedures (FTP) and Highway Fuel Economy Test (HFET) since 1974, and is internationally recognized.

The exhaust gas data collected during the baseline and treated fuel carbon balance tests for Units # 2 and # 5 are summarized on the attached computer printouts (Appendix 1). From these data, the volume fraction (VF) of each gas is determined and the average molecular weight (Mwt) of the exhaust gases computed. Next, the engine performance factor (pf) or the carbon mass in the exhaust is computed. The pf is finally corrected for exhaust temperature and exhaust pressure velocity (exhaust density), and intake air pressure (barometric) yielding a engine performance factor (PF) or carbon mass flow rate corrected for total exhaust mass flow. The PFs are shown on the bottom of the computer printouts found in Appendix 1. A positive change in PF equates to a reduction in fuel consumption.

The CMB calculations and legend are found on Figure 1 under Appendix 6. A sample calculation is found on Figure 2, also under Appendix 6.

Correction for Fuel Density

The treated fuel PF (PF2) must be corrected for any change in fuel density (measured as specific gravity), and therefore, energy content. The baseline fuel density is used as the reference. The correction factor (if applicable) for fuel density is shown on the treated fuel database computer printouts.

Correction for Barometric Pressure and Ambient (intake air) Temperature

The barometric pressure is used in the calculation of both the baseline and treated fuel PFs. These pressure readings were taken at the airport in Kotzebue and corrected for the altitude (970 feet elevation) at the powerhouse. This approach was discussed with and approved by Mr. Harmon Ranney, Environmental Coordinator. The correction is made as follows:

* barometric pressure sea level - $(970/1000)(.11)$ = atmospheric pressure corrected for altitude

The corrected barometric pressure is shown on the treated fuel computer printouts.

Ambient temperature changes are corrected for in the calculation of the exhaust mass flowrate since changes in intake air temperature will be reflected in the exhaust temperature.

III. Accuracy of the Two Test Methods

The CMB data and test method have proven to be accurate to $\pm 1\%$. The accuracy of the powerhouse flowmeters is approximately $\pm 4\%$ (measured as the difference between the amount entering the powerhouse and that actually consumed by the engines). Also, there are two flowmeters, one measuring fuel to the engines, and one measuring the fuel being returned to the day tank from the injectors. These meters also have certain inaccuracies, as do the sensors and data acquisition system for the powerhouse control panels. Therefore, the CMB is the more accurate of the two methods and is more likely to reveal the actual rate of fuel consumption.

For example, during baseline testing of Unit # 2, back-to-back baselines were conducted in an attempt to stabilize engine load. All factors influencing fuel consumption at a given power output were measured. The powerhouse data indicated the load was reduced approximately 5% (see powerhouse data on Table 1, Appendix 2) during the second baseline, yet the flowmeters were unable to register a change in fuel consumption. The CMB, on the other hand, showed a fuel consumption reduction of 1.40% (see computer printouts, Appendix 3), a change that more closely reflects the reduction in power output of the engine.

Given the accuracy of the two methods, this would be expected. It is less likely that the flowmeter, having an accuracy of \pm 4%, would register a 1% change.

IV. Discussion of the Powerhouse Data for the Baseline and Treated Fuel Tests

Both engines were tested over a fifty (50) minute period for both the baseline and treated fuel runs. Data points were taken every two and one-half (2.5) minutes. Stop watches were used to synchronize the start of data acquisition and to ensure readings were taken at the same time and at the nominated interval (2.5 minutes).

While the engines were operating under a fixed load (in droop), the following powerhouse data were recorded:

- Exhaust temperature (stack A and B, after Turbo)
- Megawatts (MW)
- KVAR
- Amps
- Megavoltamps (MVA)
- Power factor (PF)
- Kilowatt hours per gallon of fuel (Kwh/G)
- Gallons of fuel consumed per five minute interval
- Gallons per minute (gpm)

These data from each test run are compiled on Table 2, Appendix 4.

Exhaust Stack Temperature

Typically, exhaust gas temperatures are taken at the same point as the exhaust pressure velocity and exhaust gas readings when using CMB. However, the heat recovery system made accurate measurement of engine exhaust temperature impossible. Therefore, exhaust gas temperature readings at the turbocharger and prior to the heat recovery system, were used in the CMB calculations to correct for changes in total exhaust mass.

V. Discussion of the Bacharach Smoke Spot Method

Smoke is a product of incomplete combustion, and as such, is a measure of engine efficiency. Smoke is simply unburned fuel droplets not consumed during the final phase or tail of combustion when combustion temperatures are significantly lower, and most of the oxygen in

the combustion chamber has been expended. The FPC-1 catalyst improves the oxidation of these fuel droplets, extracting more useful energy and reducing smoke emissions.

Baseline smoke density was determined using the widely accepted Bacharach Smoke Spot method. The Bacharach method draws a specific volume of exhaust gas through a standard 5 micron filter medium. The particulate in the exhaust gas sample collects on the surface of the filter medium. The surface is darkened by the particulate according to the density of the particulate in the exhaust sample. The greater the particulate density, the darker the color. The Bacharach smoke scale ranges from 0 to 9, with 0 being a white, particulate free filter, and 9 being a completely black filter.

The smoke spot numbers are relative smoke density numbers for each engine tested and can be used to determine any change in smoke emissions when compared to FPC-1 treated fuel. A comparison of the baseline and treated Smoke Numbers (shown on Table 3, Appendix 5) indicate the use of FPC-1 created an approximate reduction in smoke density of 20%. Smoke reductions in other genset trials average 19.5%.

VI. Discussion of Fuel Consumption and Emissions Results

Unit # 2

Powerhouse Data

Unit # 2 was the only engine tested using both test methods with fuel under full FPC-1 treatment (January 29 and 31 powerhouse data, and January 31 CMB data). The test run on February 19th was done on partially treated fuel. This was due to a problem with the metering pump. As near as could be determined, the fuel treatment rate during the February 19th test run was approximately one-third to one-half the 1:5000 mixing ratio recommended by the manufacturer (see the discussion of the Effect of Mixing Ratio under Section VII).

The uncorrected powerhouse data (not including the run on partially treated fuel) for Unit # 2 indicates an average fuel consumption reduction of 1.79% $\{(1.41\% + 1.65\% + 2.31\%)/3\}$ for the three treated fuel test runs (January 29 and 31). The test run of January 29th (1.65%), conducted by Cominco engineers, cannot be corrected for fuel density. The test runs on the 31st have fuel density data. The average uncorrected percentage change in fuel consumption for the two treated fuel runs on the 31st is 1.86% $\{(1.41\% + 2.31\%)/2\}$.

Fuel density was 0.25% lower (correction factor for gallons consumed = 0.9975) and intake air temperature was 4.5 degrees C lower (correction factor = 0.9955, see explanation of correction factor on Figure 3, Appendix 7). The two factors combine to correct the powerhouse data collected on the 31st towards a greater reduction in fuel consumption. Therefore, the powerhouse data collected from tests run on Unit # 2 on the 31st of January indicate an average fuel consumption reduction with FPC-1 treated fuel of 2.53%.

The first treated test run on the 31st reproduced the baseline engine load more closely than the treated test of the 29th or the 2nd treated test of the 31st. The fuel consumption reduction was the greatest during this test (2.31% uncorrected). The reduction was 2.98% after correcting for fuel density and intake air temperature. Because of the precision of load reproduction during this test, the results obtained may be considered the most accurate, and therefore, the most representative of the effect of FPC-1 upon fuel consumption in Unit #2.

The final treated test run on Unit # 2 (February 19th), as mentioned above, was done while running on undertreated fuel. Therefore, a valid comparison of the data and results from this test cannot be made, particularly the powerhouse data which is less sensitive to fuel consumption change (see discussion under section III. Accuracy of the Two Test Methods).

CMB Data

The CMB methodology corrects fuel consumption for changes in fuel density, intake air temperature, and pressure (barometric) from the baseline. The treated CMB test run on Unit # 2 (January 31) compared to the baseline CMB test run (January 18) shows a 4.75% reduction in fuel consumption.

Again, the final treated fuel CMB (February 19) was run on undertreated fuel. The CMB showed a 3.69% fuel consumption reduction in fuel consumption over the baseline, a drop in efficiency gain of over 1.0% from the improvement seen under full fuel treatment. Although the improvement is significant, the results of this test run should not be weighted as heavily as results seen under full treatment (January 31).

Unit # 5

Powerhouse Data

The powerhouse test runs of January 29 and 31 were under full treatment with FPC-1. Unfortunately, there were no CMB test runs on Unit # 5 when under full FPC-1 treatment. The powerhouse data for the 29th indicates a fuel consumption reduction (uncorrected) with FPC-1 fuel treatment of 1.30%. The fuel density was unknown, but the intake air temperature was 6.4 degrees C. lower. Using the same formula as that used for Unit # 2 to correct for intake air temperature (see Figure 3, Appendix 7), the gallons consumed would be corrected 0.64% (correction factor = 0.9936) towards a reduction in fuel consumption of 1.90%.

The powerhouse data from the 31st can be corrected for both fuel density and intake air temperature. Like Unit # 2, the fuel density was 0.25% lower (correction factor = 0.9975). Intake air temperature was 6.4 degrees C. lower (correction factor = 0.9936) on the 31st, also. The powerhouse data indicates an increase in fuel consumption of 0.72% (uncorrected). After correcting for fuel density and intake temperature, fuel consumption was actually reduced by 0.20%. The average reduction in fuel consumption for the two powerhouse test runs on Unit #5 with FPC-1 treated fuel is 1.05%.

CMB Data

The only CMB test comparing baseline to treated fuel for Unit # 5 was that of February 19 when the fuel was undertreated. The CMB data indicates a 3.76% reduction in fuel consumption.

The magnitude of improvement was not expected by testing engineers. A possible explanation for this may be found in the difficulty in maintaining a constant load during this test. The varying load led to slightly erratic exhaust gas pressure velocity readings. An inaccuracy in these readings could have led to a slightly greater change in fuel consumption than otherwise expected, although given the number of readings taken, any error would move towards the average. It should be noted, however, that the change seen in Unit # 5 agrees closely with that seen during testing of Unit # 2 (3.69%) on the same day.

Emissions Changes

The NDIR analysis and Bacharach smoke density test also indicate reductions in CO and smoke of 40% and 20%, respectively, for Unit # 2 under full treatment. While undertreated, the CO emissions returned to baseline levels, while smoke remained reduced by 20%, as observed under full treatment. These data agree with prior experience. Changes in CO caused by the addition or removal of FPC-1 from the fuel have always occurred more rapidly than changes in smoke.

Unit # 5 showed no change in CO with partially treated fuel, thus agreeing with the results from Unit # 2 observed on the same day (February 19th). Also, in agreement with Unit # 2, the smoke levels were reduced 20%.

These changes, created by FPC-1, further support the observed reductions in fuel consumption, as well as the mode of action of the catalyst. Results from seventeen previous genset tests in engines of 3,500 to 11,000 horsepower and 500 to 1000 rpm ranges reveal similar improvements.

VII. The Effect of Mixing Ratio and Engine Preconditioning

Mixing Ratio

The tests runs on February 19th were done on fuel only partially treated with FPC-1. UHI determined the recommended mixing ratio by conducting several studies with FPC-1 fuel treatment at various mixing ratios and concentrations of the active ingredient. These studies showed efficiency gains are maximized with fuel treatment rates falling between 80% and 120% (1:6000 to 1:4000 mixing ratio) of the recommended mixing ratio (1:5000), although higher concentrations do trend toward slightly greater gains.

However, when fuel treatment rates fall below 80% (1:6000), significant losses in efficiency gain are sustained. At approximately 20% of mixing ratio, any improvement created by FPC-1

is so small it cannot be measured with typical instrumentation.

With a treatment ratio of approximately 30% to 50% during the tests on the 19th, it is not surprising that improvements in Unit # 2 (wherein historical data exists) are lower than those observed during previous tests under full treatment. It would follow that data from Unit # 5 would also show diminished improvements.

Engine Preconditioning

The effect of FPC-1 on engine efficiency is also influenced by the length of time the engine has run on treated fuel. This is known as the engine conditioning or preconditioning period. Further, once the catalyst has been removed from the fuel, the engine undergoes a reversal of this trend, called a deconditioning or "return-to-baseline" period.

Observed in both the laboratory and field tests, once the fuel is treated with FPC-1, the engine starts into a gradual preconditioning period that may last several hundred hours. During this period, the engine steadily trends toward greater efficiency gain. Along with the gains in engine efficiency, smoke and carbon monoxide emissions also trend downward.

Once FPC-1 is removed from the fuel, the engine shows a gradual reversal of this trend, and over time, returns to baseline efficiency. The "return to baseline" engine efficiency and emissions output requires approximately the same amount of time as did the preconditioning.

Therefore, although the effectiveness of the catalyst is certain to be reduced with partial treatment, the engines could still experience significant efficiency gains over the baseline.

VIII. Observations by Cominco Personnel

Engine Cleanliness

After approximately 250+ hours of FPC-1 fuel treatment, Unit # 3 was rebuilt by powerhouse mechanics. These same mechanics observed the combustion chamber engine components were much cleaner than seen with previous teardowns.

It is a well documented fact that carbon deposits rob an engine of efficiency and shorten engine component life, particularly rings, valves, seats, and injectors. A study of engine component life could allow the rebuilt interval to be extended considerably with FPC-1 treated fuel, thus increasing availability, and reducing repair and downtime costs.

Opacity Observations

On February 19th, opacity readings were taken on Unit # 6, a low emissions engine. Reportedly, this engine has historically shown opacity readings in the 5% to 10% range. On the 19th, while operating on partially treated fuel, the engine registered zero (0) opacity for the

first time.

Cominco may also observe reduced oxide of nitrogen emissions (NOx). Prior studies indicate the addition of FPC-1 can reduce NOx emissions approximately 2% to 4%.

IX. Conclusions

(1) The data compiled during the Red Dog powerhouse trial on Units 2 and 5 confirm the mode of action of the FPC-1 catalyst. Fuel consumption and emissions are reduced at the same power settings, indicating improved flame speed.

(2) The powerhouse flowmeters and methodology are less accurate than the CMB instruments and methodology, as demonstrated by the back-to-back baseline tests on Unit # 2 (January 17 and 18).

(3) Smoke density was reduced approximately 20%, which agrees with reductions in prior genset tests.

(4) Carbon monoxide (CO) was reduced approximately 40% in Unit # 2 under full treatment. Neither engine showed CO reductions when running on partially treated fuel.

(5) The powerhouse data that can be corrected for both fuel density and ambient temperature, showed an average fuel consumption reduction of 2.53% for Unit # 2 and 1.05% for Unit # 5 for test runs under full treatment.

(6) The CMB method shows fuel consumption was reduced 4.75% in Unit # 2 when under full treatment, and 3.69% while undertreated. Unit # 5 showed a fuel consumption reduction of 3.76% using the CMB while undertreated.

(7) Due to the consistency and accuracy of the CMB method, the results of the CMB test runs should be weighted much heavier than those obtained with the powerhouse method, for all the reasons discussed in the body of the report.

Appendix 1

Re-Test

Company Name: Cominco Alaska Location: Red Dog Operations Date: 1/18/95
 Test Portion: Baseline Stack Diam.: 32 Inches
 Engine Type: Wartsila Mile/Hrs
 Equipment Type: Generator ID #: 2 Baro: 29.12
 Fuel Sp. Gravity(SG) .807 Temp: 87 Time: 920

Reading #	Exh Temp	Pv Inch	CO	HC	CO2	O2	
5	863.6	1.25	0.02	8	5.42	12.3	
7.5	863.6	1.25	0.02	10	5.41	12.3	
10	863.6	1.25	0.02	13	5.38	12.4	
12.5	863.6	1.3	0.02	13	5.34	12.4	
15	863.6	1.25	0.01	13	5.33	12.4	
17.5	863.6	1.25	0.01	10	5.32	12.1	
20	863.6	1.25	0.02	10	5.3	12.1	
22.5	863.6	1.25	0.02	10	5.28	12.2	
25	863.6	1.25	0.02	12	5.28	12.1	
27.5	863.6	1.25	0.02	13	5.26	12.1	
30	863.6	1.25	0.02	10	5.31	12	
32.5	863.6	1.25	0.01	10	5.32	11.9	
35	863.6	1.25	0.01	10	5.25	11.9	
37.5	863.6	1.25	0.01	10	5.25	12	
40	863.6	1.25	0.02	10	5.25	12	
42.5	863.6	1.25	0.02	10	5.29	11.9	
45	863.6	1.25	0.02	10	5.29	11.9	
47.5	863.6	1.25	0.01	10	5.27	11.9	
50	863.6	1.25	0.02	10	5.26	11.9	
27.500	863.600	1.253	.017	10.632	5.306	12.095	Mean
14.06828585	.000	.011	.005	1.422	.052	.187	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
1.06E-05	0.000168421	.053	.121	29.333	122,824	4,053

Company Name: Cominco Alaska **Location:** Red Dog Operations **Test Date:** 1/31/95
Test Portion: Treated **Stack Diam:** 32 **Inches**
Engine Type: Wartsila **Mile/Hrs:**
Equipment Type Generator **ID #:** 2 **Baro:** 29.73
Fuel Sp. Gravity: .805 **Temp:** 64 **Time:** 11:30
SG Corr Factor: 1.002

Reading #	Exh Temp	T2	CO	HC	CO2	O2	
2.5	845.6	1.2	0.01	10	5.37	12.7	
5	845.6	1.2	0.01	10	5.33	12.7	
7.5	845.6	1.15	0.01	10	5.37	12.7	
10	845.6	1.15	0.01	10	5.33	12.7	
12.5	845.6	1.15	0.01	10	5.36	12.7	
15	845.6	1.15	0.01	9	5.31	12.8	
17.5	845.6	1.15	0.01	9	5.32	12.7	
20	845.6	1.15	0.01	9	5.34	12.7	
22.5	845.6	1.15	0.01	9	5.33	12.7	
25	845.6	1.15	0.01	9	5.31	12.8	
27.5	845.6	1.2	0.01	9	5.31	12.7	
30	845.6	1.2	0.01	9	5.31	12.7	
32.5	845.6	1.2	0.01	9	5.28	12.8	
35	845.6	1.2	0.01	9	5.27	12.7	
37.5	845.6	1.15	0.01	9	5.25	12.7	
40	845.6	1.15	0.01	9	5.23	12.8	
42.5	845.6	1.15	0.01	9	5.23	12.7	
45	845.6	1.15	0.01	9	5.24	12.7	
47.5	845.6	1.15	0.01	9	5.21	12.8	
50	845.6	1.15	0.01	9	5.22	12.8	
26.250	845.600	1.165	.010	9.250	5.296	12.730	Mean
14.79019946	.000	.024	.000	.444	.051	.047	Std Dev

VFHC	VFCO	VFCO2	VFO2
9.25E-06	0.0001	.053	.127

**% Change PF =	4.75
%	

Performance factor adjusted for fuel density: 4,245

** A positive change in PF equates to a reduction in fuel consumption.

Re-Test

Company Name: Cominco Alaska **Location:** Red Dog Operations **Date:** 1/18/95
Test Portion: Baseline **Stack Diam.** 32 **Inches**
Engine Type: Wartsila **Mile/Hrs**
Equipment Type: Generator **ID #:** 2 **Baro** 29.12
Fuel Sp. Gravity(SG) .807 **Temp:** 87 **Time:** 9:20

Reading #	Exh Temp	Pv Inch	CO	HC	CO2	O2	
5	863.6	1.25	0.02	8	5.42	12.3	
7.5	863.6	1.25	0.02	10	5.41	12.3	
10	863.6	1.25	0.02	13	5.38	12.4	
12.5	863.6	1.3	0.02	13	5.34	12.4	
15	863.6	1.25	0.01	13	5.33	12.4	
17.5	863.6	1.25	0.01	10	5.32	12.1	
20	863.6	1.25	0.02	10	5.3	12.1	
22.5	863.6	1.25	0.02	10	5.28	12.2	
25	863.6	1.25	0.02	12	5.28	12.1	
27.5	863.6	1.25	0.02	13	5.26	12.1	
30	863.6	1.25	0.02	10	5.31	12	
32.5	863.6	1.25	0.01	10	5.32	11.9	
35	863.6	1.25	0.01	10	5.25	11.9	
37.5	863.6	1.25	0.01	10	5.25	12	
40	863.6	1.25	0.02	10	5.25	12	
42.5	863.6	1.25	0.02	10	5.29	11.9	
45	863.6	1.25	0.02	10	5.29	11.9	
47.5	863.6	1.25	0.01	10	5.27	11.9	
50	863.6	1.25	0.02	10	5.26	11.9	
27.500	863.600	1.253	.017	10.632	5.306	12.095	Mean
14.06828585	.000	.011	.005	1.422	.052	.187	Std Dev

VFHC 1.06E-05	VFCO 0.000168421	VFCO2 .053	VFO2 .121	Mtw1 29.333	pf1 122,824	PF1 4,053
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Company Name: Cominco Alaska **Location:** Red Dog Operations **Test Date:** 2/19/95
Test Portion: Treated **Stack Diam:** 32 **Inches**
Engine Type: Wartsila **Mile/Hrs:**
Equipment Type Generator **ID #:** 2 **Baro:** 29.79
Fuel Sp. Gravity: .807 **Temp:** 82
SG Corr Factor: 1.000 **Time:** 11:00

Reading #	Exh Temp	L2	CO	HC	CO2	O2	
2.5	876.2	1.15	0.02	10	5.35	11.9	
5	876.2	1.15	0.02	10	5.37	11.8	
7.5	876.2	1.2	0.02	10	5.33	11.9	
10	876.2	1.2	0.02	10	5.34	11.9	
12.5	876.2	1.2	0.02	10	5.32	11.9	
15	876.2	1.2	0.02	10	5.33	11.9	
17.5	876.2	1.25	0.02	9	5.31	11.9	
20	876.2	1.2	0.02	10	5.32	11.9	
22.5	876.2	1.2	0.02	9	5.32	11.9	
25	876.2	1.2	0.02	9	5.32	11.9	
27.5	876.2	1.2	0.02	9	5.3	11.9	
30	876.2	1.25	0.02	8	5.29	11.9	
32.5	876.2	1.2	0.02	9	5.28	11.9	
35	876.2	1.2	0.02	9	5.29	11.9	
37.5	876.2	1.2	0.02	9	5.3	11.9	
40	876.2	1.2	0.02	9	5.27	11.9	
42.5	876.2	1.2	0.02	9	5.28	11.9	
45	876.2	1.2	0.02	8	5.29	11.8	
47.5	876.2	1.2	0.02	10	5.27	11.9	
50	876.2	1.2	0.02	9	5.3	11.9	
26.250	876.200	1.200	.020	9.300	5.309	11.890	Mean
14.79019946	.000	.023	.000	.657	.027	.031	Std Dev

VFHC 9.30E-06	VFCO 0.0002	VFCO2 .053	VFO2 .119	Mtw2 29.326	pf2 122,665	PF2 4,203
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Performance factor adjusted for fuel density:

4,203

****% Change PF = 3.69 %**

*** A positive change in PF equates to a reduction in fuel consumption.*

Company Name: Cominco Alaska Location: Red Dog Operations Date: 1/17/95
 Test Portion: Baseline Stack Diam.: 32 Inches
 Engine Type: Wartsila Mile/Hrs:
 Equipment Type: Generator ID #: 5 Baro: 28.83
 Fuel Sp. Gravity(SG) .807 Temp: 87 Time: 16:30

Reading #	Exh Temp	Pv-Inch	CO	HC	CO2	O2	
5	852.8	1.2	0.02	10	5.42	11.1	
7.5	852.8	1.2	0.02	10	5.445	11.1	
10	852.8	1.2	0.02	10	5.47	11.1	
12.5	852.8	1.2	0.02	10	5.4	11.1	
15	852.8	1.2	0.02	10	5.45	11.1	
17.5	852.8	1.2	0.02	10	5.415	11.1	
20	852.8	1.2	0.02	10	5.43	11	
22.5	852.8	1.2	0.02	10	5.45	11	
25	852.8	1.2	0.02	10	5.395	11	
27.5	852.8	1.2	0.02	10	5.415	11.1	
30	852.8	1.2	0.02	9	5.42	11	
32.5	852.8	1.2	0.02	10	5.41	11	
35	852.8	1.2	0.02	10	5.435	11	
37.5	852.8	1.2	0.02	10	5.415	11	
40	852.8	1.2	0.02	10	5.41	11.1	
42.5	852.8	1.2	0.02	10	5.405	10.9	
45	852.8	1.2	0.02	9	5.44	11	
47.5	852.8	1.2	0.01	10	5.435	11.1	
50	852.8	1.2	0.01	10	5.405	11.1	
52.5	852.8	1.2	0.02	9	5.4	10.9	
55	852.8	1.2	0.01	10	5.415	11	
30	852.800	1.200	.019	9.857	5.423	11.038	Mean
15.51209206	.000	.000	.004	.359	.020	.067	Std Dev

VFHC	VFCO	VFCO2	VFO2	Mtw1	pf1	PF1
9.86E-06	0.000185714	.054	.110	29.310	120,060	4,011

Company Name: Cominco Alaska **Location:** Red Dog Operations **Test Date:** 2/19/95
Test Portion: Treated **Stack Diam:** 32 **Inches**
Engine Type: Wartsila **Mile/Hrs:**
Equipment Type Generator **ID #:** 5 **Baro:** 29.80
Fuel Sp. Gravity: .807 **Temp:** 86
SG Corr Factor: 1.000 **Time:** 14:30

Reading #	Exh Temp	Pv-Inch	CO	HC	CO2	O2	
5	860.9	1.15	0.01	8	5.48	11.6	
7.5	860.9	1.15	0.02	8	5.42	11.5	
10	860.9	1.15	0.02	10	5.46	11.7	
12.5	860.9	1.15	0.02	10	5.43	11.7	
15	860.9	1.15	0.02	10	5.41	11.7	
17.5	860.9	1.2	0.02	10	5.4	11.6	
20	860.9	1.2	0.02	10	5.39	11.6	
22.5	860.9	1.15	0.02	10	5.41	11.6	
25	860.9	1.15	0.02	10	5.4	11.7	
27.5	860.9	1.15	0.02	8	5.39	11.7	
30	860.9	1.15	0.02	10	5.38	11.7	
32.5	860.9	1.2	0.02	8	5.37	11.7	
35	860.9	1.15	0.02	10	5.34	11.7	
37.5	860.9	1.15	0.02	10	5.37	11.7	
40	860.9	1.15	0.02	8	5.38	11.7	
42.5	860.9	1.25	0.02	9	5.37	11.7	
45	860.9	1.2	0.02	8	5.36	11.7	
47.5	860.9	1.25	0.02	10	5.35	11.6	
50	860.9	1.2	0.02	8	5.34	11.7	
52.5	860.9	1.2	0.02	10	5.34	11.7	
28.750	860.900	1.175	.020	9.250	5.390	11.665	Mean
14.79019946	.000	.034	.002	.967	.038	.059	Std Dev

VFHC 9.25E-06	VFCO 0.000195	VFCO2 .054	VFO2 .117	Mtw2 29.329	pf2 120,869	PF2 4,162
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Performance factor adjusted for fuel density: 4,162

****% Change PF = 3.76 %**

*** A positive change in PF equates to a reduction in fuel consumption.*

Appendix 2

Table 1. Powerhouse Data for Back-to-Back Baseline Runs of Unit # 2

<u>Unit No.</u>	<u>E. Temp.</u>	<u>MW</u>	<u>PF</u>	<u>KVAR</u>	<u>Amps</u>	<u>MVA</u>	<u>Kwh/G</u>	<u>gpm</u>
2	854.6 F	3.75	.879	2018	584	4.26	12.36	4.84
*2	863.6 F	3.77	.934	1438	555	4.04	12.42	4.84

* Re-test

Appendix 3

Re-Test

Company Name: Cominco Alaska **Location:** Red Dog Operations **Date:** 1/18/95
Test Portion: Baseline **Stack Diam.** 32 **Inches**
Engine Type: Wartsila **Mile/Hrs**
Equipment Type: Generator **ID #:** 2 **Baro** 29.12
Fuel Sp. Gravity(SG .807 **Temp:** 87 **Time:** 920

Reading #	Exh Temp	Pv Inch	CO	HC	CO2	O2	
5	863.6	1.25	0.02	8	5.42	12.3	
7.5	863.6	1.25	0.02	10	5.41	12.3	
10	863.6	1.25	0.02	13	5.38	12.4	
12.5	863.6	1.3	0.02	13	5.34	12.4	
15	863.6	1.25	0.01	13	5.33	12.4	
17.5	863.6	1.25	0.01	10	5.32	12.1	
20	863.6	1.25	0.02	10	5.3	12.1	
22.5	863.6	1.25	0.02	10	5.28	12.2	
25	863.6	1.25	0.02	12	5.28	12.1	
27.5	863.6	1.25	0.02	13	5.26	12.1	
30	863.6	1.25	0.02	10	5.31	12	
32.5	863.6	1.25	0.01	10	5.32	11.9	
35	863.6	1.25	0.01	10	5.25	11.9	
37.5	863.6	1.25	0.01	10	5.25	12	
40	863.6	1.25	0.02	10	5.25	12	
42.5	863.6	1.25	0.02	10	5.29	11.9	
45	863.6	1.25	0.02	10	5.29	11.9	
47.5	863.6	1.25	0.01	10	5.27	11.9	
50	863.6	1.25	0.02	10	5.26	11.9	
27.500	863.600	1.253	.017	10.632	5.306	12.095	Mean
14.06828585	.000	.011	.005	1.422	.052	.187	Std Dev

VFHC 1.06E-05	VFCO 0.000168421	VFCO2 .053	VFO2 .121	Mtw1 29.333	pf1 122,824	PF1 4,053
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Company Name: Cominco Alaska **Location:** Red Dog Operations **Date:** 1/17/95
Test Portion: Baseline **Stack Diam.** 32 **Inches**
Engine Type: Wartsila **Mile/Hrs**
Equipment Type: Generator **ID #:** 2 **Baro** 28.83
Fuel Sp. Gravity(SG .807 **Temp:** 87 **Time:** 1500

Reading #	Exh Temp	Pv Inch	CO	HC	CO2	O2	
5	854.6	1.15	0.02	12	5.47	12.6	
7.5	854.6	1.15	0.02	10	5.425	12.4	
10	854.6	1.15	0.02	10	5.41	12.4	
12.5	854.6	1.25	0.02	10	5.41	12.3	
15	854.6	1.25	0.02	10	5.395	12.4	
17.5	854.6	1.25	0.02	10	5.41	12.4	
20	854.6	1.25	0.02	10	5.37	12.4	
22.5	854.6	1.25	0.02	12	5.39	10.8	
25	854.6	1.25	0.02	12	5.36	10.8	
27.5	854.6	1.25	0.02	12	5.39	10.8	
30	854.6	1.25	0.02	12	5.385	10.9	
32.5	854.6	1.25	0.02	11	5.375	10.8	
35	854.6	1.25	0.02	11	5.35	10.8	
37.5	854.6	1.25	0.02	11	5.32	10.8	
40	854.6	1.25	0.02	10	5.32	10.8	
42.5	854.6	1.25	0.02	10	5.31	10.8	
45	854.6	1.25	0.02	9	5.325	10.8	
47.5	854.6	1.25	0.02	11	5.33	10.8	
50	854.6	1.25	0.02	10	5.305	10.8	
52.5	854.6	1.25	0.02	10	5.325	10.9	
55	854.6	1.25	0.02	10	5.295	10.8	
30.000	854.600	1.236	.020	10.619	5.365	11.348	Mean
15.51209206	.000	.036	.000	.921	.047	.775	Std Dev

VFHC 1.06E-05	VFCO 0.0002	VFCO2 .054	VFO2 .113	Mtw1 29.313	pf1 121,314	PF1 3,997
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Appendix 4

Table 2. Powerhouse Data for Baseline and Treated Fuel Runs of Unit # 2 and Unit # 5

UNIT # 2									
<u>Test Date</u>	<u>E. Temp.</u>	<u>MW</u>	<u>PF</u>	<u>KVAR</u>	<u>Amps</u>	<u>MVA</u>	<u>Kwh/G</u>	<u>G/test</u>	<u>gpm</u>
*Jan 18	863.6 F	3.77	.934	1438	555	4.04	12.42	242.0	4.84
Jan 29	na	3.74	.942	1341	545	3.97	12.60	238.0	4.76
Jan 31	845.6 F	3.76	.933	1447	550	4.02	12.60	236.4	4.73
Jan 31	845.6 F	3.77	.948	1252	544	3.96	12.59	238.6	4.77
+Feb 19	876.2 F	3.80	.939	1398	554	4.03	12.19	247.0	4.94
UNIT # 5									
Jan 17	852.8 F	3.75	.927	1522	555	4.05	13.39	221.0	4.42
Jan 29	na	3.73	.908	1637	564	4.09	13.56	218.2	4.36
Jan 31	na	3.75	.932	1456	552	4.04	13.41	222.7	4.45
+Feb 19	860.9 F	3.76	.929	1485	555	4.06	13.35	223.0	4.46

* The Jan. 31st run that is bolded most closely matches the load during the baseline on Jan. 18th.

+ The Feb 19th run was done on partially treated fuel.

Appendix 5

Table 3: Smoke Numbers

<u>Engine</u>	<u>Base Smoke No.</u>	<u>Treated Smoke No.</u>
No. 2	5.0	na
*No. 2	5.0	4.0
No. 2		4.0
No. 5	5.0	4.0

* 2nd test runs for both baseline and treated fuels.

Appendix 6

Figure 1
CARBON MASS BALANCE FORMULAE

ASSUMPTIONS: $C_{12}H_{26}$ and SG = 0.82
 Time is constant
 Load is constant

DATA:

Mwt = Molecular Weight
 pf1 = Calculated Performance Factor (Baseline)
 pf2 = Calculated Performance Factor (Treated)
 PF1 = Performance Factor (adjusted for Baseline exhaust mass)
 PF2 = Performance Factor (adjusted for Treated exhaust mass)
 CFM = Volumetric Flow Rate of the Exhaust
 SG = Specific Gravity of the Fuel
 VF = Volume Fraction
 d = Exhaust stack diameter in inches
 Pv = Velocity pressure in inches of H₂O
 Pb = Barometric pressure in inches of mercury
 Te = Exhaust temperature °F
 VFHC = "reading" ÷ 1,000,000
 VFCO = "reading" ÷ 100
 VFCO₂ = "reading" ÷ 100
 VFO₂ = "reading" ÷ 100

EQUATIONS:

$$Mwt = \frac{(VFHC)(86) + (VFCO)(28) + (VFCO_2)(44) + (VFO_2)(32) + [(1 - VFHC - VFCO - VFCO_2 - VFO_2)(28)]}{86(VFHC) + 13.89(VFCO) + 13.89(VFCO_2)}$$

$$pf1 \text{ or } pf2 = \frac{3099.6 \times Mwt}{86(VFHC) + 13.89(VFCO) + 13.89(VFCO_2)}$$

$$CFM = \frac{(d/2)^2 \pi}{144} \left(1096.2 \sqrt{\frac{Pv}{1.325(Pb/Te + 460)}} \right)$$

$$PF1 \text{ or } PF2 = \frac{pf \times (Te + 460)}{CFM}$$

FUEL ECONOMY:
 PERCENT INCREASE (OR DECREASE) $\frac{PF2 - PF1}{PF1} \times 100$

Figure 2.

SAMPLE CALCULATION FOR THE CARBON MASS BALANCE

BASELINE:

Equation 1 (Volume Fractions)

$$\begin{aligned} \text{VFHC} &= 13.20/1,000,000 \\ &= 0.0000132 \end{aligned}$$

$$\begin{aligned} \text{VFCO} &= 0.017/100 \\ &= 0.00017 \end{aligned}$$

$$\begin{aligned} \text{VFCO}_2 &= 1.937/100 \\ &= 0.01937 \end{aligned}$$

$$\begin{aligned} \text{VFO}_2 &= 17.10/100 \\ &= 0.171 \end{aligned}$$

Equation 2 (Molecular Weight)

$$\begin{aligned} \text{Mwt1} &= (0.0000132)(86) + (0.00017)(28) + (0.01937)(44) + (0.171)(32) \\ &\quad + [(1 - 0.0000132 - 0.00017 - 0.01937 - 0.171)(28)] \end{aligned}$$

$$\text{Mwt1} = 28.995$$

Equation 3 (Calculated Performance Factor)

$$\text{pf1} = \frac{3099.6 \times 28.995}{86(0.0000132) + 13.89(0.00017) + 13.89(0.01937)}$$

$$\text{pf1} = 329,809$$

Equation 4 (CFM Calculations)

$$\text{CFM} = \frac{(d/2)^2\pi}{144} \left(1096.2 \sqrt{\frac{Pv}{1.325(Pb/Te + 460)}} \right)$$

d = Exhaust stack diameter in inches
 Pv = Velocity pressure in inches of H₂O
 Pb = Barometric pressure in inches of mercury
 Te = Exhaust temperature °F

$$\text{CFM} = \frac{(10/2)^2\pi}{144} \left(1096.2 \sqrt{\frac{.80}{1.325(30.00/313.100 + 460)}} \right)$$

$$\text{CFM} = 2358.37$$

Equation 5 (Corrected Performance Factor)

$$\text{PF1} = \frac{329.809(313.1 \text{ deg F} + 460)}{2358.37 \text{ CFM}}$$

$$\text{PF1} = 108,115$$

TREATED:**Equation 1 (Volume Fractions)**

$$\begin{aligned} \text{VFHC} &= 14.6/1,000,000 \\ &= 0.0000146 \end{aligned}$$

$$\begin{aligned} \text{VFCO} &= .013/100 \\ &= 0.00013 \end{aligned}$$

$$\begin{aligned} \text{VFCO}_2 &= 1.826/100 \\ &= 0.01826 \end{aligned}$$

$$\begin{aligned} \text{VFO}_2 &= 17.17/100 \\ &= 0.1717 \end{aligned}$$

Equation 2 (Molecular Weight)

$$\text{Mwt2} = (0.0000146)(86) + (0.00013)(28) + (0.01826)(44) + (0.1717)(32) \\ + [(1 - 0.0000146 - 0.00013 - 0.01826 - 0.1717)(28)]$$

$$\text{Mwt2} = 28.980$$

Equation 3 (Calculated Performance Factor)

$$\text{pf2} = \frac{3099.6 \times 28.980}{86(0.0000146) + 13.89(0.00013) + 13.89(0.01826)}$$

$$\text{pf2} = 349,927$$

Equation 4 (CFM Calculations)

$$\text{CFM} = \frac{(d/2)^2 \pi}{144} \left(1096.2 \sqrt{\frac{Pv}{1.325(Pb/Te + 460)}} \right)$$

d = Exhaust stack diameter in inches

Pv = Velocity pressure in inches of H₂O

Pb = Barometric pressure in inches of mercury

Te = Exhaust temperature °F

$$\text{CFM} = \frac{(10/2)^2 \pi}{144} \left(1096.2 \sqrt{\frac{.775}{1.325(29.86/309.02 + 460)}} \right)$$

$$\text{CFM} = 2320.51$$

Equation 5 (Corrected Performance Factor)

$$\text{PF2} = \frac{349,927(309.02 \text{ deg F} + 460)}{2320.51 \text{ CFM}}$$

$$= 115,966$$

Fuel Specific Gravity Correction Factor

Baseline Fuel Specific Gravity - Treated Fuel Specific Gravity/Baseline Fuel Specific Gravity + 1

$$.840-.837/.840+1=1.0036$$

$$PF2 = 115,966 \times \text{Specific Gravity Correction}$$

$$PF2 = 115,966 \times 1.0036$$

$$PF2 = 116,384$$

Equation 6 (Percent Change in Engine Performance Factor:)

$$\% \text{ Change PF} = \frac{PF2 - PF1}{PF1} \times 100$$

$$\begin{aligned} \% \text{ Change PF} &= [(116,384 - 108,115)/108,115](100) \\ &= +7.65 \end{aligned}$$

Note: A positive change in PF equates to a reduction in fuel consumption.

Appendix 7

FIGURE 3

**THE INFLUENCE OF INTAKE AND CHARGE AIR TEMPERATURE ON
FUEL CONSUMPTION**

Based on mill experience and discussions with engine manufacturers, the impact of a change of 10 degrees Centigrade in intake air temperature on fuel consumption is approximately 1%. i.e., as intake air temperature is reduced fuel consumption increases, assuming load is held constant. Although Wartsila was unable to provide "correction factors", the attached charts for the VASA 32 show the relationships between charge air temperature, intake air temperature, fuel consumption, exhaust gas temperature, etc.

Calculation of Fuel Consumption correction factor based on Intake Air Temperature differences for Unit #2 Baseline (1/18/95) vs. Treated (1/31/95):

1/18/95 Intake Air Temperature 80 degrees F. = 26.7 degrees C.

1/31/95 " " " 72 degrees F. = $\frac{22.2}{4.5}$ degrees C.

$$\% \text{ Correction} = \frac{1\% (4.5 \text{ degrees C.})}{10 \text{ degrees C.}} = 0.45\%$$

$$\text{Correction Factor} = \frac{100\% - 0.45\%}{100} = .9955$$

WÄRTSILÄ DIESEL

Wartsila Diesel, Inc
201 Defense Highway
Suite 100.
Annapolis, Maryland USA
Telephone: (410) 573-2100
Telecopier: (410) 573-2265

Technical Service

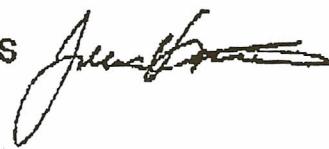
TELEFAX MESSAGE
Date: February 15, 1995**To:** Greg Flenders**Company:****Phone:****Fax:** (801)374-0345**From:** Juha Vainio - Service Coordinator**Pages including this****cover page:** 5

Re:**Red Dog Mine - 6 x 16V32 - Fuel Consumption**

Sorry, we don't have kind of corrector factor what you asked, but
here by something regarding fuel / air relation.

Sold maximum out put you can check with customer.

RGDS

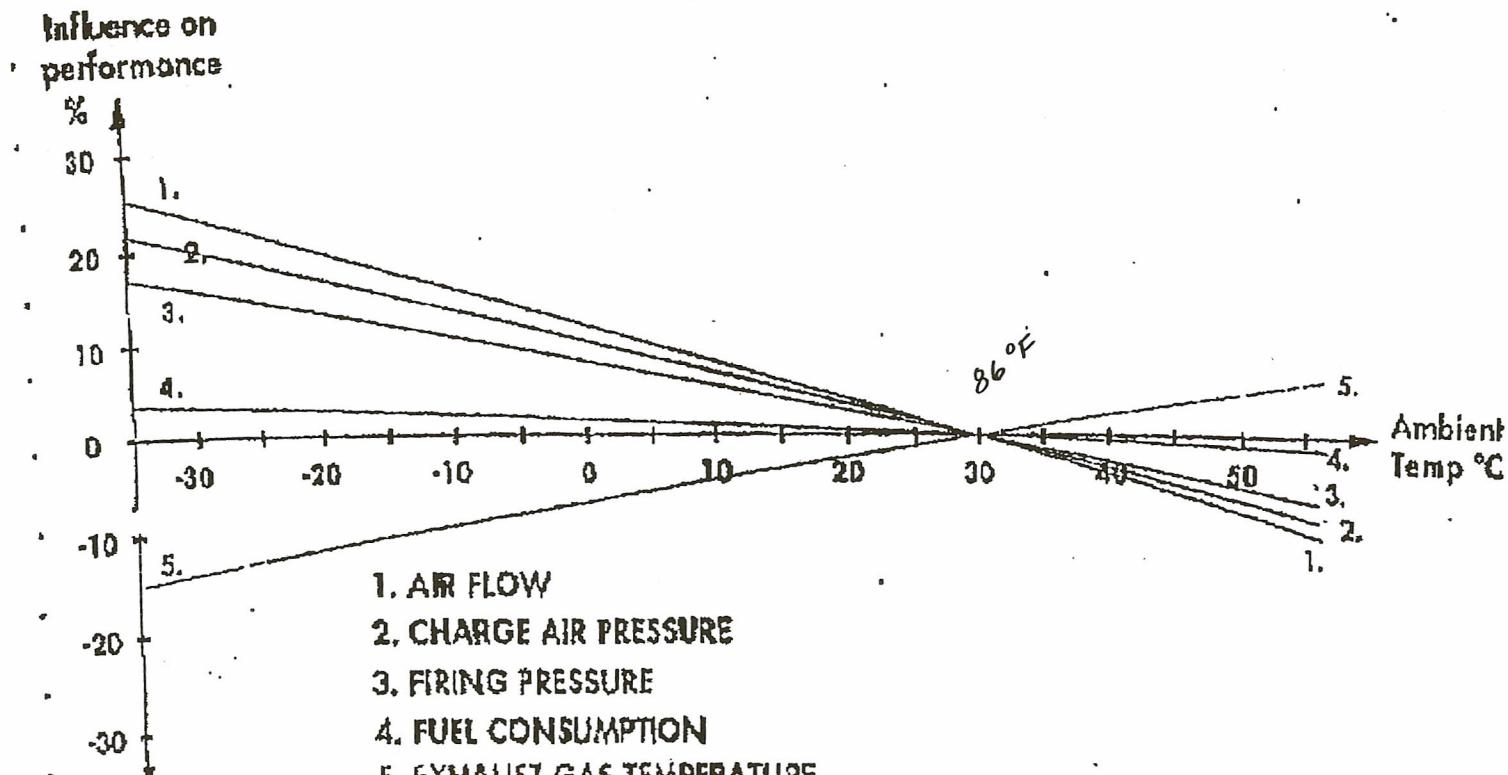


WÄRTSILÄ VASA
32

+22

WÄRTSILÄ DIESEL

THE INFLUENCE OF AMBIENT TEMPERATURE ON ENGINE PERFORMANCE



FPC[®] TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____ 2. _____

Re-Test

Company: Cominco Red Dog Test Date: 31 JAN 95

Test Portion: Baseline

Water Temp. _____



Oil Pressure _____

Treated

Air Restriction _____

Equipment Tested:

Make WARTSILL #2

Miles _____ I.D. # _____

Engine Type 32V16 Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam. _____ Inches Straight Curved

BP: 29.72 Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: .805 SG @ 86.4 °F Start Time: 10³⁰A

10F2

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
7	1			.01	10	5.37	12.7	
10	2			.01	10	5.33	12.7	
12 ^{1/2}	3			.01	10	5.37	12.7	
15	4			.01	10	5.33	12.7	
17 ^{1/2}	5			.01	10	5.36	12.7	
	6			.01	9	5.31	12.8	
	7			.01	9	5.32	12.7	
25	8			.01	9	5.34	12.7	
	9			.01	9	5.33	12.7	
30	10			.01	9	5.31	12.8	
	Average							

Signature of Technicians: W J G Finish Time: _____

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____ 2. _____

Re-Test

Company: Cominco Red Dog

Test Date: 31 Jan 95

Test Portion: Baseline

Water Temp. _____

Treated

Oil Pressure _____

Equipment Tested:

Make Wartsila #2

Air Restriction _____

Miles _____ I.D. # _____

Engine Type _____

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: 23.73 Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: 80J SG @ 86.7 °F Start Time: _____

20 F 2

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
35	1			.01	9	5.31	12.7	
	2			.01	9	5.31	12.7	
	3			.01	9	5.28	12.8	
40	4			.01	9	5.27	12.7	
	5			.01	9	5.25	12.7	
45	6			.01	9	5.23	12.8	
	7			.01	9	5.23	12.7	
50	8			.01	9	5.24	12.7	
	9			.01	9	5.21	12.8	52 1/2
	10			.01	9	5.22	12.8	55
	Average		1.16					

Signature of Technicians: Wd G Finish Time: _____

Scan:	200	185	105.92	254.70
ACR:	.010	5.20	5.28	12.73
SO:	00	0.445	0.031	0.048

Carbon Mass Balance Field Data Form

Company: _____ Location: _____ Test Date: 1-31-95
 Test Portion: Baseline: _____ Treated: ✓ Exhaust Stack Diameter: 32 Inches
 Engine Make/Model: _____ Miles/Hours: _____ I.D.#: 2
 Type of Equipment: _____

Fuel Specific Gravity: _____ @: _____ (°F)
 Barometric Pressure: _____ Inches of Mercury
 Intake Air Temperature: _____ (°F) Start Time: _____

RPM	Exhaust Temp °F	P Inches of H ₂ O	% CO	HC ppm	% CO ₂	% O ₂	Smoke Number
1.	11.	1.20	1.20				
2.	12.	1.20	1.20				
3.	13.	1.15	1.20				
4.	14.	1.15	1.20				
5.	15.	1.15	1.15				
6.	16.	1.15	1.15				
7.	17.	1.15	1.15				
8.	18.	1.15	1.15				
9.	19.	1.15	1.15				
10.	20.	1.15	1.15				

Start: 233

End Time: _____

Names of Customer Personnel Participating in Test:

1. LEN: 1.16.5'

2. JO: 0.023

Signature of Technicians:

ENGINE 2 WARTSILA UASA 16U32

DISPLAY OF RUPPI-BLOCK NUMBER: 161

CYLINDER 1 2 3 4 5 6 7 8

B CYL LINER 1	135	126	143	<153>	139	136	137	140
A CYL LINER 2	134	134	<156>	142	140	138	135	137
N CYL LINER 3	130	141	153	137	<147>	138	136	138
K EXH VALVE 1 WAVE	9	13	0	0	0	0	0	0
EXH VALVE 2 WAVE	8	8	1	0	0	0	0	0
A EXH TEMPERATURE	475	465	461	467	453	431	475	457
EXH VALVE DIFF	16	21	3	55	16	2	20	40
EXH TEMP DEV	20	12	9	15	1	-21	20	17
MAIN BEAR	96	91	92	95	95	95	91	91
2 CYL	137	127	147	137	132	140	134	140
3 CYL	135	135	157	135	135	135	135	135
4 CYL	135	135	157	135	135	135	135	135
5 CYL	135	135	157	135	135	135	135	135
6 CYL	135	135	157	135	135	135	135	135
7 CYL	135	135	157	135	135	135	135	135
8 CYL	135	135	157	135	135	135	135	135
MAIN EXH TEMP DEV	15	0	15	15	426	483	456	442
MAIN EXH TEMP DEV	15	0	15	15	6	6	15	15

MEAN TEMPERATURES

1995-01-31

RUN. HOURS

452

10:00

29880

845.6

12 TEST 1

Diesel Generator Specific Fuel Consumption Log

Cust
Loca

Engine #: _____

Date: 31 Jan '95 Base: _____ Treated: _____

Engine: Make: _____
Model: _____
Eng. Hrs: _____

Alternator: _____
Make: _____
Rating: _____

Density: _____ **Base:** _____ **Treated:** _____

Temperature Degree F

Item: 2 Code: CAK

TOWN	WEATHER	ALASKA this hour						TODAY'S DATA		
		TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	.....								
Deadhorse	ptly cldy	3 NE 8	-11	20	91%	29.51r	5	-6		
Galbraith Lk	.....								
Umiat	.....								
Lonely	.....								
Barrow	mstly clr	-4 NE 15	-36	10	79%	29.49r	-4	-11	0.35	
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	mstly cldy	25 SE 25G31	-6	15	81%	29.28f	26	23	0.04	
Shishmaref	no report	16 N 8	3	10	92%	29.25r	25	0		
Port Clarence	.....								
Tin City	cloudy	-4 NE 26	-50	1/4	83%	29.16r	-3	-5		
Nome	cloudy	29 E 15	8	10	85%	29.17s	33	29	0.08	
Gambell	no report	1 N 23G29	-40		91%	29.19r	2	0		
Unalakleet	ptly cldy	24 E 16	0	35	60%	29.23s	33	23	0.04	
Emmonak	.....								
Andreafsky	.....								
Saint Marys	mstly cldy	26 SE 14	5	10	85%	29.15r	37	26		
Mekoryuk	cloudy	25 NW 8	14	1/2	92%	29.05s	32	25		
Bethel	cloudy	29 E 5	26	35	75%	29.12s	37	27	Trace	
Aniak	no report	29 CALM	29	10	51%	29.14s	37	27		
St Paul Islnd	lgt snow	20 NW 23	-12	3/4	88%	29.22r	23	20	0.02	
Dillingham	cloudy	28 N 7	20	25	89%	29.14f	35	27	0.04	
Chulitna	.....								
Port Alsworth	.....								
Iliamna	mstly cldy	27 NW 6	21	25	81%	29.13f			0.01	
King Salmon	mstly cldy	28 N 3	28	30	89%	29.10s	35	23		
Adak	mstly cldy	28 NW 11	12	7	66%	29.69s	28	23	0.03	
Shemya AFB	cloudy	27 NW 5	24	10	58%	29.82s	28	26	0.03	
Nikolski	.....								
Dutch Harbor	cloudy	30 W 20G30	4	5	61%	29.24s	32	27		
Cold Bay	lgt snow	32 NW 18	9	1	100%	29.09r	35	31	0.32	
Sand Point	cloudy	37 CALM	37	5	82%	29.05s	38	36	0.05	
Port Heiden	ptly cldy	37 SE 8	28	20	57%	29.06f	37	33		
Anaktuvuk Ps	no report	5 CALM	5	10	83%	29.32s	16	2		
Ambler	no report	19 N 9	5	10	96%	29.33f	26	19		
Shungnak	.....								
Prospect Crk	.....								
Bettles	mstly cldy	12 N 11	-8	40	73%	29.35s	12	-4		
Chandalar	ptly cldy	0 CALM	0	15	51%					
Fort Yukon	mstly cldy	-6 CALM	-6	10	68%	29.41s	0	-19		
Circle	.....								
Five Mile Cmp	.....								
Manley HotSpr	.....								
Tanana	.....								
Galena	cloudy	5 NW 5	1	35	83%	29.28f	23	3		
Minchumina	no report	1 CALM	1	10	79%	29.17s	2	-13		
Puntilla Lake	.....								
McGrath	cloudy	-2 CALM	-2	40	83%	29.19f	10	-10		
Fairbanks Int	mstly cldy	7 CALM	7	60	87%	29.23f	8	-12		
Ft Wainwright	.....								
Eielson AFB	mstly cldy	9 CALM	9	70	70%	29.21f	9	-8		
Big Delta	ptly cldy	15 E 13G21	-8	40	61%	29.16f	17	3		

Item: 2 Code: CAK

TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	clear	7	CALM	7	60	83%	29.50r		-8	
Deadhorse	ptly cldy	0	SE 5	-4	7	91%	29.48s	5	-4	
Galbraith Lk	.....								
Umiat	ptly cldy	-9	CALM	-9	20	78%	29.46r		-11	
Lonely	.....								
Barrow	mstly clr	-9	E 10	-31	10	82%	29.47r	-4	-11	0.35
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	mstly cldy	25	E 26G30	-7	10	81%	29.28s	26	23	0.04
Shishmaref	no report	15	SW 6	8	10	84%	29.21r	17	0	
Port Clarence	.....								
Tin City	no report							-4	-5	
Nome	cloudy	31	E 14	11	10	85%	29.15r	33	30	0.08
Gambell	no report	0	N 25G32	-43		83%	29.14r	2	0	
Unalakleet	mstly cldy	23	E 14	1	35	63%	29.24r	33	23	0.04
Emmonak	.....								
Andreafsky	.....								
Saint Marys	cloudy	29	E 17	5	10	82%	29.13s	37	29	
Mekoryuk	cloudy	27	NW 7	18	10	88%	29.01s	32	25	
Bethel	mstly cldy	27	E 8	16	35	78%	29.11r	37	27	Trace
Aniak	no report	27	CALM	27	10	55%	29.15s	37	27	
St Paul Islnd	lgt snow	20	NW 21G30	-11	1	88%	29.16r	23	20	Trace
Dillingham	mstly cldy	27	N 9	14	30	92%	29.15s	35	27	0.04
Chulitna	.....								
Port Alsworth	.....								
Iliamna	lgt snow	21	NW 3	21		88%	29.13f			0.01
King Salmon	mstly cldy	23	CALM	23	15	88%	29.10r	35	23	
Adak	lgt snow	27	NW 10	12	4	63%	29.63r	28	23	0.03
Shemya AFB	cloudy	28	N 10	13	10	63%	29.80s	28	26	0.03
Nikolski	.....								
Dutch Harbor	cloudy	30	NW 13G25	11	5	72%	29.19r	32	27	
Cold Bay	lgt snow	32	W 14	13	1	100%	29.06r	35	31	0.26
Sand Point	no report	37	NE 5	34		76%	29.04r	38	36	0.05
Port Heiden	mstly cldy	33	E 3	33	25	64%	29.06f	37	33	
Anaktuvuk Ps	no report	5	CALM	5	10	69%	29.34s	16	5	
Ambler	no report	21	NE 6	14	10	84%	29.36s	26	21	
Shungnak	.....								
Prospect Crk	.....								
Bettles	mstly cldy	10	N 11	-10	40	84%	29.36f	10	-4	
Chandalar	.....								
Fort Yukon	cloudy	-11	CALM	-11	10	67%	29.43f	0	-19	
Circle	cloudy	-2	CALM	-2	35	83%	29.40r			
Five Mile Cmp	.....								
Manley HotSpr	mstly cldy	1	CALM	1	10	65%	29.33f			
Tanana	cloudy	0	W 7	-12	30	79%	29.33f		-4	
Galena	mstly cldy	5	NW 6	-3	25	83%	29.33s	23	3	
Minchumina	no report	-3	CALM	-3	10	79%	29.20f	0	-13	
Puntilla Lake	mstly cldy	7	NW 6	0	45	87%	29.08fr			
McGrath	cloudy	-7	NW 6	-16	40	82%	29.22f	10	-10	
Fairbanks Int	cloudy	6	CALM	6	60	87%	29.27f	6	-12	
Ft Wainwright	cloudy	2	NE 6	-6	25	87%	29.28s			
Eielson AFB	cloudy	4	CALM	4	30	69%	29.26f	4	-8	
Big Delta	mstly cldy	14	E 13	-9	35	67%	29.21f		3	

Item: 2 Code: CAK

TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	clear	-5	SE 7	-17	60	83%	29.48r		-8	
Prudhoe Bay	clear	-4	S 6	-13	7	83%	29.48r	5	-4	
Deadhorse	clear	-7	CALM	-7	10	78%	29.45r		-11	
Galbraith Lk	clear	-9	E 10	-31	7	78%	29.45r	-4	-11	0.35
Umiat	clear	25	E 29G36	-9	7	88%	29.24s	26	23	0.04
Lonely	mstly cldy	3	NE 6	-5	10	87%	29.18s	12	0	
Barrow	cloudy	33	SE 21	8	7	85%	29.12r	33	30	0.08
Wainwright	no report	1	N 28G34	-44		83%	29.08r	2	1	
Oliktok	ptly cldy	24	E 21	-5	35	60%	29.22r	33	24	0.04
Point Lay	cloudy	28	NE 8	17	20	82%	29.09r	37	28	Trace
Kotzebue	ptly cldy	33	CALM	33	10	50%	29.15s	37	32	
Shishmaref	lgt snow	21	NW 25G30	-12	4	78%	29.09s	23	21	Trace
Port Clarence	mstly cldy	28	N 7	20	10	89%	29.15r	35	28	0.04
Tin City	cloudy	28	NE 6	22	7	85%	29.11f			
Nome	mstly cldy	25	W 8	14	15	85%	29.15f			
Gambell	ptly cldy	25	CALM	25	15	88%	29.09s	35	23	
Unalakleet	lgt snow	25	S 8	14	7	81%	29.61s	28	23	0.03
Emmonak	cloudy	28	N 14	8	10	66%	29.78r	28	26	0.03
Andreafsky	cloudy	30	E 17	7	10	78%	29.11r	37	29	
Saint Marys	cloudy	30	S 20	4	7	89%	28.97f	32	25	
Mekoryuk	mstly cldy	28	NE 8	17	20	82%	29.09r			
Bethel	ptly cldy	33	CALM	33	10	50%	29.15s			
Aniak	lgt snow	21	NW 25G30	-12	4	78%	29.09s			
St Paul Islnd	mstly cldy	28	N 7	20	10	89%	29.15r			
Dillingham	cloudy	15	NE 10	-2	20	80%	29.09f			
Chulitna	clear	28	NE 6	22	7	85%	29.11f			
Port Alsworth	mstly cldy	25	W 8	14	15	85%	29.15f			
Iliamna	ptly cldy	25	CALM	25	15	88%	29.09s			
King Salmon	lgt snow	25	S 8	14	7	81%	29.61s			
Adak	cloudy	28	N 14	8	10	66%	29.78r			
Shemya AFB	cloudy	28	W 9	15	1	85%	29.14s	32	27	
Nikolski	lgt snow	33	W 9	21	2	100%	29.02r	35	31	0.26
Dutch Harbor	lgt rain	37	CALM	37		79%	29.01r	38	36	0.05
Cold Bay	mstly cldy	34	E 11	19	10	64%	29.04f	37	34	
Sand Point	no report	7	CALM	7	10	73%	29.34s	16	7	
Port Heiden	no report	23	NE 11	6	10	74%	29.36r	26	21	
Anaktuvuk Ps	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ambler	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Shungnak	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Prospect Crk	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bettles	mstly cldy	9	N 8	-4	15	73%	29.39f	10	-4	
Chandalar	mstly clr	-10	CALM	-10	15	60%	29.43f			
Fort Yukon	mstly cldy	-18	CALM	-18	10	59%	29.46s	0	-19	
Circle	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Five Mile Cmp	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manley HotSpr	cloudy	-10	E 3	-10	7	82%	29.36f			
Tanana	cloudy	0	W 3	0	10	79%	29.35f		-4	
Galena	no report	13				58%		23	3	
Minchumina	no report	-6	CALM	-6	10	68%	29.23s	0	-13	
Puntilla Lake	clear	-1	NW 8	-16	25	83%	29.14f			
McGrath	ptly cldy	-10	CALM	-10	20	78%	29.25f	10	-10	
Fairbanks Int	cloudy	2	CALM	2	20	83%	29.29f	2	-12	
Ft Wainwright	mstly cldy	0	SE 3	0	15	87%	29.28f			
Eielson AFB	mstly cldy	0	CALM	0	15	72%	29.27f	0	-8	
Big Delta	mstly cldy	8	N 2	8	25	73%	29.22s		3	

Item: 2 Code: CAK

TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	clear	3	CALM	3	30	79%	29.46s			
Deadhorse	clear	5	NW 7	-6	7	83%	29.46s	5	-3	
Galbraith Lk	.....								
Umiat	clear	-6	CALM	-6	7	82%	29.44rr			
Lonely	.....								
Barrow	clear	-10	E 7	-23	7	78%	29.43r	-4	-11	0.35
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	cloudy	25	E 29G34	-9	7	88%	29.24r	26	23	0.04
Shishmaref	no report	2	NW 7	-9	10	83%	29.16r	12	2	
Port Clarence	.....								
Tin City	cloudy	-5	N 36	-58	1/2	83%	29.02r	-4	-5	
Nome	cloudy	32	SE 20	7	7	85%	29.09r	32	30	0.08
Gambell	cloudy	2	N 24G30	-39		87%	29.04r	2	1	
Unalakleet	ptly cldy	25	E 21	-3	10	60%	29.21s	33	25	0.04
Emmonak	.....								
Andreafsky	.....								
Saint Marys	no report		SE 14				29.09s	37	30	
Mekoryuk	cloudy	30	SE 20	4	10	92%	28.94s	32	25	
Bethel	ptly cldy	29	SE 11	13	20	82%	29.08r	37	29	Trace
Aniak	cloudy	33	CALM	33	10	50%	29.14r	37	33	
St Paul Islnd	lgt snow	21	NW 23G30	-11	4	78%	29.06s	23	21	Trace
Dillingham	mstly cldy	28	N 8	17	10	85%	29.14r	35	28	0.04
Chulitna	cloudy	15	NE 10	-2	20	80%	29.09f			
Port Alsworth	ptly cldy	24	NE 5	21	7	85%	29.12fr			
Iliamna	.....								
King Salmon	ptly cldy	25	CALM	25	15	88%	29.09s	35	25	
Adak	lgt snow	28	N 20G24	1	1	56%	29.58r	28	23	0.01
Shemya AFB	cloudy	27	NW 14	6	10	66%	29.77r	28	26	0.03
Nikolski	.....								
Dutch Harbor	cloudy	29	NW 17G25	5	3	78%	29.10r	32	29	
Cold Bay	lgt snow	33	SW 11	18	1	100%	29.00r	35	31	0.04
Sand Point	ptly cldy	36	CALM	36	10	76%	28.99r	38	36	0.03
Port Heiden	mstly cldy	35	SE 15	16	10	62%	29.01f	37	35	
Anaktuvuk Ps	no report	12	SW 5	8	10	77%	29.34s	16	10	
Ambler	no report	22	CALM	22	10	81%	29.35s	26	21	
Shungnak	.....								
Prospect Crk	.....								
Bettles	ptly cldy	10	N 9	-6	13	80%	29.41f	10	0	
Chandalar	.....								
Fort Yukon	cloudy	-19	CALM	-19	10	59%	29.46f	0	-19	
Circle	.....								
Five Mile Cmp	.....								
Manley HotSpr	cloudy	-10	E 3	-10	7	82%	29.36f			
Tanana	cloudy	-2	SW 7	-14	10	75%	29.38f			
Galena	ptly cldy	7	N 3	7	10	80%	29.32s	23	7	
Minchumina	no report	-10	CALM	-10	10	74%	29.25s	0	-13	
Puntilla Lake	clear	-1	NW 8	-16	25	83%	29.14f			
McGrath	ptly cldy	-7	W 3	-7	15	75%	29.26f	10	-7	
Fairbanks Int	cloudy	0	NE 3	0	15	83%	29.30f	2	-12	
Ft Wainwright	ptly cldy	-6	W 3	-6	15	78%	29.33f			
Eielson AFB	mstly cldy	-5	CALM	-5	10	68%	29.31f	-2	-8	
Big Delta	cloudy	9	NE 2	9	15	73%	29.22f			

Item: 2 Code: CAK

TOWN	WEATHER	ALASKA this hour						TODAY'S DATA			
		TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN	
Barter Island	clear	2	SW 8	-13	30	79%	29.46r				
Prudhoe Bay	clear	0	SW 9	-18	7	83%	29.46r	5	-3		
Deadhorse	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Galbraith Lk	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Umiat	clear	-6	CALM	-6	7	82%	29.44rr				
Lonely	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Barrow	light fog	-7	SW 2	-7	5	82%	29.40s	-4	-11	0.35	
Wainwright	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oliktok	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Point Lay	.....	.....	.....	.....	.....	.....	.....	29.12	.....	.....
Kotzebue	blwg snow	25	E	29G33	-9	5	88%	29.23s	26	23	0.04
Shishmaref	no report	4	W	8	-10	10	79%	29.15r	12	4	
Port Clarence	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tin City	cloudy	-4	N	39	-58	1/2	83%	29.02s	-4	-4	
Nome	mstly cldy	31	SE	23G29	3	7	89%	29.06r	32	30	0.08
Gambell	mstly cldy	2	N	29G33	-44		79%	29.01r	2	1	
Unalakleet	ptly cldy	25	E	23	-5	10	60%	29.20s	33	25	0.04
Emmonak	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Andreafsky	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Saint Marys	cloudy	30	SE	14	10	10	89%	29.08s	37	30	
Mekoryuk	cloudy	29	SE	13	10	7	92%	28.94r	32	25	
Bethel	mstly cldy	29	E	11	13	20	82%	29.07r	37	29	Trace
Aniak	no report	34	SE	9	23	10	48%	29.13s	37	34	
St Paul Islnd	lgt snow	21	NW	22G31	-10	4	78%	29.05r	23	21	Trace
Dillingham	mstly clr	28	N	9	15	10	85%	29.10fr	35	28	0.04
Chulitna	cloudy	16	E	13	-6	15	81%	29.12s			
Port Alsworth	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Iliamna	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
King Salmon	ptly cldy	27	N	6	21	15	88%	29.09s	35	27	
Adak	dry	25	NW	10	10	7	81%	29.56s	27	23	0.01
Shemya AFB	cloudy	27	NW	17	3	10	69%	29.75s	28	26	0.03
Nikolski	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dutch Harbor	cloudy	30	NW	16G23	8	4	72%	29.07r	32	30	
Cold Bay	lgt snow	33	SW	11	18	3	100%	28.98r	35	31	0.04
Sand Point	mstly cldy	37	CALM		37	10	76%	28.98s	38	36	0.03
Port Heiden	no report	35	SE	21G29	10		42%	29.02f	37	35	
Anaktuvuk Ps	no report	13	S	9	-2	10	73%	29.35f	16	10	
Ambler	no report	23	CALM		23	10	68%	29.35s	26	21	
Shungnak	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Prospect Crk	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bettles	ptly cldy	10	N	9	-6	13	80%	29.41f	10	0	
Chandalar	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fort Yukon	ptly cldy	-17	CALM		-17	10	59%	29.47s	0	-17	
Circle	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Five Mile Cmp	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Manley HotSpr	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tanana	cloudy	-2	SW	7	-14	10	75%	29.38f			
Galena	no report	12	N	3	12	10	80%	29.33s	23	12	
Minchumina	no report	-13	CALM		-13	10	67%	29.26f	0	-13	
Puntilla Lake	clear	-1	CALM		-1	25	83%	29.16fr			
McGrath	ptly cldy	-6	CALM		-6	15	82%	29.27f	10	-6	
Fairbanks Int	cloudy	-3	N	3	-3	15	83%	29.32f	2	-12	
Ft Wainwright	ptly cldy	-6	W	3	-6	15	78%	29.33f			
Eielson AFB	mstly cldy	-5	CALM		-5	10	68%	29.31f	-2	-8	
Big Delta	cloudy	7	E	2	7	15	76%	29.25f			

Item: 2 Code: CAK

8AM Wed 18 January		ALASKA this hour						TODAY'S DATA		
TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	clear	4	SW 8	-10	30	79%	29.45rr			
Deadhorse	clear	2	SW 9	-15	7	87%	29.45r	5	-3	
Galbraith Lk	.....								
Umiat	.....								
Lonely	.....								
Barrow	light fog	-7	SE 5	-11	5	82%	29.40r	-4	-11	0.35
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	blwg snow	25	E 28G33	-8	5	88%	29.23r	26	23	0.04
Shishmaref	ptly cldy	6	NW 3	6	10	83%	29.14s	12	6	
Port Clarence	.....								
Tin City	cloudy	-4	N 39	-58	1/2	83%	29.02s	-4	-4	
Nome	mstly cldy	32	E 22G30	5	7	85%	29.03r	32	30	0.08
Gambell	cloudy	1	N 26G38	-43		83%	28.99r	2	1	
Unalakleet	mod snow	26	E 26G31	-5	10	60%	29.20s	33	26	0.04
Emmonak	.....								
Andreafsky	.....								
Saint Marys	mstly cldy	30	SE 14	10	10	96%	29.08r	37	30	
Mekoryuk	cloudy	29	SE 8	18	10	85%	28.93r	32	25	
Bethel	dry	29	SE 16	7	20	82%	29.06r	37	29	Trace
Aniak	no report	35	E 9	24	10	46%	29.13f	37	34	
St Paul Islnd	lgt snow	21	NW 23G30	-11	6	74%	29.02r	23	21	Trace
Dillingham	mstly clr	28	N 9	15	10	85%	29.10fr	35	28	0.04
Chulitna	cloudy	16	E 13	-6	15	81%	29.12s			
Port Alsworth	.....								
Iliamna	.....								
King Salmon	cloudy	27	N 6	21	15	88%	29.09f	35	27	
Adak	dry	25	NW 10	10	7	81%	29.56s	27	23	0.01
Shemya AFB	cloudy	27	NW 17	3	10	69%	29.75s	28	26	0.03
Nikolski	.....								
Dutch Harbor	mstly cldy	31	NW 16G24	9	3	69%	29.05r	32	30	
Cold Bay	dry	33	W 8	23	10	100%	28.96s	35	31	0.04
Sand Point	ptly cldy	37	CALM	37	10	76%	28.98r	38	36	0.03
Port Heiden	no report	35	SE 20G25	11		44%	29.03r	37	35	
Anaktuvuk Ps	no report	13	S 9	-2	10	73%	29.35f	16	10	
Ambler	no report	21	S 5	17	10	74%	29.35s	26	21	
Shungnak	.....								
Prospect Crk	.....								
Bettles	ptly cldy	10	N 10	-8	25	73%	29.42f	10	0	
Chandalar	.....								
Fort Yukon	ptly cldy	-16	CALM	-16	10	63%	29.47f	0	-16	
Circle	.....								
Five Mile Cmp	.....								
Manley HotSpr	.....								
Tanana	ptly cldy	-2	NW 7	-14	10	79%	29.40s			
Galena	no report	12	N 3	12	10	80%	29.33s	23	12	
Minchumina	no report	0	CALM	0	10	72%	29.28f	0	-13	
Puntilla Lake	clear	-1	CALM	-1	25	83%	29.16fr			
McGrath	ptly cldy	-4	E 3	-4	15	83%	29.28f	10	-4	
Fairbanks Int	ptly cldy	-6	CALM	-6	15	82%	29.33f	2	-12	
Ft Wainwright	ptly cldy	-6	W 3	-6	15	78%	29.33f			
Eielson AFB	mstly cldy	-5	CALM	-5	10	68%	29.31f	-2	-8	
Big Delta	cloudy	5	S 1	5	15	80%	29.27fr			

#2 AIG 2.575 kW

#5 AIG 3.575 kW

HOURS IN CYCLE 5 HRS

13 NOON 29570

32033

#2-253

396,900 KWH

#5-252

901000 KWH



Cominco Alaska

KWH HOURS IN CYCLE = 253 HRS

FILE NO.

BY EST 896,900 KWH ON TREATMENT DATE 29 JAN 95

SUBJECT #2 EIGINE PRELIMINARY W/ ALL TIME

7:10 AM

TEST 1

SHEET

OF

TIME	MW	AMP	KVAR	MVA	PF	KWHG	EX-A	EX-B
8	363	547	1502	397	.926	12.35	773	737
8.5	381	548	1492	404	.927	12.60	774	737
9.0	374	561	1479	401	.928	12.40	774	737
9.5	372	551	1485	401	.929	12.39	773	737
10.0	377	549	1267	323	.947	12.82	772	735
10.5	372	541	1281	394	.949	12.79	771	735
11.0	373	540	1253	323	.948	12.53	772	735
11.5	371	537	1133	391	.957	12.21	772	736
12.0	377	554	1253	403	.949	13.01	773	736
12.5	377	546	1243	397	.950	12.62	772	736
13.0	374	543	1201	391	.952	12.75	772	736
13.5	372	536	1300	391	.948	12.69	772	736
14.0	373	535	1384	399	.934	12.46	772	736
14.5	382	555	1336	399	.943	12.75	773	736
15.0	369	542	1392	400	.938	12.69	773	736
15.5	369	555	1343	320	.942	12.46	772	736
16.0	373	539	1326	403	.944	12.85	772	735
16.5	366	539	1352	393	.946	12.35	772	735
17.0	376	542	1403	395	.938	12.50	771	735
17.5	367	540	1407	4,00	.942	12.89	771	735
18.0	381	551	1313	4,01	.942	12.81	771	735
18.5								
19.0								
19.5								
20.0								

Barlow Disch - -34.2°F min - 484.2°F max

TREATMENT AT INLET - 72°F

#2 JAN 18 01727 KWH
JAN 19 020766 30+#5 JAN 18 105216 KWH
JAN 29 114226 KWH

238.47 gal/min

11/95

64°F AMBIENT

1-HOUR HOURS = 80' BASIS 01.0
= 305 31st 86.4°F 31st 31 JANUARY '92

#2 TEST(1)

011797 (18th)
022436 (31st)306 OPERATING HOURS
KWH = 1063900 KWH TOTAL

29570

6:00 AM ENR HRS 29876

TIME	MW	AMP	KVAR	MVA	PF	KWH/G	EX-A	EX-B	Balanced
ST 1:30	3.76	540	1438	4.00	.933	12.35	775	742	430.5
2.5	3.71	551	1431	4.07	.936	12.82	775	742	
5.0	3.73	543	1370	3.98	.934	12.55	775	742	
7.5	3.80	557	1448	4.07	.931	12.75	776	743	
10.0	3.65	533	1343	3.39	.938	12.31	775	742	
12.5	3.77	561	1479	4.09	.932	12.50	776	743	
- 15.0	3.63	531	1360	3.94	.939	12.44	776	743	
17.5	3.71	542	1521	4.01	.925	12.39	775	742	
20.0	3.74	554	1417	4.04	.937	12.81	774	742	
22.5	3.77	553	1435	3.99	.933	12.56	774	742	
25.0	3.76	544	1412	3.95	.934	12.60	774	742	
27.5	3.83	561	1571	4.04	.928	12.63	774	741	
30.0	3.77	545	1339	3.98	.942	12.61	773	741	
32.5	3.77	549	1392	4.00	.934	12.59	773	740	
35.0	3.78	552	1399	4.02	.937	12.70	773	741	
37.5	3.80	555	1487	4.06	.931	12.53	773	740	
40.0	3.69	550	1367	3.99	.942	12.63	773	740	
42.5	3.82	563	1543	4.15	.918	12.59	773	740	
45.0	3.83	563	1518	4.10	.931	12.88	772	740	
47.5	3.79	547	1576	4.07	.927	12.74	772	740	
50.0	3.81	554	1582	4.07	.924	12.56	772	740	432.8
52.5	3.67	556	1512	4.06	.922	12.82	772	740	
55.0									
57.5									
60.0									

Sum: 78.92 11543.0 84.51 84.51 19.56 264.54

Mean: 3.758 577.9 2.024 2.024 .533 12.557

SD: 0.055 9.04 0.061 0.061 5.85 0.152

TOTAL FULL USED 236.45

#2 TEST 1

31 JAN '95



Fuel in F₀ F₀ A sat. F₀ T_{Fe} J_T °F F_T °F

0	1547.28		907.61				93°F	112°F
5	1600.90	53.62	888.42	30.81	22.81	22.81	1	1
10	1657.57	56.67	971.18	32.76	23.91	46.72	1	1
15	1713.26	55.69	1023.32	32.34	23.35	70.07	1	1
20	1769.51	56.25	1036.14	32.62	28.63	93.70	92°F	110°F
25	1825.76	56.10	1068.48	32.34	23.76	117.46	1	1
30	1881.86	56.10	1100.82	32.34	23.76	173.56	1	1
35	1937.97	56.11	1133.30	32.48	23.63	197.19	1	1
40	1994.22	56.85	1165.78	32.48	23.37	220.56	92°F	110°F
45	2050.47	56.25	1198.12	32.34	23.91	244.47	1	1
50	2106.57	56.11	1230.46	32.34	23.71	268.24		

236.45

4,729 P/m

2106.58	1230.46	4.1
<u>1547.28</u>	<u>907.61</u>	@ 235.90 Pd. ct.
<u>559.3</u>	<u>322.85</u>	481.51 @ 235.90

559.30
322.85

+ 235.90
236.45

#2 TEST

31 JAN '95



START 10:30 AM

TIME	MW	AMP	KVAC	MIA	PF	KWH/G	EX-A	EX-B	Buhr Paces
5+1:30	3.73	536	1225	3.92	.951	12.62	769	737	436.7
2.5	3.79	550	1224	4.00	.952	12.46	769	736	X
5.0	3.73	539	1248	4.01	.952	12.73	768	736	
7.5	3.92	553	1217	4.01	.948	12.44	768	735	
10.1	3.79	547	1240	3.88	.948	12.48	768	735	
12.5	3.92	546	1325	3.97	.938	12.54	768	735	
15.0	3.80	552	1302	3.92	.944	12.35	768	735	
17.5	3.78	546	1263	4.01	.949	12.66	768	736	
20.0	3.81	550	1273	3.98	.949	12.69	768	735	
22.5	3.77	549	1268	3.99	.949	12.83	766	735	
25.0	3.90	547	1253	4.00	.948	12.69	768	735	
27.5	3.68	533	1224	3.38	.949	12.26	768	735	
30.0	3.70	544	1227	3.96	.950	12.64	768	735	
32.5	3.73	548	1213	3.99	.945	12.55	768	736	
35.0	3.75	541	1240	3.96	.949	12.61	769	736	
37.5	3.72	551	1230	3.99	.949	12.69	770	736	
40.0	3.92	548	1321	4.05	.941	12.54	770	736	
42.5	3.71	540	1309	4.00	.946	12.62	769	736	
45.0	3.80	571	1220	3.92	.950	12.66	768	735	
47.5	3.71	529	1072	3.38	.960	12.55	769	736	
50.0	3.71	541	1221	3.95	.950	12.66	769	736	437.9
52.5	3.73	547	1235	3.99	.951	12.53	769	736	
55.0	3.69	534	1213	3.93	.945	12.70	768	735	
57.5									
60.0									

AMBIENT @ 12° F

TOTAL FUEL USED 239.63

#2 TEST 2

31 JAN 1995



Cominco

TIME	Fuel IN	A in	F1C1 OUT	A OUT	F2	TFC	J _T F°	F _T F°
0	3284.07	1909.19					92°F	110°F
5	3340.70	55.83	1941.25	32.06	23.77	23.77		
10	3396.95	56.25	1973.81	32.62	23.63	47.40		
15	3453.20	56.25	2006.35	32.48	23.77	71.17		
20	3509.31	56.31	2038.57	32.2	24.11	95.28		
25	3565.42	56.11	2070.89	32.34	23.77	119.05		
30	3621.53	56.11	2103.37	32.48	23.63	142.68		
35	3677.77	56.24	2135.71	32.34	23.90	166.58		
40	3734.16	56.39	2168.19	32.48	23.91	190.49		
45	3790.27	56.11	2200.53	32.34	23.77	214.26		
50	3846.38	56.11	2232.87	32.34	23.77	238.63		
	3846.38		2232.87					
	3284.07		1909.19					
	562.31		323.68		238.63			

Sheet3

# 5 Engine under treatment with :		1070200	kwh generated on treatment				
Test 1		306	hours of run time on treatment				
	FUEL	MW	PF	KVAR	AMP	MVA	KWH/G
#5 17 Jan	221.000	3.755	0.927	1522	555	4.046	13.389
#5 31 Jan	222.660	3.747	0.932	1456	552	4.040	13.413
Test 1							
	1.660	-0.009	0.005	-65.6	-3.0	-0.006	0.024
	0.75%	-0.23%	0.49%	-4.51%	-0.54%	-0.16%	0.18%

61CVA

Sheet2

# 5 Engine under treatment with :			901000	kwh generated				
			252	hours of run time				
	FUEL	MW	PF	KVAR	AMP	MVA	KWH/G	
#5 17 Jan 95	221.000	3.755	0.927	1522	555	4.046	13.389	
#5 29 Jan 95	218.170	3.726	0.908	1637	564	4.094	13.563	
	-2.830	-0.029	-0.019	115.3	9.5	0.048	0.174	
	-1.30%	-0.78%	-2.11%	7.04%	1.69%	1.16%	1.28%	

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. ____ 2. ____

Company: _____ Test Date: _____

Test Portion: Baseline Water Temp. _____
 Equipment Tested: Treated Oil Pressure _____

Miles _____ I.D. # _____
 Make _____

Hours _____ I.D. _____
 Engine Type _____

Naturally Aspirated
 Fuel Injection

Turbocharged
 Mechanical

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: _____

SHEET 2 OF 2

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
30	1			.01	12	5.36	12.6	
35	2			.01	12	5.32	12.6	
37	3			.01	13	5.36	12.6	
40	4			.01	12	5.36	12.6	
45	5			.01	12	5.36	12.6	
47	6							
50	7							
52	8							
55	9							
58	10							
	Average							

Signature of Technicians: W.J.G Finish Time: _____

Sun. 10/10	129	57.93	127.4
M.W. 10/11	12.3	57.353	12.74
T.Th. 10/12	0.483	0.052	0.157

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____ 2. _____

Company: _____ Test Date: 1-31-95

Test Portion: Baseline

Water Temp. _____



Oil Pressure _____

Treated
Equipment Tested: #2
Make Wartsila

Air Restriction _____

Miles _____ I.D. # _____

Engine Type _____

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: 7:40 A

S/HECT 1 OF 2

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
5	1			.01	12	5.46	12.8	
7½	2			.01	12	5.49	12.9	
10	3			.01	12	5.41	12.9	
12½	4			.01	13	5.40	12.9	
15	5			.01	13	5.41	12.9	
- 17½	6							
- 20	7							
- 22½	8							
- 25	9							
- 27½	10							
	Average							

CAL

Signature of Technicians: W.J.G. Finish Time: _____

Carbon Mass Balance Field Data Form

Company: _____ Location: _____ Test Date: 1-31-93
 Test Portion: Baseline: _____ Treated: X Exhaust Stack Diameter: _____ Inches
 Engine Make/Model: _____ Miles/Hours: _____ I.D.#: H2
 Type of Equipment: _____

Fuel Specific Gravity: _____ @: _____ (°F)
 Barometric Pressure: _____ Inches of Mercury
 Intake Air Temperature: _____ (°F) Start Time: _____

RPM	Exhaust Temp °F	P Inches of H ₂ O	% CO	HC ppm	% CO ₂	% O ₂	Smoke Number
		<u>1.95</u>	<u>1.15</u>				
		<u>1.15</u>	<u>1.15</u>				
		<u>1.20</u>	<u>1.20</u>				
		<u>1.15</u>	<u>1.20</u>				
		<u>1.20</u>	<u>1.15</u>				
		<u>1.20</u>					
		<u>1.20</u>					
		<u>1.15</u>					
		<u>1.15</u>					
		<u>1.15</u>					

End Time _____

Names of Customer Personnel Participating in Test:

Tom : 17.50

Merv : 1.17

Joe : 0.025

Signature of Technicians:

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Pg 1

Smoke Spot Numbers

1. 4.0 2. 4.0

Treated
2-19-95
4.0

4.0
4.0

Company: Cominco Red Dog

Test Date: 2-19-95

Test Portion: Baseline

Water Temp. _____



Oil Pressure _____

Equipment Tested:
Make Wartsila #2

Air Restriction _____

Miles _____ I.D. # 2

Engine Type 32 V16

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam 32 Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: 0.807 SG @ 87 °F Start Time: 11:00

Minutes	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
5 min	1	x 82°F		.02	10	5.35	11.9	
7 1/2	2			.02	10	5.33	11.8	
10	3			.02	10	5.33	11.9	
12 1/2	4			.02	10	5.34	11.9	
15	5	x 83°F		.02	10	5.32	11.9	
17 1/2	6			.02	10	5.33	11.9	
20	7			.02	9	5.31	11.9	
22 1/2	8			.02	10	5.32	11.9	
25	9	x 83°F		.02	9	5.32	11.9	
27 1/2	10			.02	9	5.32	11.9	
	Average							

Signature of Technicians: _____ Finish Time: _____

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

Pg. 2

1. _____ 2. _____

Company: Cominco Red Dog Test Date: 2-19-95

Test Portion: Baseline

Water Temp. _____

Treated Oil Pressure _____

Air Restriction _____

Equipment Tested:

Make Wirtzila #2

Miles _____ I.D. # #2

Engine Type _____

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: 11:00 A

2 of 2

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
30	1			.02	9	5.30	11.9	
32 1/2	2			.02	8	5.29	11.9	
35	3	<u>x 83.4</u>		.02	9	5.28	11.9	
37 1/2	4			.02	9	5.29	11.9	
40	5			.02	9	5.30	11.9	
42 1/2	6			.02	9	5.27	11.9	
45	7	<u>x 83.8</u>		.02	9	5.28	11.9	
47 1/2	8			.02	8	5.29	11.8	
50	9			.02	10	5.27	11.9	
52 1/2	10	<u>@ 55m / 84.8°</u>		.02	9	5.30	11.9	
	Average							

Signature of Technicians: _____ Finish Time: _____

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____ 2. _____

Company: _____ Test Date: 2-18-90

Test Portion: Baseline

Water Temp. _____

Treated
Equipment Tested:

Oil Pressure _____

Air Restriction _____

Make _____

Miles _____ I.D. # 2

Engine Type _____

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: _____

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
1	0.0 / 250	1.15	1.20					
2	26.8 / 27.5	1.15	1.25					
3	5.0 / 30.0	1.20	1.26					
4	2.8 / 32.5	1.20	1.26					
5	10.0 / 33.0	1.20	1.20					
6	12.5 / 37.5	1.20	1.20					
7	15.0 / 40.0	1.25	1.20					
8	17.5 / 42.5	1.20	1.20					
9	20.0 / 45.0	1.20	1.20					
10	22.5 / 47.5	1.20	1.20					
	Average							

Signature of Technicians: _____ Finish Time: _____

ENGINE 2 WARTSILA VASA 16U32 COMPUTED VALUES :

	CYLINDER	1	2	3	4	5	6	7	8
B CYL LINER 1		140	139	143	(155)	138	138	143	145
A CYL LINER 2		136	141	(159)	145	134	132	140	139
H CYL LINER 3		144	141	150	139	(144)	(133)	141	143
K EXH VALVE 1 WAVE		0	0	0	0	1	0	0	0
EXH VALVE 2 WAVE		0	0	0	1	0	0	0	0
A EXH TEMPERATURE		496	487	469	476	476	444	496	474
EXH VALVE DIFF		12	4	9	12	10	2	5	48
EXH TEMP DEV		27	19	- 1	6	7	- 26	26	4
MAIN BEAR	95	91	96	97	95	95	95	96	94
B CYL LINER 1		135	140	139	129	132	145	147	128
A CYL LINER 2		131	137	142	131	131	140	143	139
H CYL LINER 3		137	137	132	131	144	142	142	141
K EXH VALVE 1 WAVE		0	0	0	0	0	0	0	0
EXH VALVE 2 WAVE		0	0	0	1	0	0	0	1
B EXH TEMPERATURE		458	446	461	453	456	507	470	464
EXH VALVE DIFF		0	0	0	10	0	0	0	3
EXH TEMP DEV		- 13	- 20	- 10	- 18	- 21	37	0	- 7

MEAN TEMPERATURE
1995-02-19
RUN HOURS 11:58
38244

°F 819.8

ENGINE 2 WARTSILA VASA 16U32 DISPLAY OF RUPI-BLOCK NUMBER: 4

	CYLINDER	1	2	3	4	5	6	7	8
B CYL LINER 1		139	139	142	153	137	136	138	144
D CYL LINER 2		136	140	156	140	138	131	135	138
H CYL LINER 3		140	140	147	139	142	132	142	141
K EXH VALVE 1 WAVE		0	0	0	0	0	0	0	0
K EXH VALVE 2 WAVE		0	1	0	0	0	0	1	0
A EXH TEMPERATURE		492	485	467	471	473	440	490	470
EXH VALUE DIFF		16	11	11	17	10	6	22	43
EXH TEMP DEU		25	18	10	4	6	27	23	3
MAIN BEAR	95	91	95	92	95	95	95	95	95
B CYL LINER 1		129	129	127	127	128	128	128	127
D CYL LINER 2		130	130	129	129	129	129	142	138
H CYL LINER 3		129	129	129	129	129	140	142	140
K EXH VALVE 1 WAVE		0	0	0	0	0	0	0	0
K EXH VALVE 2 WAVE		0	1	0	0	0	0	0	0
A EXH TEMPERATURE		452	445	445	446	446	449	500	466
EXH VALUE DIFF		15	10	20	14	14	18	14	15
EXH TEMP DEU		15	10	20	14	14	18	14	15

ENTER NEXT RUPI-BLOCK NUMBER: 5

MEAN TEMPERATURE
1995-02-19
RUN. HOURS

467
11.00
38240

°F 872.6

19 FEBRUARY 95

#2 Generator Test

START 10:50 AM

CUMMING HAVING 30243



START	MUL	AMP	VOLTAGE	MVA	PF	KW/H/G	A EX TEMP	B EX TEMP	BONCER WATER TEMP
03.5	3.85	558	1436	4.06	.934	12.26	798	765	491.8
05.0	3.92	554	1532	4.03	.930	12.13	798	765	5
07.5	3.81	561	1496	4.02	.934	12.38	798	765	5
10.0	3.83	556	1486	4.04	.929	12.19	797	765	491.8
12.5	3.72	550	1501	4.01	.928	12.15	797	765	5
15.0	3.79	557	1469	4.08	.933	12.41	797	766	
17.5	3.81	560	1442	4.08	.936	12.49	798	766	491.6
20.0	3.84	564	1460	4.09	.934	12.24	798	766	5
22.5	3.79	567	1471	4.11	.934	12.11	798	766	5
25.0	3.87	561	1382	3.97	.935	12.25	798	766	492.6
27.5	3.83	560	1322	4.03	.923	12.14	797	767	5
30.0	3.84	560	1235	4.01	.944	12.20	797	767	5
32.5	3.85	557	1413	* 4.08	* 9.39	* 12.63	799	767	493.1
35.0	3.83	557	1343	4.00	.946	12.34	799	767	
37.5	3.73	547	1410	4.00	.937	12.09	799	767	5
40.0	3.75	540	1323	4.01	.945	12.02	800	768	493.4
42.5	3.85	548	1338	3.97	.945	11.83	800	767	5
45.0	3.74	542	1212	3.97	.950	12.30	801	768	5
47.5	3.77	539	1254	3.93	.949	11.81	801	769	494.2
50.0	3.81	548	1221	3.99	.951	11.25	802	770	5
			7265						
26.02									
3.80	Lignite Hours	18 Jan '95	29570						
0.049		19 Feb '95	30243						
	8,446.1								
	11,086	80.57	18.77	283.52					
	557	4.03	1.93	12.19					
	8.02	0.049	0.049	.007	0.205				
	27.876								
	1,325								
	38.23								

MINIMUM 77°F

19-FEB-95



ADDITIVE FUEL TEST #2 ENG.

TIME	FUEL IN	Δ IN	FUEL OUT	Δ OUT	FE	JT° F	FT° F	AMBIENT° F
START	3349	—	1969	—	—	94°	120°	84'
5 MIN	3403	54	2000	31	23	"	"	"
10 MIN	3460	57	2031	31	26	"	"	"
15 MIN	3516	56	2063	32	24	"	"	"
20 MIN	3572	56	2094	31	25	"	"	"
25 MIN	3628	56	2125	31	25	"	"	"
30 MIN	3684	56	2157	32	24	"	"	"
35 MIN	3741	57	2188	31	26	"	"	"
40 MIN	3797	56	2220	32	24	"	"	"
45 MIN	3853	56	2251	31	25	"	"	85°
50 MIN	3909	56	2282	31	25			85°

$$\begin{array}{r}
 560 \\
 -313 \\
 \hline
 247
 \end{array}$$

313

(247 gal)

- 62 -

Treated
2-19-95

4.0 4.0

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. 4.0 2. 4.0

Company: COMINCO RED DOG Test Date: 19 FEB 95

Test Portion: Baseline

Water Temp. _____

Treated

Oil Pressure _____

Air Restriction _____

Equipment Tested:

Make WARTSILA No. 25 Miles _____ I.D. # _____

Engine Type 32V16 Hours _____ I.D. _____

Fuel Injection Naturally Aspirated

Mechanical Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: 2:30

AMBIENT

PG. 1 of 2

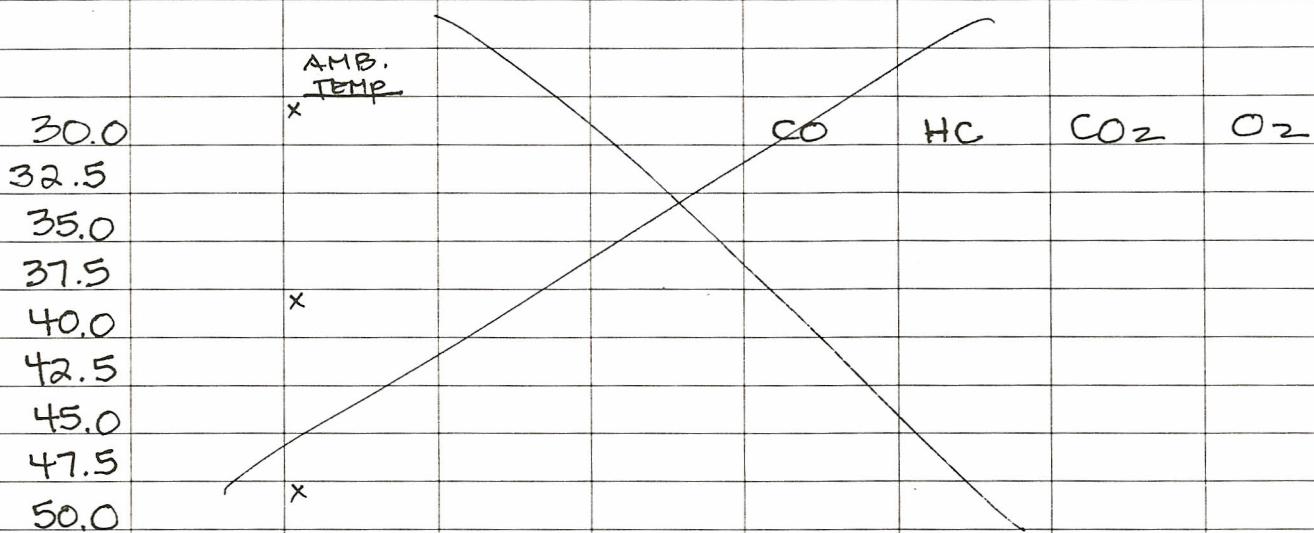
START
86.6°

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
5.0	1			.01	8	5.48	11.6	
7.5	2			.02	8	5.42	11.5	
10.0	3	x 86.6°		.02	10	5.46	11.7	
12.5	4			.02	10	5.43	11.7	
15.0	5			.02	10	5.41	11.7	
17.5	6			.02	10	5.40	11.6	
20.0	7	x 86.6°		.02	10	5.39	11.6	
22.5	8			.02	10	5.41	11.6	
25.0	9			.02	10	5.40	11.7	
27.5	10			.02	8	5.39	11.7	
	Average							

Signature of Technicians: _____ Finish Time: _____

WARTSILA #5

19 FEB 95



p. 2 of 2

	AMB. TEMP °F	CO	HC	CO ₂	O ₂
30	X 86.2	.02	10	5.38	11.7
32.5		.02	8	5.37	11.7
35		.02	16	5.34	11.7
37.5		.02	10	5.37	11.7
40	X 86.6	.02	8	5.38	11.7
42.5		.02	9	5.37	11.7
45		.02	8	5.376	11.7
47.5		.02	10	5.35	11.6
50	X 86.2	.02	8	5.34	11.7
52.5		.02	10	5.34	11.7

Item: 2 Code: CAK

ENGINE TEST DATA FOR 1956-02-19 - COMPUTED VALUES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
EXH VALVE 1 VALUE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EXH VALVE 2 VALUE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EXH TEMPERATURE	478	479	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	
EXH TEMP DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
MAIN PRESSURE	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	
CYL LINER 1	126	126	131	132	131	131	137	125	132	126	126	126	126	126	126	126	126	126	126	
CYL LINER 2	129	132	136	136	132	130	130	129	133	129	129	129	129	129	129	129	129	129	129	
CYL LINER 3	130	128	136	128	132	132	132	127	132	130	130	130	130	130	130	130	130	130	130	
EXH VALVE 1 WAVE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EXH VALVE 2 WAVE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EXH TEMPERATURE	478	479	478	478	462	472	463	463	463	463	463	463	463	463	463	463	463	463	463	
EXH VALUE DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
EXH TEMP OEM	126	128	130	132	130	132	130	126	132	126	126	126	126	126	126	126	126	126	126	
MEAN	126	128	130	132	130	132	130	126	132	126	126	126	126	126	126	126	126	126	126	
TEMPERATURE	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	468	
1956-02-19	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	15:00	
RUN. HOURS	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	32772	

860

ENGINE 5 MÄRTSILÄ UASA 16U32 COMPUTED VALUES :

	CYLINDER	1	2	3	4	5	6	7	8
B CYL LINER 1		122	129	129	126	125	121	121	125
A CYL LINER 2		121	126	131	127	122	126	125	126
N CYL LINER 3		120	130	120	130	122	116	126	123
K EXH VALVE 1 WAVE		0	0	1	0	0	0	0	0
EXH VALVE 2 WAVE		1	0	0	0	0	0	0	0
A EXH TEMPERATURE		432	468	468	467	457	468	472	447
EXH VALUE DIFF		4	37	37	37	37	37	37	25
EXH TEMP DEU		28	1	1	1	1	1	1	1
MAIN BEAR	GR.	92	96	97	97	95	95	94	92
B CYL LINER 1		126	126	120	122	131	126	125	133
A CYL LINER 2		120	132	134	129	129	130	123	129
N CYL LINER 3		126	127	131	120	132	130	126	134
K EXH VALVE 1 WAVE		0	1	0	0	0	0	1	0
EXH VALVE 2 WAVE		0	0	0	0	0	0	0	0
B EXH TEMPERATURE		477	498	488	486	471	467	441	446
EXH VALUE DIFF		3	22	19	36	13	9	25	3
EXH TEMP DEU		15	13	10	14	0	5	21	14

REFIN TEMPERATURE

1995-02-19

RUN : 400.00

461

15.47

327.00

860.8

860.9

19-FEB-95



ADDITIVE FUEL TEST #5 ENG

TIME	FUEL IN	Δ IN	FUEL OUT	Δ OUT	Fe	JT ^{OF}	FT ^{OF}	AMBIENT ^{OF}
0	6087	—	3889	—	—	93	125	87
5 min	6141	54	3921	32	22	11	11	11
10 min	6195	54	3953	32	22	11	11	11
15 min	6254	59	3989	36	23	11	11	11
20 min	6309	55	4022	33	22	11	11	11
25 min	6366	57	4056	34	23	11	11	86.5
30 min	6422	56	4090	34	22	11	11	11
35 min	6476	54	4122	32	22	11	11	11
40 min	6533	57	4157	35	22	11	11	11
45 min	6590	57	4191	34	23	11	11	11
50 min	6646	56	4225	34	22	11	11	87

559

-336

223

223

19 FEBRUARY 95
#5 Generator Test
START: 2:45 PM

ENGINE Hours 32779
KWH 131225 

TIME	MW	AMP	KVAR	MVA	PF	KWH/G	AIR TEMP	BEX TEMP	Boilover Discr Term
START									11
02.5	3.74	555	1541	4.04	.924	13.20	755	772	464.5
05.0	3.74	556	1501	4.05	.926	13.24	756	772	
07.5	3.78	558	1493	4.06	.930	13.46	755	772	
10.0	3.79	561	1518	4.10	.930	13.54	754	771	
12.5	3.74	555	1456	4.03	.931	13.31	754	770	465.0
15.0	3.79	559	1440	4.07	.935	13.43	754	770	
17.5	3.78	565	1637	4.13	.918	13.25	754	771	
20.0	3.79	564	1706	4.10	.910	13.26	754	771	
22.5	3.72	562	1685	4.15	.914	13.34	755	772	
25.0	3.71	564	1661	4.14	.916	13.23	755	772	464.5
27.5	3.76	553	1394	4.03	.940	13.18	755	772	
30.0	3.76	540	1159	3.93	.952	13.32	755	772	
32.5	3.78	552	1357	4.03	.944	13.64	755	772	
35.0	3.75	568	1752	4.14	.903	13.29	755	771	
37.5	3.80	543	1182	3.98	.957	13.43	755	772	464.6
40.0	3.80	540	1110	3.92	.958	13.26	754	771	
42.5	3.80	534	1336	3.99	.933	13.53	755	772	
45.0	3.78	546	1336	3.98	.942	13.45	755	772	
47.5	3.69	562	1710	4.13	.910	13.31	756	772	
50.0	3.74	566	1721	4.14	.911	13.50	755	771	464.2

20.24 11,103 25,655 81.14 18.58 267.17

3.76 555.1 1,484.7 4.057 0.928 13.35

0.032 9.84 196.8 0.022 0.016 0.120

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____ 2. _____

Company: Corvaco Test Date: 2-19-95

Test Portion: Baseline Water Temp. _____

Treated Oil Pressure _____

Air Restriction _____

Equipment Tested:

Make _____ Miles _____ I.D. # 51

Engine Type _____ Hours _____ I.D. _____

Fuel Injection Naturally Aspirated

Mechanical Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: _____

	RPM	Exh. Temp °F	P _v Inch H ₂ O	CO	HC	CO ₂	O ₂	Remarks
1	00 /200	1.15	1.15	01.	8	5.69	14.8	
2	2.0 /21.1	1.15	1.20					
3	3.0 /20.0	1.15	1.15					
4	2.5 /22.5	1.15	1.15					
5	10.0 /350	1.15	1.15					
6	12.5 /32.5	1.20	1.25					
7	15.0 /40.0	1.20	1.20					
8	17.5 /42.5	1.15	1.25					
9	20.0 /45.0	1.15	1.20					
10	22.5 /47.5	1.15	1.20					
	Average							

1.165

Signature of Technicians: _____ Finish Time: _____

1.175

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____ 2. _____

PAGE 1

Company: Cominco ALASKA REO Date: 1/17/95 Test Date: 1/17/95

Test Portion: Baseline

Water Temp. _____

Treated

Oil Pressure _____

Equipment Tested:

Air Restriction _____

Make NARTSILIA #5

Miles _____ I.D. # _____

Engine Type _____

Hours _____ I.D. _____

Fuel Injection

Naturally Aspirated

Mechanical

Turbocharged

Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: _____

	RPM ✓	Exh. Temp ✓ °F	P _v ✓ Inch H ₂ O	CO ✓	HC ✓	CO ₂ ✓	O ₂ ✓	Remarks
5	0			.02	10	5.43 5.41	11.1 → 5.42	
7.5	2.5			.02	10	5.46 5.43	11.1 → 5.445	
10	5			.02	10	5.48 5.46	11.1 → 5.47	
12.5	7.5			.02	10	5.41 5.39	11.1	5.408
15	10			.02	10	5.49 5.41	11.1	5.45 Auto Calc
17.5	12.5			.02	10	5.41 5.42	11.1	5.415
20	15			.02	10	5.44 5.42	11.0	5.43
22.5	17.5			.02	10	5.45 5.45	11.0	5.45
25	20			.02	10	5.37 5.42	11.0	5.395
27.5	22.5			.02	10	5.42 5.41	11.1	5.415 Auto Calc
Average								

Signature of Technicians: _____ Finish Time: _____

S.O / 50

#5 Baseline

FPC® TECHNOLOGY, INC.
CARBON MASS BALANCE FIELD DATA FORM

Smoke Spot Numbers

1. _____

2. _____

PAGE 2

Company: COMINCO ALASKA R.D. Test Date: 1/17/95Test Portion: Baseline

Water Temp. _____

Oil Pressure _____

Treated

Air Restriction _____

Equipment Tested:

Make WORCESTERSHIRE #5

Miles _____ I.D. # _____

Engine Type _____

Hours _____ I.D. _____

Fuel Injection Naturally Aspirated Mechanical Turbocharged Exhaust Stack Diam _____ Inches Straight Curved

BP: _____ Inches Hg @ _____ °F Ambient Temp: _____ °F

Fuel: _____ SG @ _____ °F Start Time: _____

	RPM	Exh. Temp °F	P _v Inch H ₂ O	✓CO	✓HC	CO ₂ ✓	✓O ₂	Remarks
30	125			.02	9	5.43 5.41	11.0	5.42
32.5	27.5			.02	10	5.40 5.42	11.0	5.41
35	30			.02	10	5.44 5.43	11.0	5.435
37.5	32.5			.02	10	5.40 5.43	11.0	5.415
40	35			.02	10	5.40 5.42	11.1	5.41 Auto CAL
42.5	37.5			.02	10	5.41 5.40	10.9	5.405
45	40			.02	9	5.44 5.44	11.0	5.44
47.5	42.5			.01	10	5.44 5.43	11.1	5.435
50	45			.01	10	5.43 5.38	11.1	5.405
52.5	47.5			.02	9	5.39 5.41	10.9	5.40 Auto CAL
55	Average			.01	10	5.42 5.41	11.0	5.415

Signature of Technicians: _____ Finish Time: _____

Carbon Mass Balance Field Data Form

Company: Coweta Location: Red Dog Test Date: 1-17-85
 Test Portion: Baseline: X Treated: _____ Exhaust Stack Diameter: 32 Inches

Engine Make/Model: Vasa 16V32 Miles/Hours: _____ I.D.#: 5
 Type of Equipment: _____

Fuel Specific Gravity: _____ @: _____ (°F)
 Barometric Pressure: _____ Inches of Mercury
 Intake Air Temperature: _____ (°F) Start Time: _____

RPM	Exhaust Temp °F	P Inches of H ₂ O	% CO	HC ppm	% CO ₂	% O ₂	Smoke Number
1.		1.20	1.20				
2.		1.20	1.20				
3.		1.20	1.20				
4.		1.20	1.20				
5.		1.20	1.20				
6.		1.20	1.20				
7.		1.20	1.20				
8.		1.20	1.20				
9.		1.20	1.20				
10.		1.20	1.20				

End Time _____

Names of Customer Personnel Participating in Test:

Signature of Technicians:

Diesel Generator Specific Fuel Consumption Log

Customer: Cominco Alaska Inc.Engine #: 5Date: 17 JAN '98 Base: /

Treated: _____

Location: Red Dog Operations

Density: _____ Base: _____ Treated: _____

Engine: Make: _____
Model: _____
Eng. Hrs: _____Alternator:
Make: _____
Rating: _____Test Sequence #: 1MVA**Temperature Degree F**

TIME Start Finish	Elapsed Time	Nom Load kW	kWh Start Finish	MW kWh	PF Av	KVAR Kv Volts	Amps	FUEL METER Start/Finish	Fuel Gallons	Kw/g g/kWh	Exhaust Gas Temp	Air In Dry/Wet	J.W. Out/In	Fuel In
	2.5		N/A	3.75	0.929	1520	553			13.35	446.5			
	5		4.08	3.81	0.929	1491	560			13.58	446.5			
	7.5		4.01	3.77	0.929	1516	552			13.46	446.2			
	10		4.06	3.74	0.926	1593	555			13.58	446.9	10		
	12.5		4.05	3.74	0.924	1545	545			13.22	447.2	X		
	15		4.09	3.77	0.923	1553	554			13.36	447.4			
	17.5		3.99	3.69	0.929	1497	546			13.25	447.3			
	20		4.00	3.69	0.925	1652	559			13.44	447.6			
	22.5		4.10	3.80	0.928	1531	558			13.09	448.0			
	25		4.07	3.77	0.928	1522	561			13.57	448.0			
	29.5		4.00	3.70	0.925	1526	549			13.32	448.7			
	30		4.08	3.80	0.930	1497	553			13.26	449.2			
	32.5		4.06	3.81	0.928	1509	561			13.50	449.6			

Diesel Generator Specific Fuel Consumption Log

Customer: Cominco Alaska Inc. Engine #: 5 Date: 17 JAN '95 Base: / Treated: /
 Location: Red Dog Operations Density: Base: Treated:
 Engine: Make: Alternator: Test Sequence #: 1
 Model: Make:
 Eng. Hrs: Rating:

MVA

Temperature Degree F

TIME Start Finish	Elapsed Time	Nom Load kW	kWh Start Finish	MW kWh	PF Av	KVAR KV Volts	Amps	FUEL METER Start/Finish	Fuel Gallons	KWh/G g/kWh	Exhaust Gas Temp	Air In Dry/Wet	J.W. Out/In	Fuel In
35			4.05	3.76	0.928	1504	554			13.36	449.9			
37.5			4.01	3.71	0.926	1526	553			13.38	450.0			
40			4.00	3.70	0.927	1516	550			13.35	450.4			
42.5			4.05	3.77	0.928	1505	554			13.37	450.4			
45			4.06	3.76	0.925	1536	552			13.26	450.6			
47.5			4.05	3.75	0.929	1514	556			13.46	450.8			
50			4.08	3.80	0.928	1520	563			13.58	451.0			
52.5			4.05	3.77	0.932	1479	559			13.43	450.7			
55														

Sum: 80.940 78.86 19.426 31,952 11,647 553-332 = 281.17
 New: 4.05 3.75 0.927 1,521.5 554.6 221 13.39
 SD : 0.034 0.039 0.0022 25.02 4.87 221/80 = 0.132
 25.02/80 = 0.3125
 4.87/80 = 0.060875

2.42 Gals

840 F
AMBIENT

Diesel Generator Specific Fuel Consumption Log

Customer: _____

Engine #: 5

Date: 17-JAN

Base: _____

Treated: _____

Location: _____

Density: _____

Base: _____

Treated: _____

Engine: Make: _____
Model: _____
Eng. Hrs: _____Alternator: Make: _____
Rating: _____

Test Sequence #: _____

7713/6960

Temperature Degree F

TIME Start Finish	Elapsed Time	Nom Load kW	kWh Start Finish	kWh	kW Av	Kv Volts	Amps	FUEL METER Start/Finish	Fuel Gallons	g/kWh	Exhaust Gas Temp	Air In Dry/Wet	J.W. Out/In	Fuel In
8266	7292							7766 / 6992	21 GAL				94° F	120° F
- 7713 -	6960							7822 / 7025	23 GAL				11	11
553	332							7877 / 7059	21 GAL				11	11
332								7933 / 7092	23 GAL				11	11
(22 L)	6 GAL							7989 / 7126	22 GAL				11	11
								8045 / 7159	23 GAL				11	
								8100 / 7192	22 GAL				11	11
								8154 / 7225	21 GAL				11	11
								8210 / 7258	23 GAL	19.9 82			11	11
								8266 / 7292	22 GAL	221 CAL			11	11
7766 6992	7822 7025	7877 7059	7933 7092	7989 7126	8045 7159	8100 7192	8154 7225	8210 7258	8266 7292					
- 7713 - 6960	- 7766 - 6992	- 7822 - 7025	- 7877 - 7059	- 7933 - 7092	- 7989 - 7126	- 8045 - 7159	- 8100 - 7192	- 8154 - 7225	- 8210 - 7258					
53	56	55	56	56	56	55	54	56	56					
-32	-33	-34	-33	-34	-33	-33	-33	-33	-33					
21 GAL	23 GAL	21 GAL	23 GAL	22 GAL	23 GAL	22 GAL	21 GAL	23 GAL	22 GAL					

ENGINE 5 WARTSILA VASA 16U32 DISPLAY OF RUPI-BLOCK NUMBER: 51

	CYLINDER	1	2	3	4	5	6	7	8
B CYL LINER 1		127	139	136	128	124	121	122	129
A CYL LINER 2		130	129	122	123	140	126	130	129
N CYL LINER 3		126	128	129	133	122	118	127	125
K EXH VLVE 1 WAVE		0	1	0	0	0	0	0	0
EXH VLVE 2 WAVE		0	0	0	0	0	0	0	0
A EXH TEMPERATURE		452	457	450	455	449	455	459	439
EXH VALUE DIFF		32	33	36	6	33	20	17	21
EXH TEMP DEV		- 4	1	- 6	- 1	- 7	- 1	3	- 17
MAIN BEAR	95	92	95	96	96	95	93	94	92
B CYL LINER 1		125	126	132	130	131	135	125	133
A CYL LINER 2		129	132	148	129	127	129	124	130
N CYL LINER 3		128	129	136	127	131	132	125	131
K EXH VLVE 1 WAVE		0	0	0	0	0	0	0	0
EXH VLVE 2 WAVE		0	0	0	0	0	0	0	0
B EXH TEMPERATURE		469	464	473	457	470	457	442	442
EXH VALUE DIFF		7	13	23	24	25	4	29	10
EXH TEMP DEV		14	8	17	1	14	1	- 14	- 14

MEAN TEMPERATURE 456
 1995-01-17 17:46
 RUN. HOURS 32015

L 9 x 32
L 9 x 32



FILE NO.

BY

DATE 29-JAN-95

SUBJECT # 5 ENGINE PRELIMINARY w/ ADDITIVE

TEST 1 START 9.25 AMEND 10.15 AM

SHEET

OF

TIME	MW	AMP	KVAR	MVA	PF	KWH/E	EX-A	EX-B
5	3.71	569	1625	4.16	.892	13.55	709	729
2.5	3.70	570	1676	4.13	.891	13.66	709	730
5.0	3.77	573	1665	4.15	.899	13.61	710	730
7.5	3.75	577	1618	4.18	.892	13.60	710	730
10.0	3.79	584	1616	4.12	.891	13.55	710	730
12.5	3.77	591	1689	4.15	.886	13.74	710	730
15.0	3.75	576	1604	4.18	.898	13.57	710	730
17.5	3.74	563	1629	4.09	.915	13.57	711	731
20.0	3.68	551	1606	4.10	.920	13.53	711	731
22.5	3.67	562	1668	4.06	.918	13.29	711	731
25.0	3.74	567	1672	4.10	.914	13.44	712	732
27.5	3.69	554	1620	4.05	.917	13.48	712	732
30.0	3.77	557	1587	4.06	.921	13.63	712	732
32.5	3.75	561	1709	4.07	.914	13.64	712	732
35.0	3.68	554	1641	4.06	.915	13.54	711	731
37.5	3.76	556	1642	4.09	.916	13.55	711	731
40.0	3.70	569	1658	4.08	.910	13.64	711	732
42.5	3.71	556	1607	4.03	.912	13.39	714	734
45	3.71	559	1643	4.06	.915	13.50	715	735
47.5	3.69	549	1607	4.00	.918	13.67	716	737
50.0	3.72	557	1591	4.05	.919	13.67	717	737
52.5								

BOILER DISCHARGE 400.1 START 394.5 END
 AMBIENT AT INTAKE 72



FILE NO. BY DATE

SUBJECT

	A	F2	Fe	SHEET	OF
	IN	IN	OUT	1 out	FT °F
0	1145.26	54.74	678.71		94°
5	1200.0	57.2	708.22	- 29.51	94°
10	1257.20	55.42	741.18	- 32.96	92°
15	1312.62			- 32.49	92°
20	1368.00	- 55.38	773.67	- 33.71	92°
25	1424.98	56.98	806.84	31.92	92°
30	1486.08	57.39	838.76	32.42	92°
35	1537.47	56.11	903.86	32.48	92°
40	1593.58	56.66	936.34		92°
45	1650.24		969.24	32.9	92°
50	1706.35	- 56.11	1001.71	32.47	92°
55					110°
					X 23.847

	Fuel IN	Fuel A IN	Fuel OUT	# 5 A OUT	Fe	FT °F	FT °F
0	2699.19		1712.95			93°	110°
5	2752.10	53.91	1745.25	32.13	21.78	93°	110°
10	2809.19	57.03	1779.20	33.95	23.14		
15	2865.27	56.11	1813.30	34.1	22.01		
20	2921.77	56.5	1847.67	34.37	22.13		
25	2977.58	55.81	1881.63	33.96	21.85		
30	3032.93	55.33	1915.63	34.0	21.35		
35	3090.16	57.23	1950.37	34.74	22.49		
40	3145.56	55.4	1984.05	33.68	21.72		
45	3201.64	56.08	2013.15	34.1	21.98		
50	3256.84	55.2	2051.87	33.72	21.48		
					X = 21.99	219.93	

#5 - TEST 1

FOUR DENS . 805 @ 84°F

31 JAN 95

	105216 (19 th) KWH		306 OPERATING HOURS					Cominco	32033 (S)
1:28 PM	115918 (31 st) KWH		1070200 - KWH TOTAL		6:00 AM ENDS 4 HRS				32339
TIME	MW	AMP	KVArR	MVA	PF	KWH/G	EX-A	EX-B	Bureau Disc.
ST 2:00	3.77	557	1542	4.06	.923	13.21	-	-	
2.5	3.76	567	1502	4.13	.924	13.36	731	756	412.3
5.0	3.77	572	1530	4.04	.924	13.52	732	757	
7.5	3.74	548	1481	4.07	.931	13.37	733	758	
10.0	3.76	545	1462	4.04	.932	13.27	733	758	
12.5	3.75	551	1431	3.94	.934	13.27	734	758	
15.0	3.72	543	1382	4.02	.932	13.48	733	758	
17.5	3.78	554	1445	4.04	.934	13.61	734	759	
20.0	3.70	540	1391	4.07	.939	13.40	734	759	
22.5	3.70	556	1402	4.03	.938	13.40	734	759	
25.0	3.78	542	1455	3.96	.939	13.43	735	759	
27.5	3.74	561	1416	4.00	.933	13.35	735	760	
30.0	3.72	546	1452	4.07	.934	13.48	735	760	
32.5	3.76	552	1451	4.03	.933	13.29	735	760	
35.0	3.81	560	1450	4.09	.935	13.56	736	760	
37.5	3.79	552	1432	4.09	.936	13.59	736	760	
40.0	3.74	543	1446	4.06	.934	13.63	736	761	
42.5	3.73	548	1477	4.05	.927	13.22	736	761	
45.0	3.72	558	1468	3.98	.928	13.52	737	761	
47.5	3.72	546	1451	4.00	.932	13.28	737	761	
50.0	3.74	557	1453	4.07	.929	13.44	738	761	
52.5	3.74	543	1490	4.03	.931	13.37	738	761	
55.0									
57.5									
60.0									

1450 1450 1450 1450

P.M. 1450 1450 1450

TOTAL FOUR USES 222.66

E 1101 GING 5

TEST 1



TIME	Fuel IN	A Fuel/ OUT	Fuel/ OUT	A OUT	F _e	T F _e	J _T °F	F _i °F
0	5245.77		3313.23					
5	5301.44	55.67	3346.77	33.54	22.13	22.13		
10	5357.66	56.22	3380.73	33.96	22.26	44.39		
15	5413.61	55.95	3414.41	33.68	22.27	66.66		
20	5469.69	56.08	3448.36	34.05	22.03	88.69		
25	5525.78	56.09	3482.04	33.65	22.44	111.13		
30	5581.12	55.94	3515.86	33.82	22.12	133.25		
35	5637.67	55.95	3549.54	33.68	22.27	155.52		
40	5694.17	56.5	3583.50	33.96	22.54	178.06		
45	5749.84	55.67	3617.04	33.54	22.13	200.19		
50	5805.92	56.08	3650.72	33.68	22.40	222.59		
	560.1		337.49					

#5 EUE 31 Jan 1995 - 1330 hrs

5694.17

5805.92

3650.72

5245.77

3313.23

3583.50

~~560.15~~

337.49

222.66

Item: 2 Code: CAK

1PM Tue 17 January		ALASKA this hour						TODAY'S DATA		
TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	cloudy	-2	E 16	-35	20	83%	29.22s			
Deadhorse	cloudy	-2	E 14	-32	7	87%	29.21s	-2	-9	
Galbraith Lk	.....								
Umiat	cloudy	-7	CALM	-7	20	71%	29.18r		-13	
Lonely	.....								
Barrow	cloudy	2	E 24	-39	7	87%	29.22f	2	-7	Trace
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	lgt snow	20	E 36G43	-19	1/2	96%	28.94s	21	-3	Trace
Shishmaref	mstly cldy	14	SE 3	14	10	80%	28.87r	15	1	
Port Clarence	.....								
Tin City	cloudy	-1	N 45G53	-55	1/2	83%	28.78r	-1	-7	
Nome	lgt snow	32	SE 21	6	1	89%	28.72r	32	16	0.14
Gambell	mstly cldy	1	NE 47G59	-52		79%	28.74s	1	-3	
Unalakleet	ptly cldy	24	E 26	-8	4	75%	28.98s	25	18	
Emmonak	.....								
Andreafsky	.....								
Saint Marys	no report	31	SE 33G41	-1	7	82%	28.79s	33	20	
Mekoryuk	cloudy	32	S 37G45	-1	1/2	92%	28.55r	32	31	
Bethel	cloudy	32	S 22	5	35	82%	28.84r	36	30	0.02
Aniak	no report	36	S 6	31	10	44%	28.96s	37	31	
St Paul Islnd	lgt snow	27	NW 16	4	2	88%	28.57r	33	27	0.05
Dillingham	cloudy	34	SE 13G23	17	10	82%	29.02r	34	32	0.07
Chulitna	.....								
Port Alsworth	mstly cldy	36	N 7	29	30	82%	29.13r			
Iliamna	cloudy	35	E 16	15	25	79%	29.15r			
King Salmon	cloudy	38	SE 20G29	15	15	67%	29.05r	39	36	0.03
Adak	lgt snow	30	NW 22G29	3	5	75%	29.04r	35	30	0.07
Shemya AFB	lgt snow	25	N 26G38	-7	1	69%	29.43r	27	24	0.07
Nikolski	.....								
Dutch Harbor	ptly cldy	33	SE 6	27	20	75%	28.61r	36	33	
Cold Bay	rain shwr	36	E 8	27	5	96%	28.58f	41	33	0.12
Sand Point	no report	41	SE 21G33	19		65%	28.63f	42	36	0.01
Port Heiden	mstly cldy	38	SE 22G33	14	8	62%	28.89f	38	35	
Anaktuvuk Ps	no report	16	SW 11	-3	10	56%	29.12r	19	2	
Ambler	cloudy	20	SE 15G23	-4	7	65%	29.12s	20	11	
Shungnak	.....								
Prospect Crk	mstly cldy	19	E 9	5	20		29.24r	21	17	
Bettles	cloudy	10	CALM		40	76%	29.26r	11	1	
Chandalar	.....								
Fort Yukon	no report	-8	CALM	-8	10	64%	29.36s	-6	-15	
Circle	cloudy	-6	CALM	-6	35	82%	29.30fr			
Five Mile Cmp	ptly cldy	-5	CALM	-5	35		29.30s	-4	-6	
Manley HotSpr	.....								
Tanana	cloudy	11	E 11	-9	40	67%	29.28r	28	-2	0.01
Galena	mstly cldy	18	E 22	-14	15	74%	29.11r	19	8	0.18
Minchumina	no report	2	CALM	2	10	76%	29.22r	3	-6	
Puntilla Lake	cloudy	25	SE 11	8	8	96%	29.19rr			
McGrath	cloudy	19	CALM	19	45	92%	29.15r	21	11	0.02
Fairbanks Int	cloudy	11	W 6	3	60	96%	29.26r	14	6	
Ft Wainwright	mstly cldy	12	N 3	12	85	80%	29.25s	14	9	
Eielson AFB	mstly cldy	12	NW 2	12	70	77%	29.22r	14	8	
Big Delta	cloudy	16	E 21G39	-16	40	56%	29.22r		12	

Item: 2 Code: CAK

11AM Tue 17 January		ALASKA this hour						TODAY'S DATA		
TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	light fog	-4	E 21	-45	6	87%	29.24f			
Deadhorse	light fog	-3	E 16	-37	2	91%	29.22s	-3	-9	
Galbraith Lk	.....								
Umiat	cloudy	-8	E 7	-21	7	78%	29.18f		-13	
Lonely	.....								
Barrow	lgt snow	1	E 20	-37	7	83%	29.27s	1	-7	Trace
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	lgt snow	20	E 33G39	-18	2	96%	28.92f	21	15	Trace
Shishmaref	ptly cldy	14	E 10	-3	5	84%	28.86s	15	1	
Port Clarence	.....								
Tin City	cloudy	-3	N 44G51	-58	1	83%	28.77s	-2	-7	
Nome	lgt snow	27	E 20	0	1	96%	28.67s	28	25	0.14
Gambell	mstly cldy	0	NE 46G54	-54		75%	28.73f	0	-3	
Unalakleet	ptly cldy	24	E 28G33	-10	1/2	71%	28.93r	25	18	
Emmonak	.....								
Andreafsky	.....								
Saint Marys	cloudy	32	S 36G49	-1	4	89%	28.73r	33	20	
Mekoryuk	cloudy	32	S 33G43	0	3/4	92%	28.50r	32	31	
Bethel	mstly cldy	31	S 24G31	3	10	78%	28.80r	36	30	0.02
Aniak	no report	33	SE 9G16	21	10	52%	28.92r	37	31	
St Paul Islnd	lgt snow	28	NW 16	5	2	85%	28.50r	33	27	0.05
Dillingham	cloudy	33	SE 9	21	10	85%	29.00r	34	32	0.07
Chulitna	cloudy	19	CALM	19	20	71%	29.11f		8	
Port Alsworth	ptly cldy	34	NE 8	24	7	92%	29.09r			
Iliamna	cloudy	34	E 14	15	14	82%	29.11r			
King Salmon	cloudy	37	SE 18G26	16	15	70%	29.03r	39	36	0.03
Adak	lgt snow	31	NW 29G32	0	3	78%	28.96r	35	30	0.07
Shemya AFB	lgt snow	25	N 17G28	0	7	72%	29.37r	27	24	0.07
Nikolski	.....								
Dutch Harbor	mstly cldy	33	E 3	33	12	75%	28.59s	36	33	
Cold Bay	lgt snow	33	NW 5	30	1	100%	28.62f	41	33	0.12
Sand Point	no report	42	SE 14G24	26		65%	28.69f	42	36	0.01
Port Heiden	mstly cldy	38	SE 18G29	17	15	55%	28.85fr	38	35	
Anaktuvuk Ps	no report	16	SW 15	-9	10	54%	29.08s	16	2	
Ambler	no report	20	SE 17G28	-6	10	60%	29.07f	20	11	
Shungnak	.....								
Prospect Crk	cloudy	21	N 3	21	10		29.21r			
Bettles	cloudy	11	NW 3	11	9	73%	29.23r	11	1	
Chandalar	lgt snow	15	NE 9	0	10	74%	29.30fr			
Fort Yukon	no report	-6	W 3	-6	10	64%	29.34r	-6	-15	
Circle	.....								
Five Mile Cmp	cloudy	-4	CALM	-4	20		29.30s			
Manley HotSpr	cloudy	9	NE 5	5	7	87%	29.22f			
Tanana	mstly cldy	10	N 10	-8	15	67%	29.24r		-2	
Galena	lgt snow	19	SE 18G26	-9	10	65%	29.06s	19	8	0.18
Minchumina	no report	3	CALM	3	10	72%	29.19r	3	-6	
Puntilla Lake	cloudy	22	E 8	10	10	88%	29.15r			
McGrath	lgt snow	20	NW 5	16	7	88%	29.10r	21	11	0.02
Fairbanks Int	cloudy	10	CALM	10	40	92%	29.23r	14	6	
Ft Wainwright	cloudy	9	W 5	5	15	84%	29.21r			
Eielson AFB	cloudy	8	CALM	8	15	76%	29.19r	14	8	
Big Delta	cloudy	16	E 30G44	-23	30	56%	29.18r		12	

***** Item: 2 Code: CAK *****

TOWN	WEATHER	TEMP	WIND	ALASKA this hour				TODAY'S DATA		
				FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island	.....								
Prudhoe Bay	cloudy	-5	E 17	-41	8	83%	29.27f			
Deadhorse	light fog	-4	E 16	-38	2	87%	29.22f	-4	-9	
Galbraith Lk	.....								
Umiat	cloudy	-9	E 5	-14	7	64%	29.20s			
Lonely	.....								
Barrow	lgt snow	0	E 20	-38	7	83%	29.27f	0	-7	Trace
Wainwright	.....								
Oliktok	.....								
Point Lay	.....								
Kotzebue	lgt snow	19	E 24	-14	2	96%	28.94s	19	15	Trace
Shishmaref	cloudy	14	NE 11	-5	10	88%	28.86f	15	1	
Port Clarence	.....								
Tin City	cloudy	-3	N 45G52	-58	3/4	83%	28.77f	-2	-7	
Nome	lgt snow	26	E 22G31	-3	3/4	96%	28.67s	28	25	0.02
Gambell	ptly cldy	-1	NE 41G49	-54		79%	28.75s	-1	-3	
Unalakleet	ptly cldy	24	E 28G32	-10	10	71%	28.87rr	24	18	
Emmonak	.....								
Andreafsky	.....								
Saint Marys	cloudy	32	S 36G46	-1	2	96%	28.66rr	32	20	
Mekoryuk	cloudy	32	S 22G28	5	4	92%	28.45r	32	31	
Bethel	ptly cldy	32	S 23G33	5	20	79%	28.78r	36	30	0.02
Aniak	ptly cldy	31	SE 7	23	10	54%	28.86rr	37	31	
St Paul Islnd	lgt snow	27	NW 15	5	2	88%	28.47r	33	27	0.04
Dillingham	cloudy	33	SE 7	25	10	85%	28.98r	34	32	0.07
Chulitna	cloudy	19	CALM	19	20	71%	29.11f		8	
Port Alsworth	mstly cldy	33	NE 11	18	7	92%	29.05rr			
Iliamna	cloudy	34	E 14G20	15	12	85%	29.10r			
King Salmon	cloudy	37	SE 14	19	15	67%	29.00s	39	36	
Adak	lgt snow	31	NW 23G32	3	2	78%	28.92r	35	31	0.07
Shemya AFB	lgt snow	24	N 24	-7	2	71%	29.35r	27	24	0.05
Nikolski	.....								
Dutch Harbor	ptly cldy	33	S 2	33	15	75%	28.58f	35	33	
Cold Bay	lgt snow	33	NE 3	33	3/4	100%	28.65f	41	33	
Sand Point	cloudy	40	SE 14G22	23	5	73%	28.74fr	40	36	0.01
Port Heiden	mstly cldy	37	SE 24	11	10	59%	28.89f	37	35	
Anaktuvuk Ps	no report	10	S 9	-6	10	58%	29.07f	11	2	
Ambler	no report	18	SE 9G15	3	10	62%	29.07f	20	11	
Shungnak	.....								
Prospect Crk	mstly cldy	19	E 14G21	-4	10		29.20r			
Bettles	cloudy	7	N 5	3	9	76%	29.22s	7	1	
Chandalar	lgt snow	15	NE 9	0	10	74%	29.30fr			
Fort Yukon	no report	-7	SW 3	-7	10	64%	29.33s	-7	-15	
Circle	.....								
Five Mile Cmp	cloudy	-4	CALM	-4	20		29.30r			
Manley HotSpr	cloudy	9	NE 5	5	7	87%	29.22f			
Tanana	cloudy	9	E 10	-9	10	67%	29.23s			
Galena	cloudy	19	SE 22	-13	10	57%	29.05s	19	8	
Minchumina	no report	-3	CALM	-3	10	79%	29.15r	-2	-6	
Puntilla Lake	cloudy	22	E 7	13	20	88%	29.14r			
McGrath	lgt snow	19	E 5	15	7	92%	29.08r	21	11	
Fairbanks Int	cloudy	7	NW 3	7	15	91%	29.20s	14	6	
Ft Wainwright	cloudy	10	NW 2	10	15	88%	29.19s			
Eielson AFB	cloudy	8	CALM	8	15	76%	29.19r	14	8	
Big Delta	cloudy	15	E 34G49	-26	20	61%	29.15r			

Item: 2 Code: CAK

TOWN	WEATHER	TEMP	WIND	FLSLK	VIS	HUM	BRMTR	HI	LOW	PCPN
Barter Island										
Prudhoe Bay	light fog	-6	E	14	-37	6	82%	29.32fr		
Deadhorse	light fog	-6	E	14	-37	3	91%	29.29f	-6	-9
Galbraith Lk										
Umiat										
Lonely										
Barrow	lgt snow	-1	E	20	-39	7	83%	29.32f	-1	-7
Wainwright										
Oliktok										
Point Lay										
Kotzebue	blwg snow	19	E	38G44	-22	1/2	92%	28.90f	19	15
Shishmaref										
Port Clarence										
Tin City	cloudy	-3	N	43	-58	1	83%	28.79r	-2	-7
Nome	frz drzl	26	E	21	-2	1	92%	28.69s	28	26
Gambell										
Unalakleet										
Emmonak										
Andreafsky										
Saint Marys										
Mekoryuk										
Bethel	dry	34	S	28G34	5	10	85%	28.70r	36	30
Aniak										
St Paul Islnd	lgt snow	28	NW	14	8	6	85%	28.41r	33	27
Dillingham	cloudy	33	SE	8	23	10	85%	28.97f	34	32
Chulitna										
Port Alsworth										
Iliamna	cloudy	35	E	14G24	17	10	85%	29.05rr		
King Salmon	cloudy	37	S	17G22	16	15	76%	28.97r	39	36
Adak	lgt snow	31	N	24G33	3	2	89%	28.85r	35	31
Shemya AFB	lgt snow	24	N	25G36	-8	5	66%	29.31r	27	24
Nikolski										
Dutch Harbor	clear	33	SW	3	33	12	70%	28.59s	35	33
Cold Bay	dry	35	SE	14	17	10	92%	28.72f	41	35
Sand Point										
Port Heiden	no report	36	SE	26G33	9		70%	28.92r	37	35
Anaktuvuk Ps										
Ambler										
Shungnak										
Prospect Crk										
Bettles	cloudy	7	N	3	7	13	80%	29.22f	7	1
Chandalar										
Fort Yukon										
Circle										
Five Mile Cmp	cloudy	-5	CALM		-5	20		29.30s		
Manley HotSpr										
Tanana	cloudy	8	E	14	-18	10	66%	29.22f		
Galena	cloudy	19	E	16	-7	10	59%	29.03s	19	8
Minchumina										
Puntilla Lake										
McGrath	cloudy	21	S	10	5	15	74%	29.03r	21	11
Fairbanks Int	cloudy	10	CALM		10	15	92%	29.18s	14	6
Ft Wainwright	cloudy	14	SE	1	14	15	84%	29.18s		
Eielson AFB	mstly cldy	12	CALM		12	15	73%	29.18s	14	8
Big Delta	mstly cldy	15	E	39G47	-28	20	56%	29.14f		

$1000 - 970 = 11 = .113$
*Correction for Sealevel
Basis at the Mine*

