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EFFECTS OF ENVIROFUELS DFC ON A LAND DRILLING RIG

Oil and Gas Land Drilling Rig

PUBLIC VERSION

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PATENTED TECHNOLOGY » PROVEN RESULTS » PAYBACK

EXECUTIVE SUMMARY

The application of EnviroFuels DFC (Diesel Fuel Catalyzer) to a land drilling rig that is owned by an international contract drilling company (Drilling Company) showed an increase in fuel economy and a reduction in harmful combustion emissions after five months of treatment with EnviroFuels DFC.

The fuel economy of the test engine of the drilling rig improved 6.7 percent. The field test also showed that EnviroFuels DFC was able to restore the test engine to its original rated power output. The results of the fuel and power test are summarized in Table 1.

The field test results showed that the introduction of EnviroFuels DFC into the rig's fuel stream reduced emissions of nitrogen oxides (NOx) by 11 percent, unburned hydrocarbons (UBHC) by 82 percent, and carbon monoxide (CO) by 56 percent. The results of the emissions test are summarized in Table 2.

Test Engine

Rig 412 is a land-based drilling rig owned by an international contract drilling company. Details of the test engine are summarized below:

Engine manufacturer:	Caterpillar
Model:	D399
Original manufacturer year:	1966
Hours since rebuild:	4,000

Test Procedure Summary

The drilling company provided *Rig 412* and access to the drilling site near the Dallas-Fort Worth, Texas area. EnviroFuels provided and installed AW positive displacement flow meters to measure the fuel consumed by the test engine on the rig. Warren CAT provided a 1,000-kilowatt Simplex load bank that was connected to the test engine to provide a constant load so that fuel and emissions data could be recorded while the test engine operated at a steady-state. WJ Consulting provided equipment and personnel to record emissions data.

The baseline test evaluation consisted of a 1-hour test and a 20-minute test and was conducted on May 17, 2005. After recording baseline readings, the fuel on *Rig 412* was treated with EnviroFuels DFC at a ratio of 1:625 (double-treat rate) for approximately four weeks and 1:1,250 (single-treat rate) for the remainder of the evaluation. Several interim tests were conducted after the baseline test to determine when the test engine became "fully treated" with EnviroFuels DFC. The performance changes were calculated by comparing the baseline results from May 17, 2005 to the treated performance test conducted on October 11, 2005.

Figure 1: Effect of EnviroFuels DFC on Fuel Economy

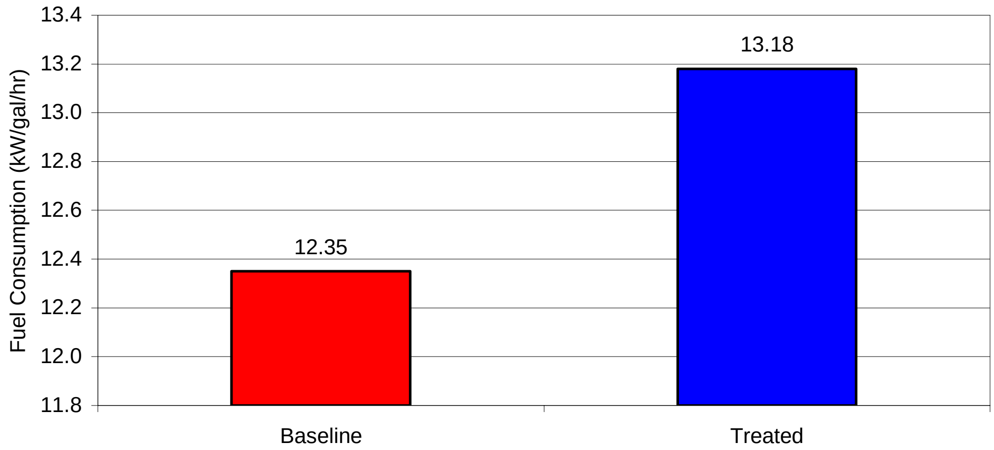

Table 1: Summary of Fuel Testing Results

	Baseline Test	Final Test	Percent Change
Test Information:			
Date	5/17/2005	10/11/2005	
Test duration	0:50:05	1:30:12	
Power Output:			
Percent power output	97%	95%	-2.1%
Power, kW	776	760	-2.1%
Fuel Consumption Data:			
Mean, gal/hr	62.8	57.7	-8.2%
Minimum, gal/hr	62.0	57.3	
Maximum, gal/hr	63.4	57.9	
Standard deviation	0.59	0.17	
Stdev/Mean	0.9%	0.3%	
Power Corrected Fuel Consumption:			
kW/gal/hr	12.35	13.18	6.7%

Figure 2: Effect of EnviroFuels DFC on Combustion Emissions

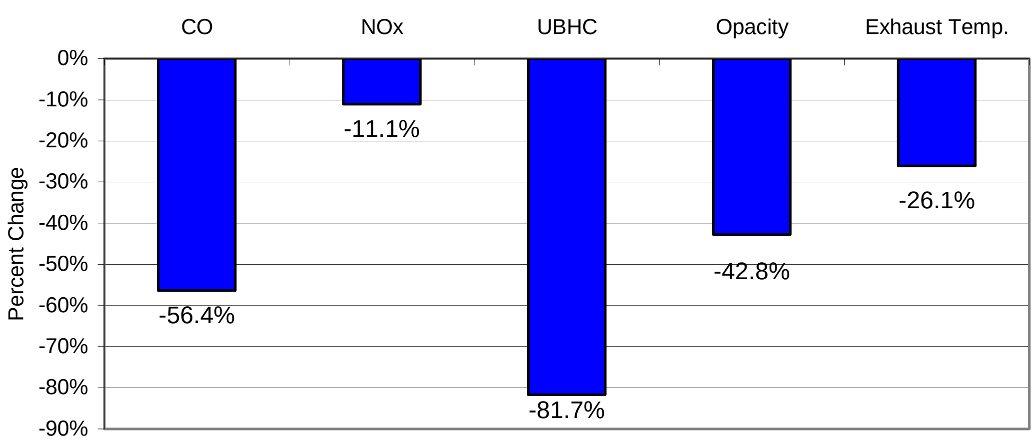

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Table 2: Emissions Test Results

Average Emissions from Emissions Monitoring Device:

Test	CO (ppm)	NOx (ppm)	UBHC (ppm)	Opacity (%)	Tgas (deg. F)	Tamb (deg. F)
Baseline	417.9	1,066.6	0.718	6.1	912.3	79.8
Final	182.4	948.7	0.131	3.5	674.2	73.3
Percent Change	-56.4%	-11.1%	-81.7%	-42.8%	-26.1%	-8.2%

Calculated Mass Emission Rates (grams per hour):

Test	CO	NOx	UBHC	Opacity	Tgas	Tamb
Baseline, g/hr	1,796	7,532	8.72			
Final, g/hr	751	6,414	1.53			
Percent Change	-58.2%	-14.8%	-82.5%			

Calculated Mass Emission Rates (grams per kilowatt-hour):

Test	CO	NOx	UBHC	Opacity	Tgas	Tamb
Baseline, g/kW-hr	2.31	9.71	0.0112			
Final, g/kW-hr	0.99	8.44	0.0020			
Percent Change	-57.3%	-13.1%	-82.1%			

INTRODUCTION

EnviroFuels, LLC (EnviroFuels) manufactures and markets EnviroFuels DFC (Diesel Fuel Catalyzer), a patented fuel-borne technology that reduces harmful combustion emissions while simultaneously increasing engine performance. EnviroFuels DFC reduces friction and generates more work in the combustion chamber of diesel engines. The combination of friction reduction and increased heat release results in significant improvements in fuel consumption and reductions in harmful combustion emissions.

In 2005, Drilling Company and EnviroFuels tested the ability of EnviroFuels DFC to improve fuel economy and reduce environmentally harmful combustion emissions, including nitrogen oxide, on a land drilling rig.

The drilling company owns over 500 land drilling rigs throughout the United States and Canada. Each drilling rig is powered by multiple diesel-fueled generator-sets (gen-sets) that, together, are capable of producing over 3,000 horsepower (hp) and 2,400 kilowatts (kW). To produce said power in drilling applications, each rig may consume over 1,500 gallons of diesel fuel per day.

The drilling company owns a large percentage of its rigs in east Texas and California. Both of these areas are considered non-attainment areas for ambient air concentrations of ozone.

Due to the presence of nitrogen gas in the atmosphere, nitrogen oxide emissions are a naturally occurring by-product of the combustion process. Nitrogen oxides are known to be a contributing factor in the generation of tropospheric ozone. The operations of nitrogen oxide emitters in non-attainment areas have become increasingly regulated by environmental regulatory agencies in an effort to reduce ambient ozone concentrations.

ENGINE SPECIFICATIONS

Rig 412 was selected by the drilling company as the test unit for the field test. *Rig 412* is powered by three Caterpillar D399 gen-sets. While each engine was treated with EnviroFuels DFC, only one engine was performance tested during the field test. The drilling company and EnviroFuels believed the selected test engine would be representative of similar engines that are in operation for the drilling company.

The particular engine that was used for the test was originally manufactured by Caterpillar in 1966. *Rig 412* operates in the Dallas-Fort Worth, Texas area. The D399 engine has a maximum sustained power output rating of 1,100-hp and 800-kW, per the original equipment manufacturer. The Caterpillar engines of *Rig 412* are shown in Figure 3.

Figure 3: Three Caterpillar D399 Engines on *Rig 412*

TEST PROCEDURE

The drilling rig was operated offline and at a steady-state operating level to ensure the performance changes due to EnviroFuels DFC could be isolated.

In developing a test protocol for the drilling rig field test, significant effort was taken to ensure that the test procedure was thorough and consistent. The test protocol utilized during the test is described below. The emissions and power output from the test engine were measured by independent third-party operators. These vendors authenticated and reviewed the emissions and power data. Additionally, the test results were reviewed by both EnviroFuels and the drilling company's personnel.

The test rig was an operational land drilling rig that was under contract to an exploration and production company. Testing could only be conducted when the rig was not drilling, approximately every 22 days. The operating schedule of the rig was considered for scheduling of testing.

The drilling rig field test consisted of four separate phases. The phases of the test were as follows:

1. Setup;
2. Baseline testing;
3. Conditioning; and
4. Treated testing.

Setup:
The drilling company selected *Rig 412* for this test and provide access to the rig throughout the duration of the test. Of the rig's three engines, Engine 1 was selected as the test engine for this test. For the results to be as consistent as possible, with the exception of the addition of EnviroFuels DFC to the fuel stream, the same test engine was used throughout the test.

To measure fuel consumption during the tests, fuel meters were installed on the test engine. Two AW positive flow displacement fuel meters were installed on the engine by EnviroFuels personnel. One fuel meter measured the fuel flow of the fuel supply line while the second meter measured the flow from the fuel return line. The difference between the two fuel meters provides the fuel consumption of the engine.

Because the performance tests were conducted while the rig was not engaged in drilling, a resistive load bank was utilized to simulate the effects of operating the engine under loaded conditions. Warren CAT provided a 1,000-kW Simplex load bank to provide the resistive force for the engine. During each performance test, the Warren CAT operator ensured that the load bank was properly connected to the test engine. The load cell provided a constant load on the engine so that fuel consumption and emissions data could be averaged over a period of time while the engine was operating at steady-state.

Warren CAT is an authorized Caterpillar factory dealer and service provider that owns, maintains, and operates the load cells used in the drilling rig evaluation. Warren CAT is an authorized maintenance provider for Caterpillar engines. The Warren CAT load cell used for the field test is displayed in Figure 4.

Figure 4: Warren CAT Load Cell

Emissions data was measured using an emissions analyzer. The emissions analyzing equipment is owned, maintained, calibrated, and operated by WJ Consulting. In preparation for a performance test, the emissions analyzer probes were placed in the exhaust flow of the engine to measure emissions concentrations.

Baseline Testing:
The baseline performance test was conducted on May 17, 2005. Once the load cell was connected to the engine, the test engine was started. After the engine was started, the fuel meters, emissions analyzer, and power meter on the load cell were checked to ensure that the data gathering equipment were operating correctly.

After the engine and load cell completed their warm-up cycles, the load cell applied a constant level of resistance to the engine. The engine subsequently reached a steady-state operating level where the engine produced an output near its maximum capacity. The intent of the field test was to determine the performance characteristics of the test engine at near-maximum operating conditions.

The baseline test occurred over a 50-minute interval. During this test interval, the following test parameters were recorded (event recording time intervals are presented in parenthesis):

Emissions Data (15-seconds interval):
- Carbon monoxide concentration
- Nitrogen oxides concentration
- Carbon dioxide concentration
- Opacity
- Ambient air temperature
- Exhaust gas temperature
- Unburned hydrocarbon concentration

Fuel Consumption (2-minute intervals):

- Total fuel consumption during test
- Hourly fuel consumption rate

Power (15-minutes interval):

- Volts
- Amps
- Kilowatts
- RPM
- Hertz
- Oil pressure
- Water temperature

Conditioning:
After the baseline test was completed, the test engine was treated with EnviroFuels DFC. The fuel supply of *Rig 412* was treated with EnviroFuels DFC at a ratio of 1 gallon of EnviroFuels DFC to 1,250 gallons of diesel fuel (1:1,250). The first treatment date was May 18, 2005. EnviroFuels and the drilling company arranged for the rig to receive treated fuel through the drilling company's fuel distributor. After the initial dosing, the fuel distributor treated the rig's fuel supply at the distributor's facility.

Several interim performance tests were performed on the test engine to determine when the engine became fully-treated.

Treated Testing:
Treated testing on the test engine of *Rig 412* occurred on October 11, 2005. The test procedure that was utilized for the baseline test was duplicated for the treated test.

Engine performance may vary along the engine's power curve. In order to correct for potential performance differences of the engine at varying operating level, the resistive load bank applied a similar level of resistance (within approximately two percent of the baseline test) to the engine to ensure that the performance of the engine would be similar to that of the baseline test.

Test data similar to the baseline test was captured during the treated test. After the data was collected, the baseline and treated test data were compared. The test data is summarized below.

On January 22, 2006 a second treated test was conducted to determine if the addition of EnviroFuels DFC enabled the test engine to reach a higher maximum power output.

RESULTS
The baseline and treated test data were reviewed for changes in fuel economy, emissions, and power generation.

The drilling rig evaluation spanned a period of five months due to problems with proper fuel treatment with EnviroFuels DFC. During the first few months after treatment was initiated on the rig, fuel samples showed the fuel was not being treated with EnviroFuels DFC. EnviroFuels and the drilling company contracted the fuel distributor to deliver treated fuel to the rig. Final testing of the rig occurred after the fueler began delivering treated fuel.

EnviroFuels reviewed baseline and treated data for slight differences in operating conditions between the baseline and treated tests. Such corrections may be necessary to isolate the effects of EnviroFuels DFC from potential environmental affects.

Temperature Correction:
Ambient air temperature can affect an engine's performance. In general, as the ambient air temperature increases, an engine can lose efficiency, measured as the amount of energy generated per amount of fuel that is consumed in the combustion process. Furthermore, an engine will display a greater difference in performance as the difference in temperature increases. While there are additional outside environmental factors that may affect an engine's performance, EnviroFuels and the drilling company were primarily concerned with the potential effects of temperature on engine performance during the field test.

EnviroFuels measured the ambient air temperatures during each test to assess the potential need to correct for temperature effects on engine performance. The average ambient air temperature during the baseline and treated tests were 79.8 and 73.3 degrees Fahrenheit, respectively. The temperature differential between the two tests of 5.5 degrees causes less than 0.5 percent change in operating efficiency of the engine and was considered to be insignificant to the evaluation. EnviroFuels believes that corrections for power output and fuel consumption were not warranted in this case due to similar test conditions between the baseline and treated tests.

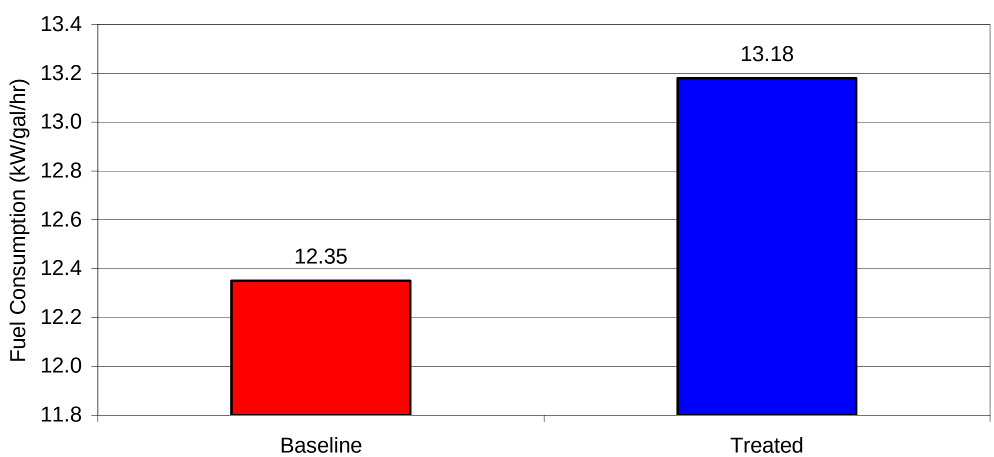
The portable emissions equipment corrects for ambient conditions including temperature and relative humidity.

Fuel Economy Results:
To further isolate the effects of EnviroFuels DFC on the rate of fuel consumption of the test engine, the fuel consumption data was examined only after the data was corrected for the different power output levels during the baseline and treated tests. Under baseline conditions, the test engine produced 12.35 kilowatts per gallon of fuel per hour. The treated engine produced 13.18 kilowatts per gallon of fuel per hour. This change constitutes a 6.7 percent increase in fuel economy after the data was corrected for power output levels. A summary of the power and fuel results are provided below.

Table 3: Fuel Economy Data

	Baseline Test	Final Test	Percent Change
Test Information:			
Date	5/17/2005	10/11/2005	
Test duration	0:50:05	1:30:12	
Power Output:			
Percent power output	97%	95%	-2.1%
Power, kW	776	760	-2.1%
Fuel Consumption Data:			
Mean, gal/hr	62.8	57.7	-8.2%
Minimum, gal/hr	62.0	57.3	
Maximum, gal/hr	63.4	57.9	
Standard deviation	0.59	0.17	
Stdev/Mean	0.9%	0.3%	
Power Corrected Fuel Consumption:			
kW/gal/hr	12.35	13.18	6.7%

Figure 5: Effect of EnviroFuels DFC on Fuel Economy



The two percent differential in load between the baseline and treated test for the rig was because two different load cells were used. The load cells differed slightly in the increments of load available. The load cell applied a constant load to the engine where the more resistance supplied by the load cell translated into more load applied to the engine.

During the power test on January 22, 2006 the test engine produced 954 kilowatts of power at the generator. This power output level represents an approximate 19 percent increase over the maximum rated sustained power level of the gen-set. This power data was recorded, verified, and reported by the Warren CAT operator.

Emissions Results:
The field test on *Rig 412* showed dramatic decreases in combustion emissions. Notably, the results showed the decreases in nitrogen oxide emissions of 11 percent and unburned hydrocarbons emissions of 82 percent.

Visible smoke, measured as opacity, also decreased. The percent change in opacity between the baseline and treated test was 43 percent.

Additionally, carbon monoxide emissions decreased by 56 percent. A decrease in carbon monoxide from the combustion process is a general indicator of more complete combustion.

The exhaust gas temperature also decreased during the treated test. The exhaust gas temperature was measured at 912 °F and 674 °F during the baseline and treated tests, respectively. The change in exhaust gas temperature is equal to a 26 percent decrease. Lower exhaust gas temperature may indicate that more heat from the combustion of the fuel is being converted into kinetic energy inside the combustion chamber, creating more work from a given amount of fuel.

Table 4: Emissions Test Results

Average Emissions from Emissions Monitoring Device:

Test	CO (ppm)	NOx (ppm)	UBHC (ppm)	Opacity (%)	Tgas (deg. F)	Tamb (deg. F)
Baseline	417.9	1,066.6	0.718	6.1	912.3	79.8
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Percent Change	-56.4%	-11.1%	-81.7%	-42.8%	-26.1%	-8.2%

Calculated Mass Emission Rates (grams per hour):

Test	CO	NOx	UBHC	Opacity	Tgas	Tamb
Baseline, g/hr	1,796	7,532	8.72			
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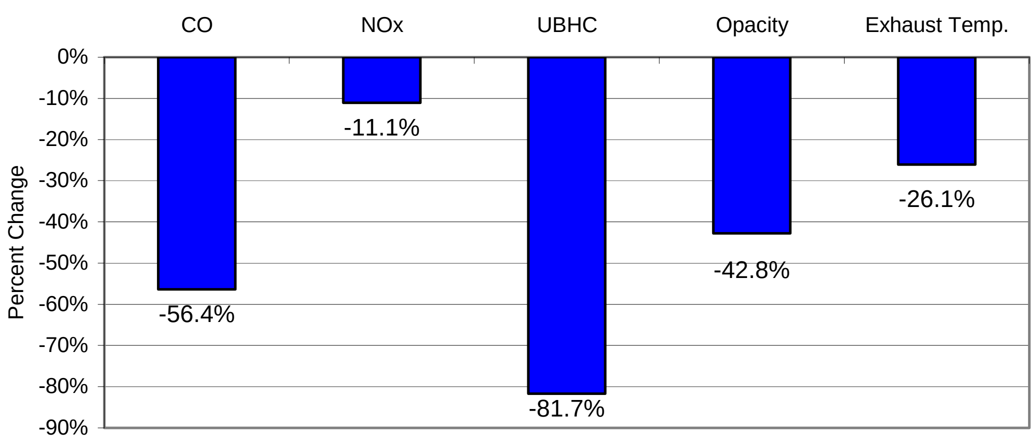
Percent Change	-58.2%	-14.8%	-82.5%			

Calculated Mass Emission Rates (grams per kilowatt-hour):

Test	CO	NOx	UBHC	Opacity	Tgas	Tamb
Baseline, g/kW-hr	2.31	9.71	0.0112			
Final, g/kW-hr	0.99	8.44	0.0020			
Percent Change	-57.3%	-13.1%	-82.1%			

Figure 5: Effect of EnviroFuels DFC on Emissions



SUMMARY

The field test conducted on *Rig 412* of the drilling company showed that the application of EnviroFuels DFC reduced harmful combustion emissions, improved fuel economy, and produced additional power. The field test showed fuel economy increased by 6.7 percent after fuel consumption was corrected for power output. Carbon monoxide emissions decreased 56 percent; nitrogen oxide emissions decreased 11 percent; and unburned hydrocarbon emissions decreased by 82 percent. At the same time the exhaust gas temperature of the test engine decreased by 26 percent. Finally, the test engine sustained a maximum power output level of 954 kilowatts or 19 percent more power than the manufacturer's rated sustained maximum power output.