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FPC Fuel Catalyst Loadbox Test of a SD45 Locomotive Engine Using a Gravimetric (Weigh Scale) Method

Test conducted
by
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RE: FPC-2 CONCLUSIONS

Gentlemen,

Four blower engines (1550, 1554, 4006, 4009) were field tested from 5/29/96 to 10/11/96 to establish base line -- 'Brake Specific Fuel Consumption' method per EMD (Referred to as BSFC). Engines were selected account all were fire starters. Two units 4006 and 1554 had started two or more fires out stack. The above units had been treated with Nalco fuel treatment as had the entire WC fleet. Besides our own (BSFC) test the UHI fuel additive people ran carbon balance tests. Four different probes measure CO2, CO, HC, O2. The gas analyzer measures smoke density in the exhaust stack.

The units were treated with FPC-2 additive for 45 days after the base line was established.

The two 4000 units missed several treatments due to being sent to NEENAH and Chippeawa Falls for extended periods. The 1500 units were treated without fail. The average fuel savings for all 4 units were 6%.

After 14 days of treatment the spark trap clean out plugs were removed for inspection. The normal black soot and high carbon deposits were minimal and a smooth black sheen was left behind. After 40 days the plugs and traps looked clean and even ash gray. After 50 days' mechanics noted that on engine bar over inspection the tops of pistons looked cleaner.

On 8/22/96 engine WC 6601 – an SD45 unit – was treated. This unit was picked because of a previous test involving magnets in which no fuel savings could be found. The unit 6601 was treated with FPC2 as consistently as possible. Being a road unit it missed treatment about 30% of the time. This unit still resulted in 4.5% fuel savings when tested on 10/10/96. The eductor tube was removed, pictures taken and mechanics noted the condition of the tube. It was clean and is beginning to look ash gray in several places.

The above tests show that the potential benefits of FPC2 are numerous when compared to Nalco -- the reduced fires, savings of component wear, and the ability to kill any microbes that grow in the fuel tank.

Sincerely,

Don Hess

Asst. to Supt. Mech.

attachments.

Abstract

A gravimetric (weigh scale) test method for determining changes in fuel consumption was employed by Wisconsin Central Transportation for a test of the FPC-2 fuel catalyst. The FPC catalyst (under the name FPC-1) was previously tested by Southwest Research Institute using the AAR recognized RP-503. The additive has also been tested by three other railroads, and on two previous occasions by Wisconsin Central. The Wisconsin Central loadbox test results on a SD45 agree with and are supported by the RP-503, the previous Wisconsin Central tests, and the other railroad tests.

(1) ***The SD45 locomotive (Unit 6601) saw a 4.57% reduction in specific fuel consumption*** (SFC), measured in pounds of fuel per horsepower hour, at Notch 8 after additive fuel treatment.

(2) Several fuel treatments were missed during the 45 day engine preconditioning period. Laboratory studies show a definite engine preconditioning period after initial fuel treatment with FPC (see RP-503 graph, Appendix 2). Interrupted additive treatment of the fuel would delay the completion of the documented engine preconditioning period. Maximum fuel efficiency created by the additive may not have been reached at the time of the final test, and therefore, the 4.57% reduction in SFC documented would be less than otherwise achievable.

Prior tests in turbocharged 645 EMD engines document FPC-2 produces greater fuel savings at notch settings lower than 8, where the SD45 was tested. Since no locomotive is constantly operated in notch 8, overall fuel consumption reductions will be greater in actual use.

(3) Visual inspection of the SD45 test engine showed cleaner eductor tubes after 45 days of additive use.

(5) Benefits observed in engines tested with FPC-2 prior to the SD45 test are:

* Engine smoking was visibly reduced.
* Sparks in the exhaust were almost eliminated.
* The tops of the carbody for all locomotives tested where much cleaner, and free of oily soot buildup.
* Exhaust stack "weeping" of raw, unburned fuel was reduced.
* Spark arresters were significantly cleaner, as are air boxes and inductor tubes.
* Carbon plugs were free from carbon, and showing bare metal.
* A bar-over examination of the piston crown/ring zone area of the 4009 show improved engine cleanliness after just a few weeks of FPC fuel treatment.

These observable benefits will lead to fewer wayside fires, improved public image, reduced carbon related maintenance and repair of injectors, ring zone areas, valves and valve seats, and air boxes. Lubricant quality will be maintained longer, reducing efficiency loss to increasing oil viscosity and increased friction, and reducing bearing, liner, and ring wear.

I. INTRODUCTION:

Wisconsin Central engineers used a gravimetric or weigh scale method for determining fuel consumption changes in locomotives based on EMD recommended practices. This method had been used successfully to measure the effect of FPC-2, the FPC products formulation for railroads, on a fleet of normally aspirated, 645 EMD locomotive engines. The method was next used to determine the effect of the additive upon fuel economy (specific fuel consumption) in a SD45 (Unit 6601) locomotive powered by a turbocharged, 20 cylinder EMD 645E.

II. METHODOLOGY:

a) Fuel Consumption Measurement

A description of the weigh scale test procedure follows:

An empty fuel oil tank is weighed on a platform scale and it's tare weight recorded. The tank is then filled with several hundred gallons of fuel, and re-weighed and the weight recorded. The difference in the full and empty weights is the net weight or mass of fuel in pounds contained in the fuel tank.

The tank is then transported to the loadbox area where the test locomotive is waiting. The intake and return lines are connected to the test fuel oil tank via a pair of three way valves and fuel line extensions. This enables the engine to warmup on fuel from it's own tank, and then, while still running, to switch over to the test fuel tank.

The engine is then warmed up at the test throttle notch setting, in this case, Notch 8. During warm up the engine speed (rpm), rack length, engine temperature, power output, and stack temperature are checked and recorded. After warmup and with the engine still running, the fuel from the test fuel tank is fed to the engine by actuating the three way valve.

Rack length, engine speed (rpm), engine temperature, and power output are recorded at regular intervals (15 minute) during a one hour (60 minute) test run. After the sixty minute test run at the prescribed notch settings, the test fuel tank is shut off, disconnected, and again taken to the weigh scale and re-weighed.

Fuel consumption is then calculated as being the difference in the pre-test weight and the post test net weights of the tank.

A SD45 powered by a 3600 horse, turbocharged EMD engine was the test subject.

b) Power Measurement

The power output of the test locomotive was determined using the loadbox shunts. The shunts measure volts and amps from which horsepower is calculated using the following formula:

volts x amps/700 = horsepower

Although the shunt increments are coarse, the four baseline fuel test runs on the 6601 make possible the calculation of an average horsepower output. The confidence level is high in this average, and therefore, horsepower was used to calculate specific fuel consumption (SFC) in pounds of fuel per horsepower hour. SFC is a more accurate measure of engine efficiency than fuel consumption alone, since it correlates fuel consumption to the work output of the engine.

The calculated horsepower, pounds of fuel consumed, and the SFC values are found on Table 1 in the Appendix.

c) Fuel Density Measurement

Studies by Wisconsin Central have shown fuel density can impact engine efficiency. Fuel density was not recorded during either the baseline or the FPC-2 treated fuel tests of Unit 6601, however, prior tests indicate fuel density for fuel supplied during the warm weather season changes very little (ave. 0.845 specific gravity). These same tests also indicate fuel density change due to warmer returning fuel is nearly identical on a percentage basis (approx. 2%) from test to test.

d) Fuel Treatment with FPC-2

The 6601 was operated on FPC-2 treated fuel for approximately 45 days before final testing was done. During that time period, called the engine preconditioning period by the manufacturer of the FPC additive, fuel treatment was inadvertently missed four times. Shortly thereafter, fuel treatment was made, however, the missed fuel treatments can only have a detrimental affect upon the overall change in fuel efficiency created by FPC-2 use.

III. DISCUSSION OF TEST RESULTS

The test data indicate Unit 6601 realized a 4.57% reduction in specific fuel consumption (SFC), after 45 days of fuel treatment with FPC-2.

The fuel consumption reduction was computed by averaging the SFC from four controlled base fuel (untreated) test runs and comparing this average to the SFC of a single controlled test of the 6601 on additive treated fuel. The comparison shows horsepower output was 2.7% greater with additive treated fuel than the average horsepower output of the base fuel tests. Horsepower output with treated fuel was also greater than the highest horsepower output of four base fuel tests.

Fuel consumption with treated fuel was also 2.0% lower than the average for the four base fuel tests of the 6601. Fuel consumption with additive treated fuel was also lower than the lowest of the four base fuel tests on the 6601.

Several fuel treatments were inadvertently missed during the FPC-2 engine preconditioning period. Although there is no way to correct for missed treatments, it is certain that missed fuel treatment can only have a negative impact upon engine efficiency.

The test data are found on Table 1 (see Appendix.)

IV. CONCLUSIONS

(1) *The SD45 locomotive (Unit 6601) saw a 4.57% reduction in specific fuel consumption*, measured in pounds of fuel per horsepower hour, at Notch 8 after FPC-2 fuel treatment.

(2) Reduction in SFC was negatively affected by interrupted fuel treatment with the additive (see Appendix 2).

(3) *Remarkable physical evidences of improved fuel combustion are abundant.* Inspection revealed the subject engine was experiencing the same cleaning effect of FPC-2 treatment observed in previous test engines

APPENDIX 1

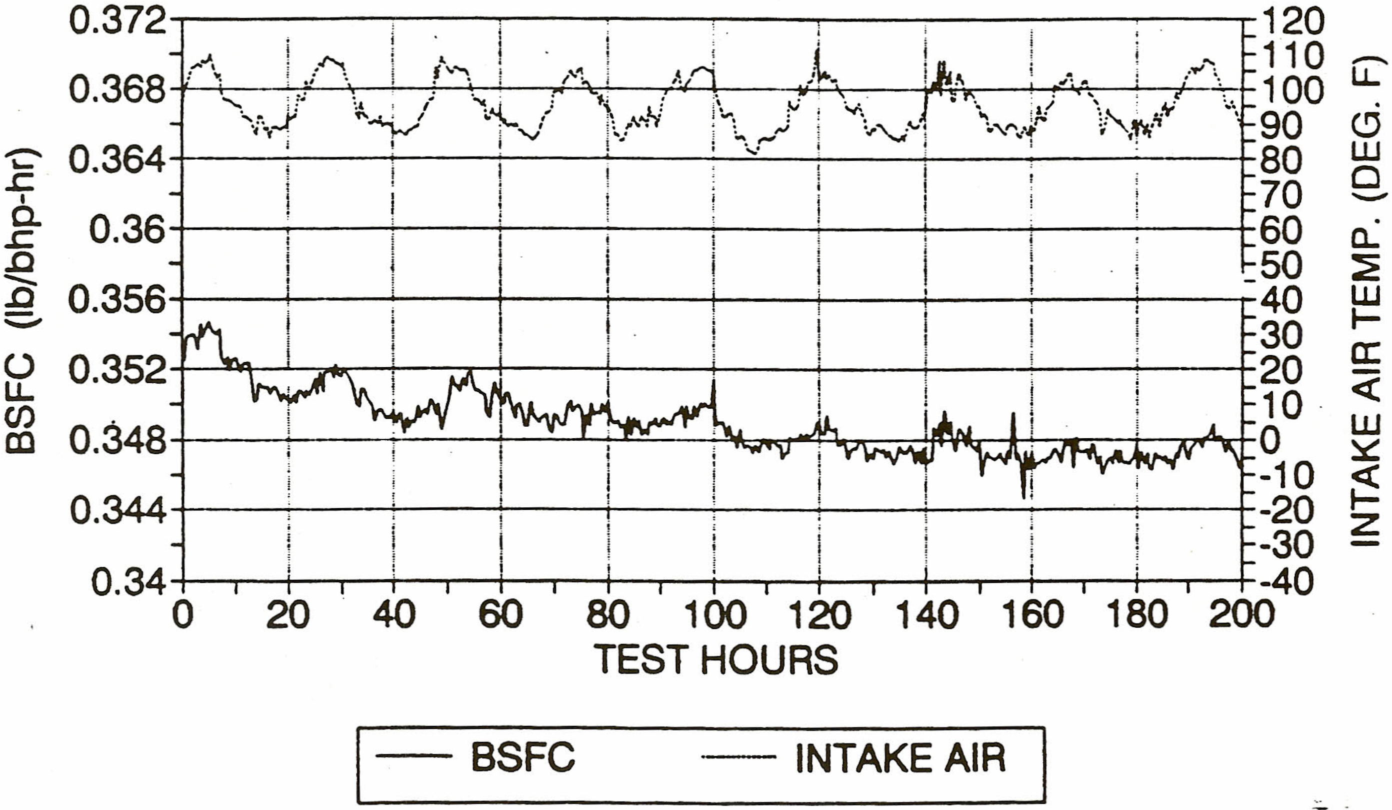
Table 1. BSFC Calculation for Unit 6601 (Notch 8)

Test Run	Date	LBS Fuel	Ave. Horsepower	SFC
1	5/29	1,363.2	3,514.7	0.388
2	5/29	1,424.0	3,518.7	0.405
1	6/10	1,381.0	3,540.0	0.390
2	6/10	1,379.0	3,502.0	0.394
Average of Base Fuel Tests:		**1,386.8**	**3,518.8**	**0.394**
FPC-2	*10/10*	*1,359.0*	*3,612.7*	*0.376*
Difference from Base Fuel:		**- 2.0%**	**+ 2.7%**	**- 4.57%**

APPENDIX 2

200-HOUR PRECONDITIONING TEST ON FPC-1 FUEL CATALYST

RP-503 PROCEDURE EMD 12-645E3B



Note: 0-100 hours at 1/4000 concentration; 100-200 hours at 1/5000 concentration

FIGURE 2

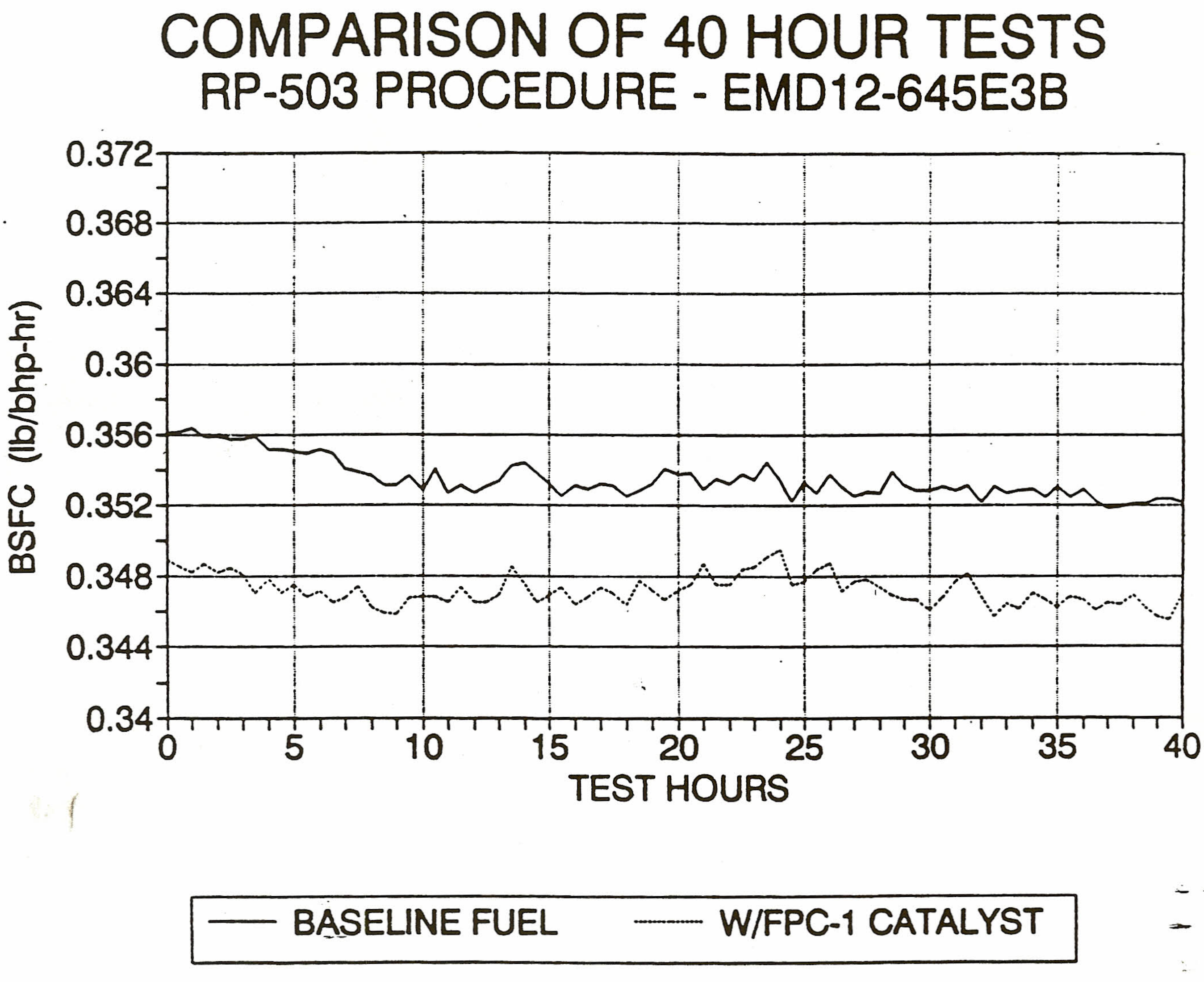

COMPARISON OF 40 HOUR TESTS
RP-503 PROCEDURE - EMD12-645E3B
BSFC (lb/bhp-hr)
0.372
0.368
0.364
0.36
0.356
0.352
0.348
0.344
0.34
0
5
10
15
20
25
30
35
40
TEST HOURS
BASELINE FUEL
W/FPC-1 CATALYST

FIGURE 4