California Environmental Engineering
ENVIRONMENTAL TESTING LABORATORY
1061 N. GROVE ST.   ANAHEIM, CA 92806
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FINAL REPORT

RESULTS OF OPACITY TESTING ON THE VESSEL, CONDOR, USING OMSTAR D1280X FUEL ADDITIVE

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July 26, 1989

Ms. Lillian Kawasaki
Director of Environmental Management
Harbor Department, Port of Los Angeles
425 S. Palos Verdes Street
San Pedro, CA 90733-0151

RE: Final Report on results of opacity testing conducted on the vessel, Condor, using Omstar D1280X fuel additive.

Dear Ms. Kawasaki,

California Environmental Engineering (C.E.E.) conducted smoke opacity tests requested by the Port of Los Angeles on the Motor Vessel Condor. All tests were conducted on number one auxiliary diesel engine, using #2 diesel fuel with Omstar D1280X fuel additive. The Wager 650 Opacity Meter was used on all tests. All tests were conducted by Larry Swiencki, Manager of C.E.E. and Greg Long an independent emission consultant. The tests were observed by Detrich Allen, Environmental Scientist from the Port of Los Angeles.

The test procedure originally intended to be used was the New Jersey peak opacity test procedure used in testing diesel trucks. After two preliminary tests we found this procedure inadequate for testing this engine. The main reason being the low RPM operation of the auxiliary engine (1200 RPM). We found when the load was applied the RPM only dropped to 900 RPM. After discussion amongst Ms. Allen, Mr. Long and myself we decided to create our own test procedure. The following is the procedure used for all tests with the approval of the Port of Los Angeles.

1. The engine was brought up to normal operating speed (1200 RPM) with the equipment on line as indicated by the number (1) one on attachment A.

2. At the command to load, the equipment indicated by the number (2) two on attachment A was energized.

3. The opacity reading was taken at 0 minutes upon load introduction and a stop watch started. See attachment B, column 1.

4. The next opacity reading was taken when the engine returned to normal operating RPM (1200 RPM). See attachment B, column 2. A recovery time was also noted at this time.

(continued)

5. After five (5) minutes of operation another opacity reading was taken. See attachment B, column 3.

6. The load added in number two (2) above was then taken off line. The opacity lenses cleaned and ready for the next test. Column one (1) "0" time opacity was then subtracted from coumn three (3) to give us net opacity. See attachment B, column 4.

7. Items one (1) thru six (6) were then repeated fifteen times.

The enginemen recorded the exhaust stack temperature, cylinder head temperatures, water temperature, the kilowatts, voltage and cycles for each test.

After all readings were recorded and entered into our computer, we determined the mean opacity of the fifteen tests. We then discarded the readings furthest from the mean in each direction (high and low). The remaining thirteen readings were then averaged to get the average net opacity percentage. See attachment B. In the comment section we also noted the color of stack smoke, exhaust stack temperature and average engine stabilization time in seconds.

The diesel fuel was supplied by General Petroleum with low sulfer content, cetane 40 and a flash point of 150°. The Omstar D1280X additive was added to each barrel of fuel in the appropriate amount under the supervision of C.E.E. manager, Larry Swiencki. The fuel was then pumped into the ship's fuel tanks, after the baseline tests were conducted.

The Opacity Test Summary Sheet (Attachment C) shows the percent reduction from baseline of the stabilized load capacity (55%), the five minute net opacity (63%), the recovery time (74%) and the exhaust temperature (46%).

The Opacity Test Summary Graph (Attachment D) shows the percent reductions of the net opacity readings.

The engine Temperature Profile (Attachment F) shows the average engine temperatures per test in graph form.

California Environmental Engineering's test results indicate that the Omstar D1280X fuel additive does reduce smoke, which in theory indicates a reduction in particulates. During our tests we also noticed that the head and exhaust stack tempreatures were reduced. We feel that this reduction in theory means a better fuel burn and possibly a reduction of (NOx) oxides of nitrogen. The engine recovery time was reduced from six (6) seconds to one point five eight (1.58) seconds. This indicates that the engine had less friction internally, therefore producing more usable horsepower. These conclusions can be drawn in theory only. C.E.E. feels that a more comprehensive analytical test, measuring Carbon Monoxide (CO), Oxides of Nitrogen (NOx), Hydrocarbons (HC), Sulfer Dioxide (SO_2), and Particulates would benefit all concerned in determining the acutal emission reductions caused by the Omstar D1280X fuel additive. C.E.E. feels that any product or device that aids in reducing emission levels in the Port of Los Angeles and South Coast Air Basin needs to be explored in an effort to clean up the air quality and meet the Federal attainment standards required by the Federal Government. If there are any questions please call Larry Swiencki at (714) 630-8555.

Sincerely,

Larry Swiencki

Larry Swiencki
Manager
California Environmental Engineering

LS/tg

GL Emission Consulting

July 25, 1989

Overview of Opacity Testing and Observations of the Auxiliary Engine of the vessel "Condor".

1. Test Engine condtion and Pre-Baseline obervations.
2. Observations since introduction of test additive.

A. Overall engine performance was considered normal in all respects. No short or long term problems were logged or noted by the ship's machinists as to engine maintenance or repair. The test Auxiliary Engine was reported to have approximately 700 logged hours of operation at the start of the test procedure. This is considered to be relatively low usage for an engine of its type and usage.

B. The Auxiliary engine Exhaust stack interior had seemingly normal to slightly heavy oily carbon and heavy particulate accumulation. This condition is consistent with most stationary type power plants. Engines of the type are normally operated at a constant R.P.M. level. Under such conditions heavy oily carbon and particulate accumulates in the exhaust stack and interior. Other types of diesel engines such as diesel trucks and other vehicles operate at varying R.P.M. levels which aid in the removal of accumulation in the exhaust system. This is due to a variety of vibration frequencies brought on by the acceleration and deceleration of these engines. Also, dramatic changes in the amount of Exhaust gases at greater pressures than that of the stationary engine, aid in the self cleaning of the exhaust systems.

*** One very serious point should be made at this time. ***

Heavily ladened exhaust stacks are very susceptible to what is known as "Stack Fires." This condition is very dangerous and <u>almost impossible</u> to predict under normal operation. To predict such an occurrence requires constant monitoring of the engine exhaust temperature and spot analysis of the accumulants in the exhaust stack. If a moderate to heavy oily accumulation of residue is present in the stack and exhaust <u>temperature</u> is adequate to cause combustion, stack fire is quite possible. Most commonly the combustion is caused by a hot glowing ember of heavy particulate matter that has dislogged from the exhaust manifold. This glowing ember then proceeds up the exhaust stack and ignites the accumulated particulate matter present in the stack interior. Diesel engine exhaust does have an adequate amount of oxygen to feed a hydrocarbon fueled fire.

These types of fires are very well know and feared by ship's crews and ship owners.

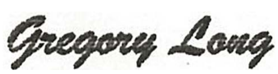
SUMMARY:

Points of interest:

*1. Lower smoke opacity readings (smoke emissions)
2. Reduction of stack interior accumulation.
*3. Reduced Hazard of stack fires.
4. Reduced fuel consumption.
*5. Safer and more economical operation.
*6. Cleaner Exhaust Emissions and Safer Health Environment.

In general all of the observations listed above translate into a marked improvement in several areas. Those items marked with an asterisk are considered to be of Extreme importance. Obviously the other items are very beneficial, but of extreme importance at this time are those which improve Health and Safety.

Further and more analytical testing of the product tested would surely reveal more information on benefit and it's possible regular use to aid in the fight for cleaner air and better health.



Gregory Long
GL Consulting

2.)

A. From the 2nd Opacity test and subsequent tests with the test additive, revealed a marked reduction in visible particulate emissions. Also, the particulate accumulation in the exhaust stack was notably less oily, almost powder dry. This would reflect that less oil and hydrocarbons are present in the exhaust. With less oil and hydrocarbons in the stack, a far less chance of stack fire obvious.
At each test procedure during the pre-test inspection, it was evident that a marked amount of the prior residue had been removed since the original baseline test. This condition could only be due to a cleaning action since the introduction of the additive.

B. Starting with the first test after the blending of the additive in the fuel system, a dramatic lowering of exhaust gas temperatures was noted.

Normally this condition would be associated with a overly rich running engine. But, under this condition the exhaust would be heavily laden with black oily particulates. Since the exhaust did not exhibit this, further examination was needed.

During the exam, it was noted that not only did the exhaust not show evidence of over richness, but to the contrary. The logs had showed a substantial decrease in fuel consumption since the additive introduction. In fact, a 1-1.5 gallon per hour reduction in fuel consumption ws observed.

The other interesting observation was that the exhaust gases had an abundance of H_2O. This would possibly explain the self cleaning of the stack interior and the lowering of the stack temperature.

C. Without other analytical instruments to measure engine performance it would be somewhat difficult to substantiate what seemed to be an increase in engine performance. This observation is based on the load recovery time associated with the load cycles during the testing procedure. The engine recovered from an instantaneous load at ever decreasing intervals since the introduction of the additive after the baseline test. Basically the load recovery time at the basceline test was approximately 6 seconds. By the end of the last test the load recovery was well under 2 seconds. This would translate into an increase in the power output of the test engine.

ATTACHMENT A
EXHAUST SMOKE OPACITY DATA

VESSEL CONTACT: Pat Fair — NAME OF VESSEL: Motor Vessel Condor
FUEL USED: Diesel #2 low sulf. — OWNED BY: Sun Viking Holdings Corp, E.A.
Cetane: 40 Flash Pt.: 150 deg F. — USED: Envir. Research — YR SHIP BUILT: 1944
FUEL SUPPLIER: Gen. Petroleum — AUX. ENGINE MAKE: GMC — REBUILT:
GRT (tons): 880.55 LGTH: 220 ft. — Aux #1 (xxx) #2 ( ) RATED HORSEPOWER:
FILTER CHANGES BEFORE BASELINE TESTS: (x) OIL (x) FUEL

GENERATOR LOAD INFORMATION

	RPM	KW	VOLTAGE	CYCLE/SEC
Cond. 1 (init. load):	1200	40	450	60
Cond. 2 (full load):	1200	55	450	60

Record "1" for initial load. Record "2" for load added during test.

LOAD:
- (1) Engine room blowers -- exhaust
- (1) Engine room blowers -- intake
- (1) Shipboard domestic lights
- (1) Interior light/appliance circuit
- (-) Refrigerator
- (-) Galley equipment
- (1) Hot water heater
- (2) Welder & Air Compressors

TEST PROCEDURE: Record peak opacity when loads "2" are added suddenly.

BASELINE TESTS: BEFORE USE OF CONDITIONER

TOTAL 15 TESTS: 699
MEAN OF 15 TESTS: 46.6

TEST DATE	METER H	PEAK OPACITY 1	2	3	4	5	AVERAGE OF 13 TESTS	INITIALS
6/30/89	700							
Calculate mean of 15 tests.		~~72~~	52	44	40	44	45.5	TESTER: L.
~~Delete 2 furthest from the~~		39	~~36~~	39	44	44	(nearest 10th)	OBSERVER: D. Allen
mean by a		47	45	49	49	55		

DATA ON CONDITIONER & TEST

CONDITIONER USED: OMSTAR DIESEL FUEL CONDITIONER — USED BEGINNING: 6-30 1989
DOSAGE RATE: 1:640 thru Test Series 2 & 3, then 1:1280
TEST EQPMT: Wagner Model 650 Smoke Opacity Meter

AFTER USE OF FUEL CONDITIONER

TEST DATE	METER HOURS	PEAK OPACITY 1	2	3	4	5	AVERAGE OF 13 TESTS	CHANGE FROM BASELINE NUMBER	PERCENT	INITIALS
7/5/89	761									
Test Series 2		32	~~35~~	30	31	29	28.8	16.7	36.7%	LPS
Since BASELINE: *		29	28	28	29	26	(nearest 10th)			DA
Days: 5	Hrs: 61	26	30	28	28	~~24~~				
Tot. 15: 431	Mean: 28.7									

TEST DATE	METER HOURS	PEAK OPACITY 1	2	3	4	5	AVERAGE OF 13 TESTS	CHANGE FROM BASELINE NUMBER	PERCENT	INITIALS
7/10/89	804									
Test Series 3		36	~~41~~	36	31	23	24.5	21	46.2%	LPS
Since BASELINE: *		19	22	28	22	19	(nearest 10th)			DA
Days: 10	Hrs: 104	22	20	21	~~16~~	19				
Tot. 15: 377	Mean: 25.1									

TEST DATE	METER HOURS	PEAK OPACITY 1	2	3	4	5	AVERAGE OF 13 TESTS	CHANGE FROM BASELINE NUMBER	PERCENT	INITIALS
7/15/89	864									
Test Series 4		~~35~~	22	28	24	21	23.9	21.6	53.0%	LPS
Since BASELINE: *		23	25	27	24	24	(nearest 10th)			DA
Days: 15	Hrs: 164	~~21~~	23	23	24	23				
Tot. 15: 365	Mean: 24.3									

TEST DATE	METER HOURS	PEAK OPACITY 1	2	3	4	5	AVERAGE OF 13 TESTS	CHANGE FROM BASELINE NUMBER	PERCENT	INITIALS
7/20/89	921.5									
Test Series 5		~~26~~	19	18	~~15~~	18	17	28.5	62.6%	LPS
Since BASELINE: *		21	18	16	21	14	(nearest 10th)			DA
Days: 20	Hrs: 221.5	15	17	15	14	15				
Tot. 15: 258	Mean: 17.0									

TEST TECHNICIAN: — 7/26/89 — SUPERVISOR/MONITOR:
SIGNATURE: Greg Long — SIGNATURE: Larry Swi...
NAME: GREG LONG ORGN: Emission Consultant — NAME: LARRY SWIENCKI ORGN: C.E.E.

* Cumulative operating days and cumulative operating hours since BASELINE.

ATTACHMENT B - Test 1

CONDOR OPACITY TEST #1 (AUX. ENGINE)

BASELINE OPACITY READINGS 6/30/89

	"0" OP %	LOAD OP %	"5 MIN" OP %	**************	NET OP %
1	5.0	13.0	77.0		72.0
2	11.0	15.0	63.0		52.0
3	9.0	14.0	53.0		44.0
4	5.0	9.0	45.0		40.0
5	7.0	11.0	51.0		44.0
6	3.0	6.0	42.0		39.0
7	9.0	13.0	45.0		36.0
8	11.0	14.0	50.0		39.0
9	10.0	14.0	54.0		44.0
10	8.0	14.0	52.0		44.0
11	5.0	10.0	52.0		47.0
12	6.0	11.0	51.0		45.0
13	9.0	14.0	58.0		49.0
14	10.0	15.0	59.0		49.0
15	5.0	10.0	60.0		55.0
					699.0
AVERAGE %	7.5	12.2	54.1		

MEAN OPACITY	46.6
MIN OP	36.0
MAX OP	72.0
AVERAGE NET	45.5

COMMENTS: SMOKE WAS MEDIUM GREY TO LT. BLACK
EXHAUST TEMP.: 360° F
AVERAGE ENGINE STABILIZATION AFTER LOAD: 6.0 SEC.

ATTACHMENT B - Test 3

CONDOR OPACITY TEST #3 (AUX. ENGINE)

BASELINE OPACITY READINGS 7/10/89 WITH ADDITIVE

	"0" OP %	LOAD OP %	"5 MIN" OP %	**************	NET OP %
1	10.0	12.0	46.0		36.0
2	0.0	2.0	41.0		41.0
3	8.0	10.0	44.0		36.0
4	13.0	17.0	44.0		31.0
5	11.0	13.0	34.0		23.0
6	11.0	13.0	30.0		19.0
7	11.0	14.0	33.0		22.0
8	8.0	10.0	36.0		28.0
9	11.0	13.0	33.0		22.0
10	12.0	14.0	31.0		19.0
11	12.0	14.0	34.0		22.0
12	11.0	13.0	31.0		20.0
13	13.0	15.0	34.0		21.0
14	13.0	15.0	31.0		18.0
15	14.0	16.0	33.0		19.0
					377.0
AVERAGE %	10.5	12.7	35.7		

MEAN OPACITY	25.1
MIN OP	18.0
MAX OP	41.0
AVERAGE NET	24.5

COMMENTS: SMOKE COLOR: LIGHT GREY TO WHITE
ENGINE LOAD RECOVERY TIME: 2.41 - 2.8 SEC.
EXHAUST TEMP.: 200° F CYLINDER HEAD TEMP.: 175°F

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ATTACHMENT B - Test 4

CONDOR OPACITY TEST #4 (AUX. ENGINE)

BASELINE OPACITY READINGS 7/15/89 WITH ADDITIVE

	"0" OP %	LOAD OP %	"5 MIN" OP %	**************	NET OP %
1	12.0	15.0	45.0		33.0
2	8.0	11.0	30.0		22.0
3	4.0	6.0	32.0		28.0
4	6.0	8.0	30.0		24.0
5	6.0	8.0	27.0		21.0
6	7.0	9.0	30.0		23.0
7	8.0	10.0	33.0		25.0
8	7.0	9.0	34.0		27.0
9	6.0	8.0	30.0		24.0
10	7.0	9.0	31.0		24.0
11	10.0	12.0	31.0		21.0
12	8.0	9.0	31.0		23.0
13	6.0	8.0	29.0		23.0
14	5.0	7.0	29.0		24.0
15	5.0	6.0	28.0		23.0
					365.0
AVERAGE %	7.0	9.0	31.3		
				MEAN OPACITY	24.3
				MIN OP	21.0
				MAX OP	33.0
				AVERAGE NET	23.9

COMMENTS: SMOKE COLOR: LIGHT GREY TO WHITE
ENGINE LOAD RECOVERY TIME: 1.52 - 1.9 SEC.
EXHAUST TEMP.: 195° F CYLINDER HEAD TEMP.: 170°F
WIND SPEED APPROX. 8 M.P.H.

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ATTACHMENT B - Test 5

CONDOR OPACITY TEST #5 (AUX. ENGINE)

BASELINE OPACITY READINGS 7/20/89 WITH ADDITIVE

	"0" OP %	LOAD OP %	"5 MIN" OP %	**************	NET OP %
1	4.0	6.0	28.0		24.0
2	7.0	9.0	26.0		19.0
3	4.0	7.0	22.0		18.0
4	11.0	13.0	24.0		13.0
5	6.0	8.0	24.0		18.0
6	5.0	8.0	26.0		21.0
7	5.0	7.0	23.0		18.0
8	8.0	10.0	24.0		16.0
9	6.0	8.0	27.0		21.0
10	8.0	10.0	22.0		14.0
11	9.0	11.0	24.0		15.0
12	5.0	7.0	22.0		17.0
13	7.0	9.0	22.0		15.0
14	7.0	9.0	21.0		14.0
15	8.0	10.0	23.0		15.0
					258.0
AVERAGE %	6.7	8.8	23.9		
				MEAN OPACITY	17.2
				MIN OP	13.0
				MAX OP	24.0
				AVERAGE NET	17.0

COMMENTS: SMOKE COLOR: LIGHT GREY TO WHITE
ENGINE LOAD RECOVERY TIME: 1.55 - 1.6 SEC.
EXHAUST TEMP.: 195° F CYLINDER HEAD TEMP.: 170°F
WIND SPEED APPROX. 10 M.P.H.

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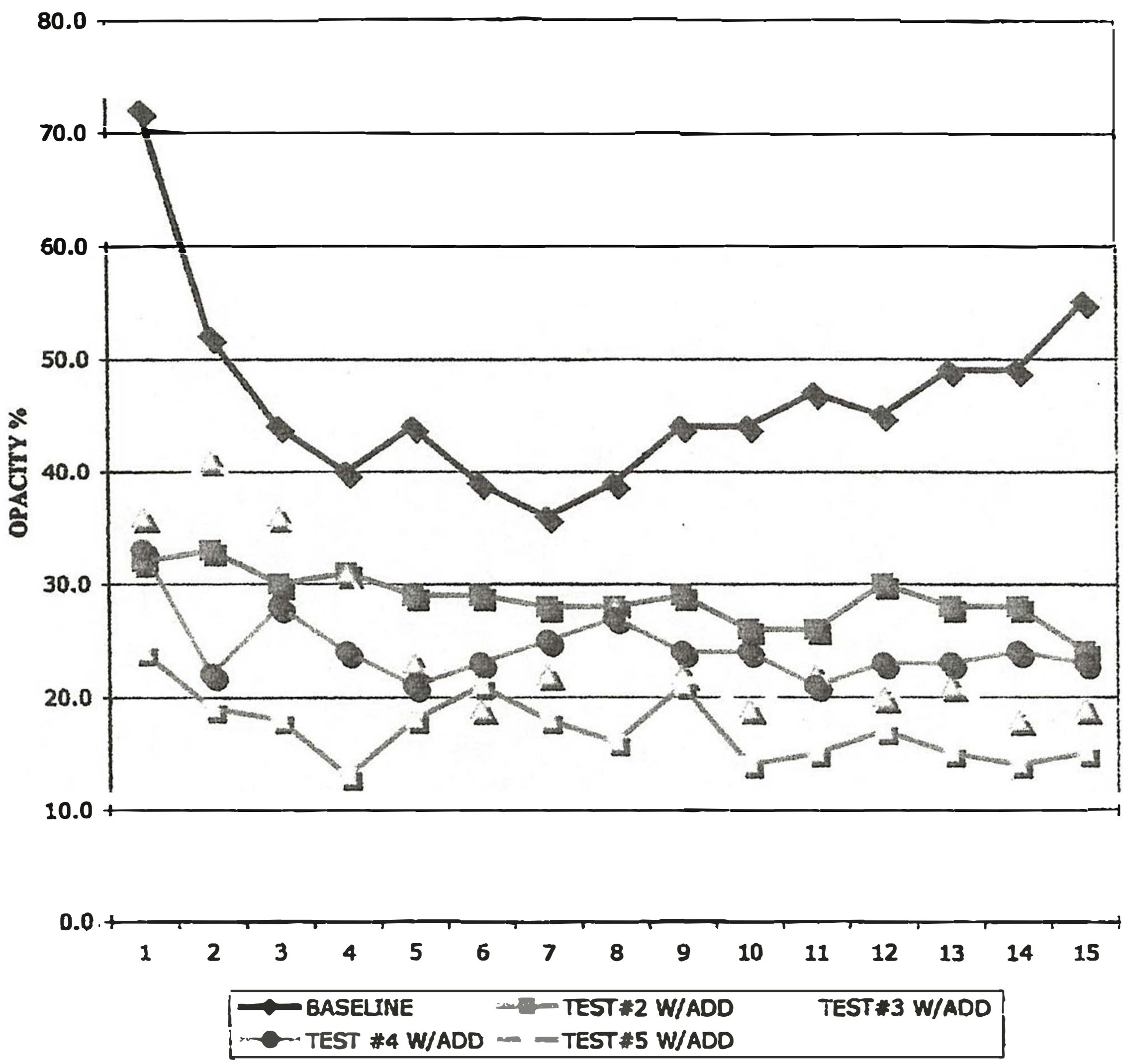
<u>ATTACHMENT D</u>

OPACITY TEST SUMMARY GRAPH

PERCENTAGE OF OPACITY NETS



<u>ATTACHMENT F</u>

ENGINE TEMPERATURE PROFILE

AVERAGE ENGINE TEMPERATURES PER TEST