SUMMARY REPORT
ON EVALUATION OF A FUEL ADDITIVE AT SOUTHWEST RESEARCH INSTITUTE SAN ANTONIO, TEXAS

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INTRODUCTION

The Association of American Railroads – Mechanical Division - developed a locomotive diesel fuel additive evaluation procedure, Recommended Practice RP503, effective February 10, 1981.

This procedure is designed to evaluate the effectiveness of diesel fuel additives for use in medium speed locomotive engines. The multiphase test measures the effect of the additive upon the base fuel, engine related effects, both positive and negative and the changes in fuel consumption, arising from use of the additive treated fuel.

The AAR RP503 study summarised in this report was conducted by Southwest Research Institute (SwRI) at San Antonio, Texas. SwRI is a non profit corporation founded in 1947 to supply research and development services to industry, business and various branches of government. With a permanent staff of over 2500 persons and approximately 1.5 million square feet of laboratory and office space in service and gross revenue in excess of US$200 million per annum, the Institute has grown into one of the largest organisations of its kind in the United States of America.

Southwest Research Institute is an independent, non-profit, applied engineering and physical sciences research and development organisation with twelve technical divisions using multi-disciplinary approaches to solving problems. The Institute occupies 765 acres and provides more than 1.5 million square feet of laboratories, test facilities, workshops and offices for 2,500 employees involved in contract work for industry and government.

Summary

The RP503 procedure is intended to provide test results under clinical laboratory conditions which would serve as one indicator to the potential user of the comparison of an untreated fuel to that of a fuel containing a fuel additive. Subsequent testing of additive treated fuel by the potential user under ***actual*** operating conditions would serve to provide additional information.

Fuel Technology field experience with similar engines in operating service indicates fuel efficiency gains under controlled test conditions is greater than that measured in the Southwest Research Institute (SwRI) study by a factor of two to three. Mr Peter Hutchins, Project Manager for the US EPA laboratory at Ann Arbor, Michigan, commented that a 2% improvement in the laboratory can equate to a 3% to 4% improvement in the field.

PROCEDURE

The RP503 test procedure consists of four phases. The tests are organised to first determine that the additive will cause no harmful effects and second to verify the claimed beneficial results.

The four test phases are:-

Phase I Fuel Properties – standard INSI/ASTM D975 tests for base fuel and treated fuel samples. These tests are mandatory.

Phase II CAT IG or CAT IG2 – standard ASTM STP509A except that the additive treated fuel is the test object, not the engine lubricant. This test is mandatory.

Phase III EMD2-567C – preliminary full size laboratory engine test with baseline and additive treated fuels. This test is optional.

Phase IV EMD645E and/or GE7FDL engines – final full size engine test with baseline and additive treated fuels. This test may be run in addition to or in lieu of the Phase III test.

The additive tested at SwRI FPC is identical in all respects to the additive marketed by Fuel Technology in Australia, FTC/FPC.

RESULTS

A description of the three test phases conducted at SwRI in 1992 is detailed in this section.

Phase I – Chemical Laboratory Evaluations

The FTC/FPC was mixed in a diesel fuel at the specified concentration. When compared with the same diesel fuel without the additive, all measured properties were virtually identical with only minor variations that are considered insignificant and attributable to experimental error. FTC/FPC thus has no measurable effect on the chemical properties of the fuel.

Phase II – Caterpillar IG2 Engine Tests

This test provided a preliminary evaluation of the additive on overall engine performance, deposits and wear before proceeding to Phase IV. Under the specific conditions of these tests, run over 960 hours, the amount of carbon and lacquer in the piston grooves and lands indicated no harmful effects are produced by the additive relative to the baseline test.

The difference between baseline test results and the treated fuel results were within test-to-test repeatability.

Phase IV – Twelve Cylinder EMD645E3B Engine Tests

This phase consisted of a 40 hour test on baseline fuel, a 200 hour conditioning period on treated fuel following by a 40 hour test on treated fuel. Statistical analysis of the data showed a BSFC improvement of 1.74% at a 99% confidence level with the FTC/FPC treated fuel.

Figure 1 below illustrates the comparison of the two 40 hour tests, eg Baseline and Treated.

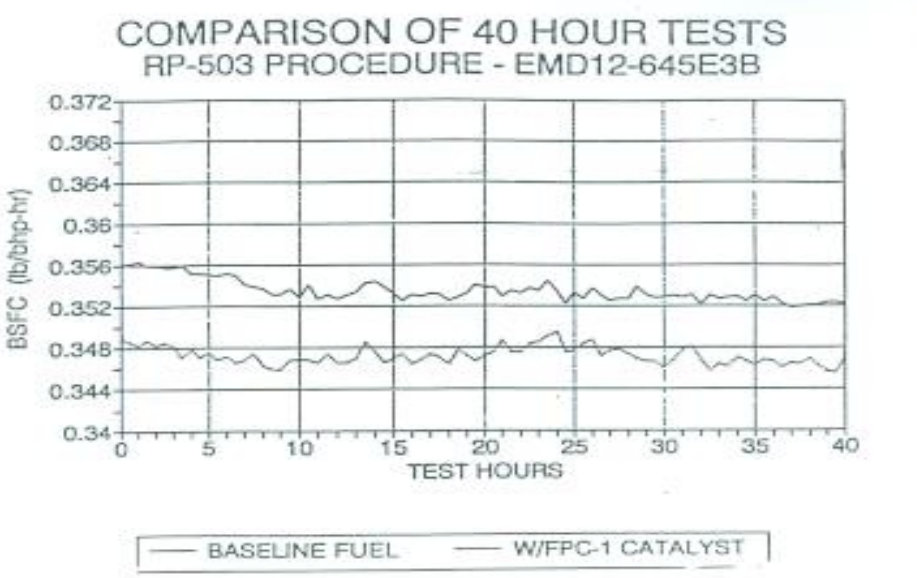


Fig 1.

Conditioning

The SwRI tests have precisely measured the "conditioning" of the test engine during the 200 hours after the start of fuel treatment. That effect is seen in Fig 2 which shows the establishment of a new consumption level after 130 hours of continuous operation. Fuel Technology have recognised this transition effect in our field and laboratory trials – larger engines appear to require longer conditioning periods.

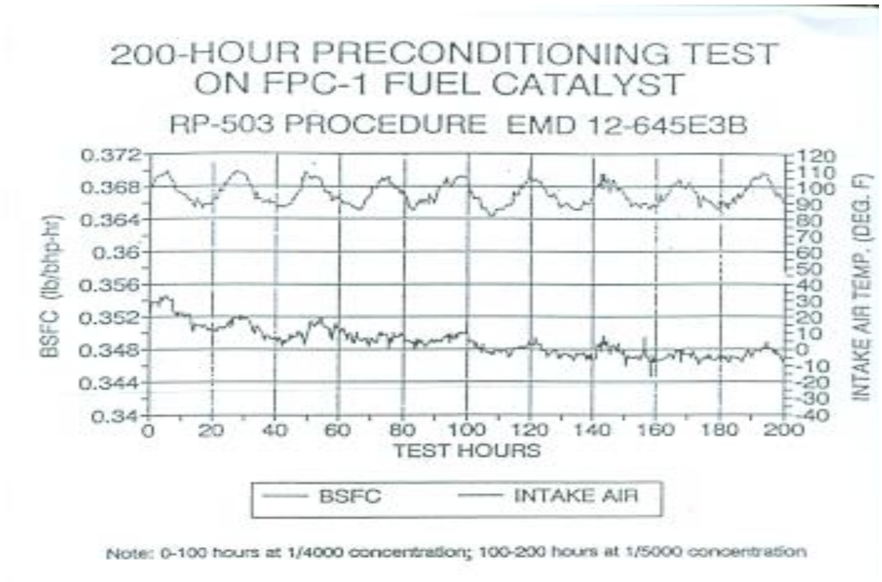


Fig. 2

TECHNICAL COMMENT ON SwRI TEST RESULTS

The test data that follows gives a technical explanation for the observed effect of FTC/FPC fuel treatment on engine performance and fuel properties during the AAR-RP5093 3 phase tests conducted at SwRI and reported in July 1992.

Phase 1 – Fuel Properties

This test sequence confirms independent tests conducted for Fuel Technology at BHP-Petroleum Laboratory, Melbourne. Fuel properties are unchanged by addition of FTC/FPC.

Phase II – Engine Life

The CAT IG2 engine wear test confirms that FTC/FPC fuel treatment has no harmful effect upon engine life. Non-steady state field tests over the past twelve years have shown that FTC/FPC fuel treatment has a positive effect in minimising carbon build-up and can actually extend engine component life.

Many engines inspected which have run on treated fuel long-term, 10,000 hours plus, have shown a significant reduction of carbon deposits in the combustion chamber and on piston crowns and ring belt area. Cleaner fuel injectors and turbochargers have also been observed.

Phase IV – Fuel Economy

Fuel economy can be improved by either a more complete combustion of the available fuel in the engine, higher combustion rates (reduced time losses) or both in combination. Steady-state laboratory tests such as the RP503 involve like new engines operated under ideal conditions. Consequently steady-state laboratory tests tend to minimise the potential for fuel economy improvement. The measured fuel economy is usually lower in laboratory studies than in field studies with similar equipment.

Engines operating in normal commercial service do not operate at constant speed and load. Non steady state operation of engines in the field create transient phenomena leading to combustion inefficiencies.

After observation of many field studies and laboratory tests we believe that the measured improvement in fuel economy with use of FTC/FPC, which is almost always greater for older engines than for like new engines, results from decreased time losses, reduced combustion gas blow by and increased completeness of combustion. The increased combustion efficiency leads to reduced CO and HC levels.

A controlled load box test conducted in Australia on an Alco M636 unit rated at 3000 HP showed efficiency gains in the range 4% to 5% between Notch 6 to 8 as a result of FTC/FPC fuel treatment. The benefits at idle and lower notch settings were significantly higher.

Fuel Technology's data base covering 23 years of fuel consumption tests on equipment ranging from relatively low power high speed engines to large power low speed engines show an average fuel consumption reduction of 5.6%.

REFERENCES

Vernon O Markworth – SwRI Project No 03-4810
Evaluation of a Fuel Additive – Final Report – July 92
Geoff J Germain PhD – Letter to Vernon O Markworth – August 92.

Medium Speed Diesel Engine Research

Southwest Research Institute San Antonio, Texas

The EMD 645E3 12-cylinder engine operates on a two-stroke cycle and produces 2,500 bhp at 904 rpm. The GE 7FDL operates on a four-stroke cycle and produces 2,500 bhp at 1,050 rpm.

Southwest Research Institute (SwRI), internationally recognized for locomotive engine research, applies its expertise in medium speed diesel engines to a wide variety of research and development programs for stationary power plants, for marine engines, and for the offshore drilling industry.

Four medium speed diesel engines are instrumented to monitor engine speed, power output, pressures, and temperatures throughout the lubricating oil, cooling water, intake air, and exhaust systems. Mass flowmeters provide continuous fuel consumption measurements, while piezoelectric pressure transducers provide cylinder pressure measurement. Injection systems are fully instrumented for various system parameters, a computerized process controller provides cycle control, and high speed data acquisition is used for combustion analyses.

The two-cylinder EMD engine is blower-scavenged with a displacement of 567 cubic inches per cylinder. Rated speed is 835 rpm, and power output is 215 bhp.

Alternative Fuels

SwRI performs experimental studies of many types of alternative fuels for medium speed engines, including methanol, ethanol, coal/water slurries, and natural gas. Studies indicate that the medium speed diesel tolerates varying fuel types if suitable modifications are made to the combustion process.

Emissions

Exhaust emissions are an important factor in medium speed engine use. SwRI can measure and analyze engine emissions and perform development work to reduce emissions through improved components and operating procedures.

Lubricant Evaluations

The evolution of the medium speed diesel engine, with higher horsepower per cylinder and lower lubricating oil consumption, places a severe demand on lubricating oils. SwRI conducts numerous tests for oil companies and railroads to evaluate new and multi-viscosity lubricating oils. Motoring friction horsepower studies have shown significant changes in engine friction with changes in oils.

Durability and Reliability Testing

Long-term engine operation is routinely conducted on a seven-day, 24-hour basis for evaluation of engine components subjected to alternative fuel use or component redesign. SwRI developed a 500-hour screening test procedure in cooperation with the Association of American Railroads to evaluate changes made to the medium speed diesel engine. The procedure screens engine and fuel system modifications before field trials.

Performance Evaluations

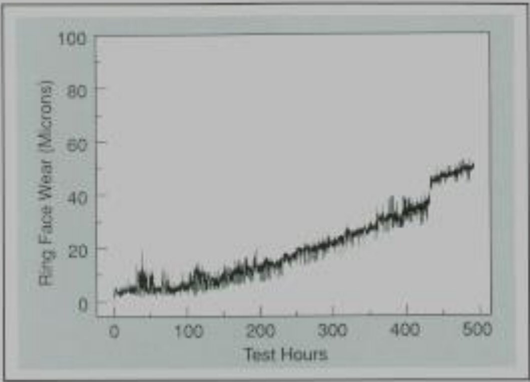
Emphasis on performance and fuel economy has led to the development of procedures that accurately assess changes in engine performance due to engine and system modifications. With these techniques, SwRI measures changes of less than one percent in power and fuel economy, an accuracy rate not normally attained.

Air Filter Evaluations

Flow benches at SwRI accommodate both baggie and paper element filters. The benches are available for standard air filter tests according to SAE J726 and for first article tests. SwRI offers specialized research programs that require measurement of particle size, media analysis, and procedures development.

Wear Measurements

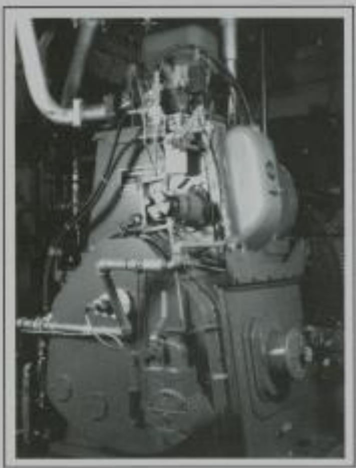
SwRI applies the Surface Layer Activation (SLA) technique to measure piston ring wear in the medium speed engine without disassembly of the power assembly. In addition to piston ring wear, the technique is used to measure short term wear of cylinder liners, valves, and injector components.



Piston ring wear is measured using the SLA technique.

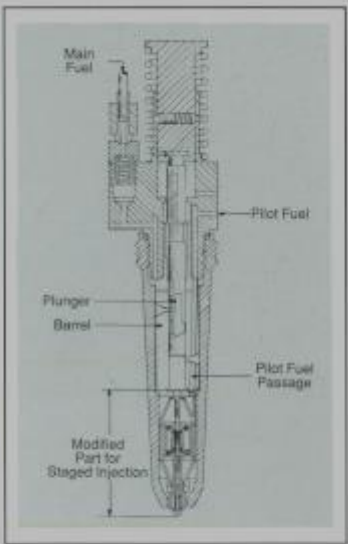
Fuel Injection Systems

SwRI designs and develops fuel injection systems. The Institute invented the staged injector, and has designed gas injectors for natural gas operation and an electronically controlled injector that provides high pressure injection at variable timing throughout the engine operating range.



The single-cylinder research engine is uniquely designed, with a displacement of 668 cubic inches and 188 bhp at 1,050 rpm. It emulates the four-stroke, multicylinder, turbocharged diesel engine.

An experimental injector was designed for high pressure gas injection.



Experimental staged injectors are used for low cetane number fuels.

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We welcome your inquiries.
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