Summary Report on Investigation
of
Improvements in Fuel Efficiency and Other Benefits Derived from Employing the Fitch Fuel Catalyst on Diesel Propulsion & Generator Engines
Prepared Nov., 2012

Introduction

In May, 2011 large commercial fishing company launched a comprehensive 18-month investigation of the potential benefits of utilizing the Fitch Fuel Catalyst. The primary benefit is reduced fuel cost related expense associated with operating its fleet of tuna seiners.

Background on the Fleet and Operations

Most of the company's tuna seiners operate from fishing ports in the South Pacific. The typical seiner is in the 200-foot (70meter) class with gross tonnage of 1500 to 2000 tons.

The vessels carry up to 200,000 gallons of fuel in up to 20 fuel tanks. The boats tend to make 4 or 5 lengthy 2 to 3 month trips with a crew of about 20 people operating under the Distant Water Tuna Fleet charter of the Jones Act.

The vessels in the current fleet, many having been built in the early 1980's are using mechanical 2 and 4-stroke engines (primarily EMD 16 and 18 cylinder models for propulsion and Caterpillar 3412's and D-353's for electrical and hydraulic power. On average, the typical boat consumes about 3,000 gallons of fuel per day (about 80,000 gallons per normal 2-month voyage).

Fitch Fuel Catalyst Background

The Fitch Fuel Catalyst (FFC) modifies the molecular composition of liquid hydrocarbon fuels such as diesel, fuel oil, bunker fuel, and gasoline permitting achievement of more complete and therefore more efficient combustion. Fitch Fuel Catalysts are manufactured by Advanced Power Systems Int'l., Inc.(APSI) of Torrington, CT. APSI holds U.S. and International patents for the product line Fitch models for commercial engines are sized by horsepower and peak total fuel flow. Models for heating oil applications enjoy United Laboratories rating (UL). Heavy-duty models enjoy American Bureau of Shipping certification

Brief Review of the Evaluation Program of the FFC for Fishing Vessels

After installing a Fitch heavy-duty model (FHD10-38-1.5) on the main EMD engine in May, 2011, the company sponsored three different evaluations to gauge the financial reward from implementing the Fitch device on all engines, fuel purifiers and support vessels. These evaluations include:

1) Field test on Caterpillar 3412 gen-set on a vessel in the South Pacific.
2) Water Brake dynamometer test on a Caterpillar 3412 propulsion engine at the Hawthorne Caterpillar dealer located in San Diego, CA.
3) Resistive/reactive load bank test on a Caterpillar 3406 powered 300 kilowatt gen-set at the Hawthorne Caterpillar dealer located in San Diego, CA.

Analysis of Results

Engine performance (horsepower and torque, responsiveness and noise) benefited from the presence of Fitch treatment. The ramp mode data(2 sets with FFC verses one baseline) clearly indicated significant fuel savings of nearly 20% compared to baseline numbers when data are normalized to horsepower and torque produced by the engine. Also, it is obvious from the comparison of the 4 sets of graphs of the ramp mode data that engine performed dramatically better with the FFC fuel. The engine reached much higher levels of torque and horsepower with the FFC treated fuel.

Fuel savings were significant and well documented in all three evaluations. Differences between results can be primarily attributed to differences in the quality of the fuel used in each project. In the field test onboard the ship; savings were in the range 8.5 to 12 % in part due to the quality of the fuel supplied. In Test 2) the dyno test in San Diego we procured aged fuel that had been in storage for at least 6 months. In Test 3) the load bank test, it was decided to use the current ULSD #2 fuel supplied from the dyno test cell's day tank. Even with this relatively high quality fuel, a significant economic benefit from employing the FFC (1/4gph) was apparent. With the normal fuel employed by the fleet in the South Pacific, the fuel savings and other benefits to emissions and engine performance will be substantially greater than this test measures. The combination of the series of three separate evaluation projects clearly supports this conclusion.

Analysis of Life Cycle Benefit

The Fitch in-line units like the model F150HDG used in the three demonstration projects have a 10,000 hour useful service life. The minimum savings rate of ¼ gph shown in the Test 3) load bank test over the range of zero to 300 kilowatts would equate to a fuel savings of 2,500 gallons. Because of difference in fuel quality between the test fuel and the actual fuel used on these engines in service on the vessels, this is a very conservative estimate of what the customer will actually experience.

The heavy-duty FHD canister models like the one installed on the main EMD engine on the ship also come with a 10,000 service life the catalyst core can be maintained and its service life extended by periodic rinsing with warm water and a mild detergent Replacement cores are available for those models when replacement becomes necessary.

Conclusions and Recommendations

The Fitch Fuel Catalyst has performed within the range of the manufacturer's representation and independent tests. The results are also in line with typical results experienced on similar equipment on a global scale. The Fitch technology provides an excellent return on investment. This improved fuel efficiency and better combustion will extend the operating range of each vessel and the maintenance interval.

Based upon the above referenced trio of complementary evaluations the company has decided to incorporate the Fitch Fuel Catalysts as part of standard equipment on all of their operating vessels.

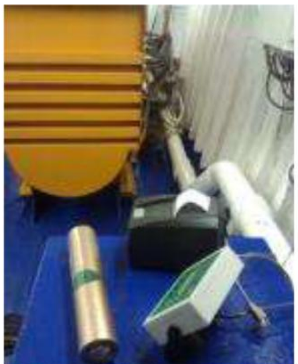
<u>**Ship Board Field Test**</u>

In July 2012 a test was conducted on a Caterpillar 3412 engine on board the ship while the vessel was docked for 2-weeks in Pago Pago unloading a large load of skipjack tuna caught in the waters off American Samoa.

The method used for measuring consumed fuel was a weigh scale with built-in time-stamp to weigh fuel drawn from a 55-gallon drum.

Fuel Measurements

The drum was filled with about 230-240 pounds of diesel drawn from the ship's 5836 gallon day tank. The scale was initialized and zeroed prior to mounting drum of fuel.



<u>Baseline Test</u>

The engine was started and brought up to operating temperature. The fuel was topped off and measurements commenced at 280 pounds scale weight (including drum and fuel supply assembly). Recordings of time and fuel weight were taken at approximately 5 pound intervals as displayed on the scale LCD indicator when a stable reading was established.

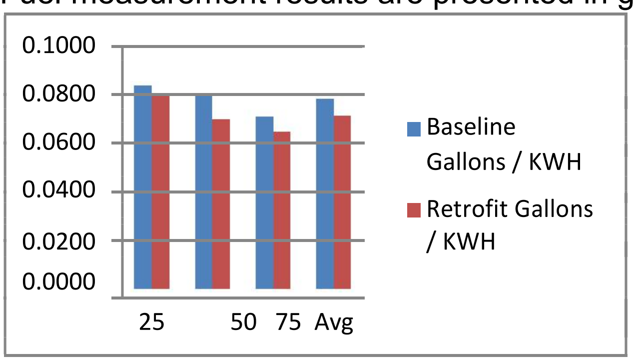
<u>Retrofit Test</u>

The drum was replenished with fuel up to 350 pounds (including drum and fuel supply assembly). The FFC was then connected into the engines fuel system

and after approximately 2 hour conditioning run until the fuel weight reached approximately 270 pounds.

The Fitch Fuel Catalyst (Model F150HDG) (left photo below) was mounted on the bulkhead opposite the engine injector pump in the fuel line after the Racor water separator as shown below(right photo).

Fuel measurement results are presented in graphical and tabular form below



Load Percentage	Baseline Gallons / KWH	Retrofit Gallons / KWH	% Change
25	0.0840	0.0797	-5.1%
50	0.0797	0.0698	-12.4%
75	0.0712	0.0648	-9.0%
Average	0.0783	0.0714	-8.8%

Dynamometer Test of Caterpillar 3412 Mechanical Engine

Rebuilt Caterpillar 3412-12-cylinder (~800 horsepower) mechanical diesel engine. Fitch Fuel Catalyst model F150HDG shown installed on engine frame in photo (to right of blue-colored dynamometer absorber). This model engine uses an in-line pump for fuel supply and nearly 100% of all fuel supplied to engine is consumed. This is in contrast to many other mechanical engines and all electronic engines in that there is virtually no unburned fuel returned to the supply tank. In order to attain full treatment of the fuel with the Fitch Fuel Catalyst, fuel was pre-circulated in one of the 55-gallon drums through the device for several hours prior to the engine test using a small transfer pump.

Test Facilities
Hawthorne Power Systems (Division of Hawthorne CAT) Dynamometer Facility, San Diego, CA

Test Equipment
A digital scale was used for measuring weight to nearest tenth of a pound and timer for measuring elapsed time to nearest second. e-Instruments™ Gas Analyzer was used for measurements of exhaust gases (O_2, CO and CO_2) and EGT temperatures inside the exhaust stack. A Super Flow 3100 water-brake engine dynamometer and WinDyn data monitoring and recording system provided engine performance parameters.

Purpose
Measure fuel consumption, engine stack temperatures, exhaust emissions, horsepower and torque with and without a Fitch Fuel Catalyst (FFC) in-line unit retrofitted to a diesel engine under comparable loads.

Description of Test Procedure
Fuel consumption was measured by change in weight of the fuel container for Baseline and Retrofit cycles. Fuel was supplied from 55-gallon drums filled with 6-month aged marine grade diesel fuel. The line to the suction side of the fuel pump and return line from the fuel rail were placed in 55-gallon drum placed on a weigh scale.

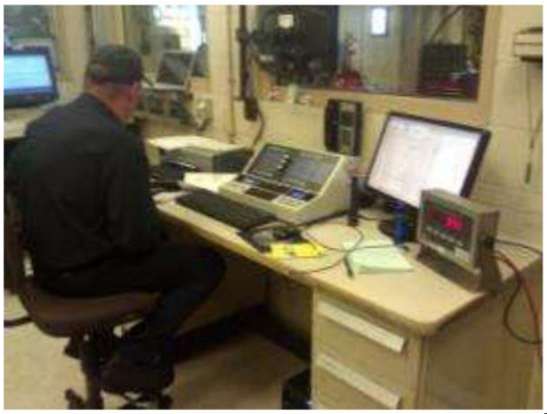
The Baseline test was conducted from one drum without Fitch treatment. The Retrofit test was conducted using fuel from the second 55-gallon drum that had been pre-circulated through the FFC

Test Protocol

The plan called for continuous ramp from zero to maximum load, transition mode testing and maximum load testing at 100%.

Baseline Test

The engine was started and brought up to operating temperature. Recordings of time and fuel weight were taken at approximately 5 pound intervals.



Retrofit Test

The drum of untreated fuel was removed from the scale platform and replaced with the drum of fuel that had been pre-circulated through the FFC for about 3 hours. The FFC was then connected into the engines fuel system. The engine was re-started and brought up to operating temperature before measurements commenced.

Fuel Measurements

Fuel measurement results are presented in graphical and tabular form below.

The dyno operator observed that the engine operated at a higher RPM with the FFC treated fuel and responded more easily to load changes than with the untreated fuel. This is borne out by the horsepower and torque data captured verses elapsed time shown below. The continuous ramp runs (baseline and retrofit) show substantial reduction in fuel consumption along with increased horsepower and torque.

Fuel consumption results are presented in relation to the horsepower and torque produced by the engine under various loads, the fuel weight consumption data was cross-referenced to the engine dyno data provided in the WinDyn data files. The Super Flow dyno monitors and displays continuous readings of all measured parameters; however, the WinDyn system samples and stores a digital record every 30 seconds of elapsed time.

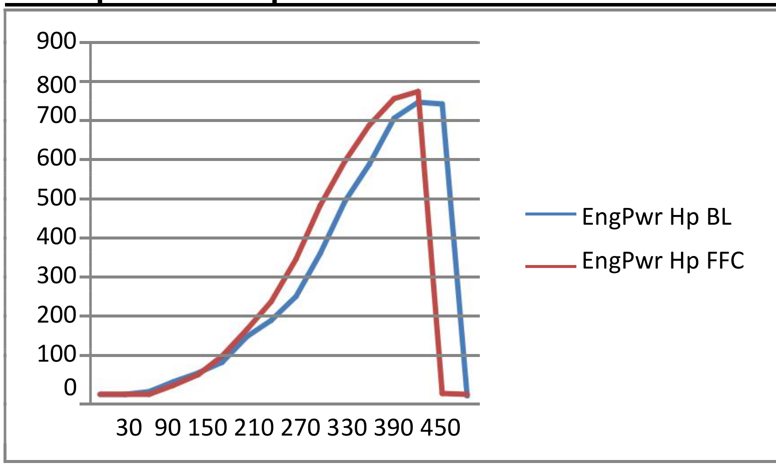
Maximum Load Test

The 100% load run with the FFC fuel showed a 2.49gph reduction in average gross fuel consumption. Relative to horsepower, a 0.77% reduction in gal/hp-hr was calculated with a corresponding 2% increase in hp. Relative to torque, a 2.48% reduction in gal/ftlb-hr was calculated with a corresponding 3.9% increase in torque. Below are two screen shots of the WynDyn display at the highest values seen (778hp and 2,013.3ftlbs) during this 100% run verses baseline maximums

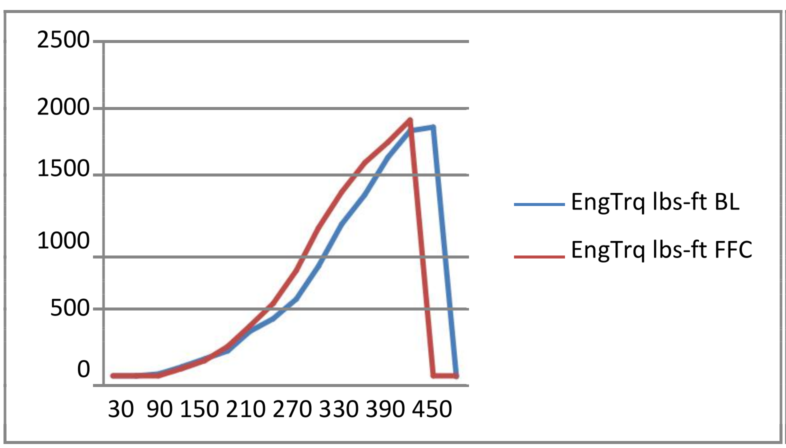
(753.5hp and 1,870.4ft-lbs). This represents an improvement of 3.25% in horsepower and 7.64% in torque as a result of pre-treating the fuel with the Fitch Fuel Catalyst.

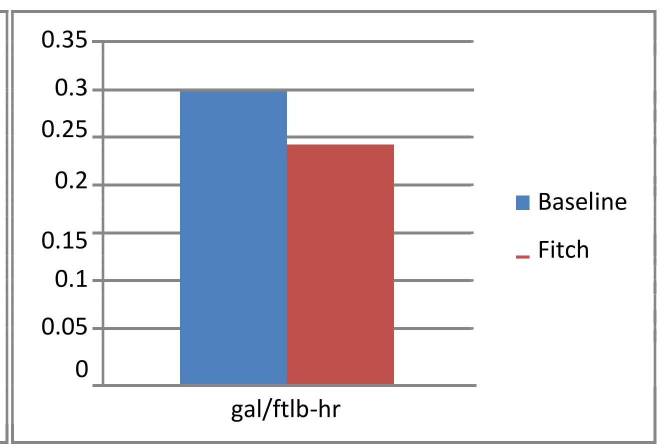
Continuous Ramp Protocols

Horsepower Comparison first FFC run verses Baseline



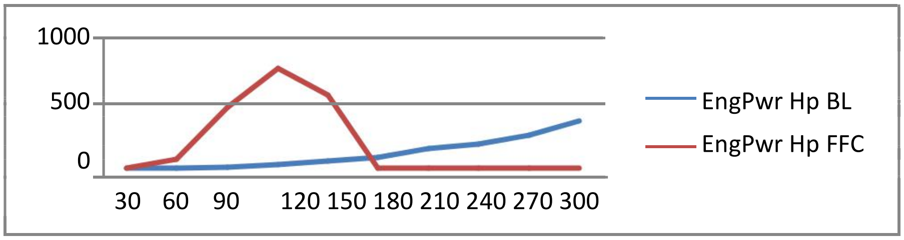
There was a reduction in fuel consumed of 0.1338gal/hp-hr which equates to 19.21%. **Torque Comparison first FFC run verses Baseline**



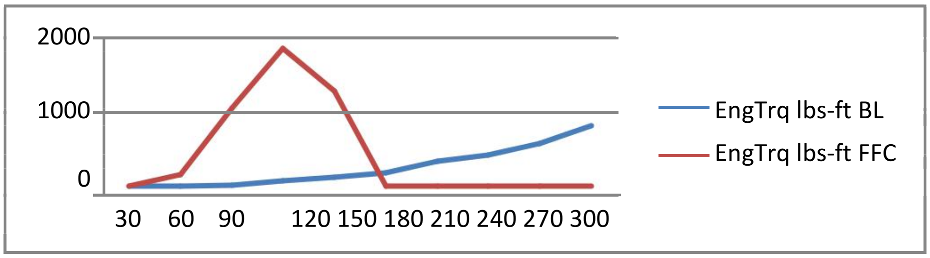


There was a reduction in fuel consumed of 0.054gal/ftlb-hr which equates to 18.25%.

Horsepower Comparison second FFC run verses Baseline



Torque Comparison second FFC run verses Baseline



Exhaust Gas Temperature and Emissions Analysis

Temperatures inside the stack were recorded at most data points with a probe. Percent oxygen (O2) and carbon dioxide (CO2) in the exhaust stack were measured as well as concentrations of carbon monoxide (CO) in parts per million (ppm). CO2 and CO were reduced with FFC in later runs (50, 75, 100 and 100(2)). Average flue temps were consistently higher with FFC than without although the difference decreased the longer the engine ran. The higher flue temps indicate excess BTU's, related to better fuel combustion with FFC treated fuel are being vented out the stack.

Load Bank Test on Caterpillar 3406 powered 300Kw generator

The final phase of the evaluation program of the FFC also occurred at Hawthorne Power Systems dyno facility in San Diego. In this case, fuel consumption of a generator powered by a 400hp Caterpillar 3406 engine was measured with a laboratory quality fuel flow meter manufactured by AIC Systems in Switzerland.

The AIC fuel meters use a piston displacement method to measure the suction of the fuel drawn from the tank to replenish fuel consumed by the engine. The return fuel is diverted back to the engine intact after passing through a heat exchanger to dissipate heat in the closed loop fuel supply. The accuracy and repeatability of the measurements obtained during tests with the AIC meter was better than 99%. Although the differences in fuel consumption observed at each of the five load points measured in the baseline and retrofit tests were small, they could be relied upon because of the extreme accuracy of the meter. Twenty readings were taken for each load point (0, 25, 50, 75 and 100%) and within each set there was never more than one-tenth of a gallon per hour (gph) variance in the readings.

In addition to the power data provided by a programmable resistive/reactive load bank, exhaust temperature (EGT) and other exhaust data were obtained with the e-Instruments Gas Analyzer used previously.

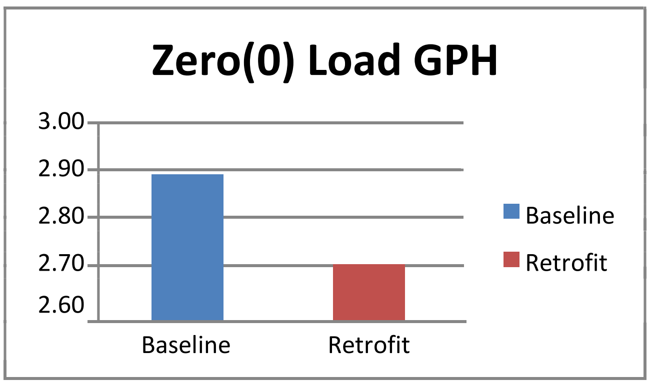
Caterpillar 3406 engine **End view of engine with AIC meter and FFC**

Some of the key elements of the load bank test are shown on this page. The load bank itself was a permanent unit located on top of the roof of the test bays. The operator pre-programmed the agreed upon test protocol into the computer control module. The test sequence was 20 minutes at each load point (0, 75, 150, 225 and 300 kilowatts) representing 0, 25, 50, 75 and 100 percent of maximum power.

The 200-gallon capacity day tank shown below was filled with ULSD#2 drawn from the facility's 4,000 gallon underground storage tank. Prior to starting the retrofit tests with the FFC, the remaining fuel in the day tank was circulated through a second F150HDG unit (on corner of cart in front of tank) using a small transfer pump.

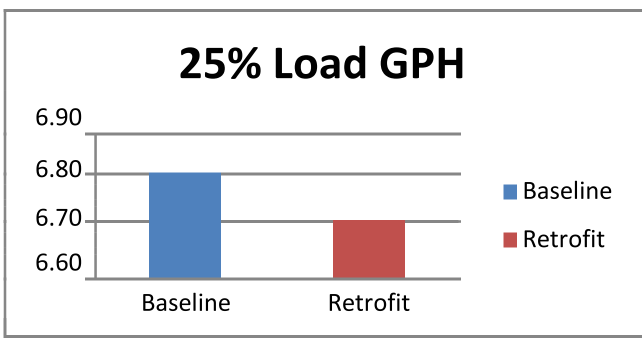
200 gallon day-tank used to supply ULSD#2 for test. Close-up of AIC-6008 fuel flow meter

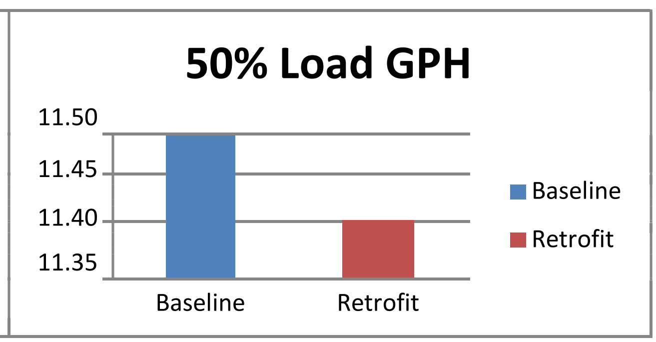
Fuel Measurement Results

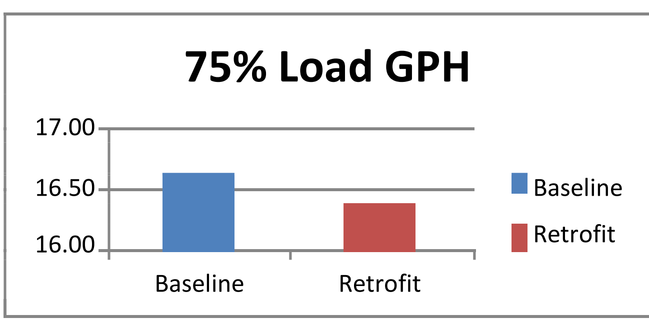


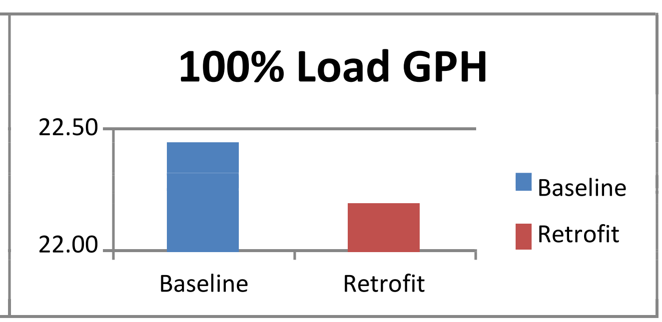
The engine was started and brought up to normal operating temperature prior to commencing the test for baseline and retrofit data collection. Upon starting of the pre-programmed script which controlled the load applied to the gen-set, data collection began.

A fuel consumption reading was taken each minute for each 20-minute segment. EGT and emission readings were taken with the portable Gas Analyzer every third reading.









The above charts illustrate a comparison of the average of the 20 readings taken at each load point. There was never more than one-tenth (0.10) gph range in any set of data. At least 18 of the 20 readings were exactly the same demonstrating the accuracy of the fuel meters used.

In all cases, the fuel consumption with the FFC was measurably less under identical load and operating conditions. On average, the improvement was ¼ gph. Another positive measurement was that the engine ran slightly cooler with the FFC as shown in the comparison of EGT temperature in the following table. It also appears the benefits of reduced fuel consumption, lower EGT and lower emission increased over time. The longer the engine ran with the FFC the greater the improvement observed.

Load %	**Zero**	**25**	**50**	**75**	**100.0**
FFC- ^{o}F	416.4	659.0	796.3	885.3	973.6
BL- ^{o}F	416.1	660.2	804.3	895.6	986.0
Diff- ^{o}F	0.3	-1.2	-8.0	-10.3	-12.4

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See more details at: www.fitchfuelcat.com, www.greenfuelcatalyst.com