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Division of
CAD Railway Industries

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REPORT NO.
ARD-0128

A Project Report on

Fit for Use Evaluation of Fuel additive

Prepared for

Enerteck

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Enerteck
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EXECUTIVE SUMMARY

Enerteck's fuel additive was tested and evaluated on a single cylinder medium-speed diesel research engine (SCRE-251) at ESDC's test facility to determine the impact of fuel economy and exhaust emissions when using this fuel additive. The engine was fitted with a non-chromed cylinder liner. This evaluation test consisted of ESDC's Simplified Fuel Additive Test (SFAT) which includes a baseline-preconditioning-performance test sequence. Baseline and Performance tests were performed during 20 hours while preconditioning period was of total 35 hours. The simulated operation mode was at full load which represents 1050 rpm and 250 HP. Engine operating parameters, fuel consumption and emissions were collected during these runs.

During the performance test, it was observed that BSFC at full load (1050 rpm and 250 hp) worsened by 0.61 %. This result is not considered significant statistically since it is within the overall margin of error of the measurement equipment which is fixed at 1%.

From emissions results, it was observed that the brake specific values for CO increased by 1.5%, NO_x diminished by 1.3%, THC augmented by 0.7% and PM decreased by 3.0% respectively. Since the error margin of the test equipment is fixed at 2%, the only significant value in emissions results is the Particulate matter diminution of 3%.

From borescopic investigation, it was observed that there are no adverse effects on in cylinder components.

From over all evaluation of fuel consumption, emissions, and borescopic investigation it is observed that Enerteck fuel additive does not have adverse effects on engine performance and presented no downsides compared to base fuel. In addition, it is suggested that further studies be done on additive mixing ratio.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

ASTM	American Society for Testing and Materials
BSFC	Brake-Specific Fuel Consumption
CFR	Code of Federal Register (US)
CxHy	Combustibles
CO_2	Carbon Dioxide
CO	Carbon Monoxide
ECOM	ECOM North America, Ltd.
EPA	Environmental Protection Agency (US)
ESDC	Engine Systems Development Centre Inc.
FS	Full Scale
IMEP	Indicated Mean Effective Pressure
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
PM	Particulate Matter
SFAT	Simplified Fuel Additive Test
THC	Total Hydrocarbon

1. INTRODUCTION

Enerteck's fuel additive was evaluated on a single-cylinder medium-speed diesel research engine (SCRE-251) equipped with non-chromed liner at Engine Systems Development Centre (ESDC) in October 2009. The objective of the test was to determine the fit-for-use and the effects of the fuel additive on engine performance and exhaust emissions. A description of the test approach and the test results are presented in this report.

2. TECHNICAL APPROACH

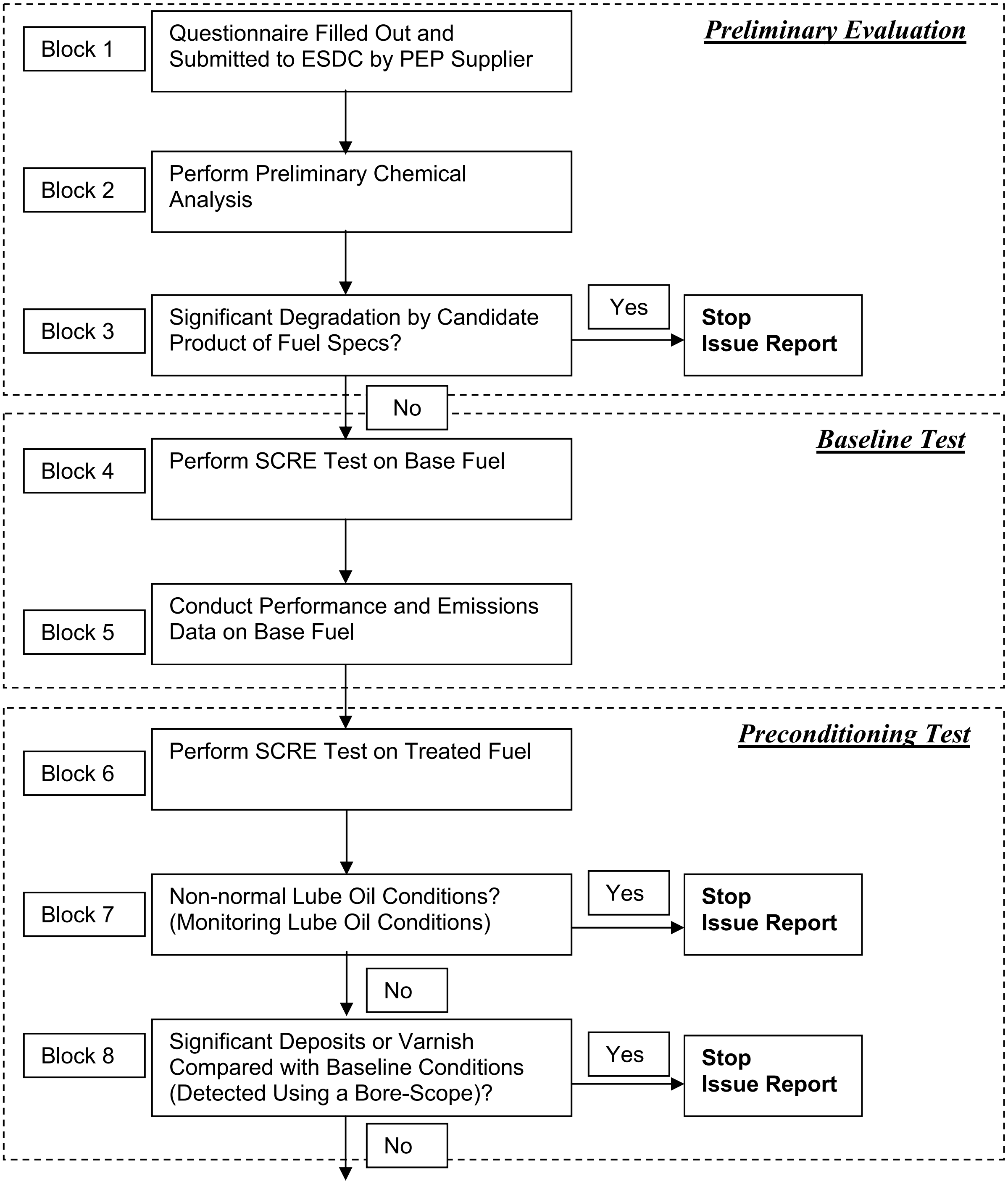
2.1 Evaluation Test Procedure

The evaluation test procedures were conducted by following ESDC's Simplified Fuel Additive Test (SFAT) protocol.

Note: ESDC's Simplified Fuel Additive Test (SFAT) contains the following three phases

Phase I - 20 hours of baseline
Phase II - 35 hours of preconditioning
Phase III - 20 hours of performance

The test was completed following the flow chart presented below.


Preliminary Evaluation
Block 1
Questionnaire Filled Out and Submitted to ESDC by PEP Supplier
Block 2
Perform Preliminary Chemical Analysis
Block 3
Significant Degradation by Candidate Product of Fuel Specs?
Yes
Stop Issue Report
No
Baseline Test
Block 4
Perform SCRE Test on Base Fuel
Block 5
Conduct Performance and Emissions Data on Base Fuel
Preconditioning Test
Block 6
Perform SCRE Test on Treated Fuel
Block 7
Non-normal Lube Oil Conditions? (Monitoring Lube Oil Conditions)
Yes
Stop Issue Report
No
Block 8
Significant Deposits or Varnish Compared with Baseline Conditions (Detected Using a Bore-Scope)?
Yes
Stop Issue Report
No

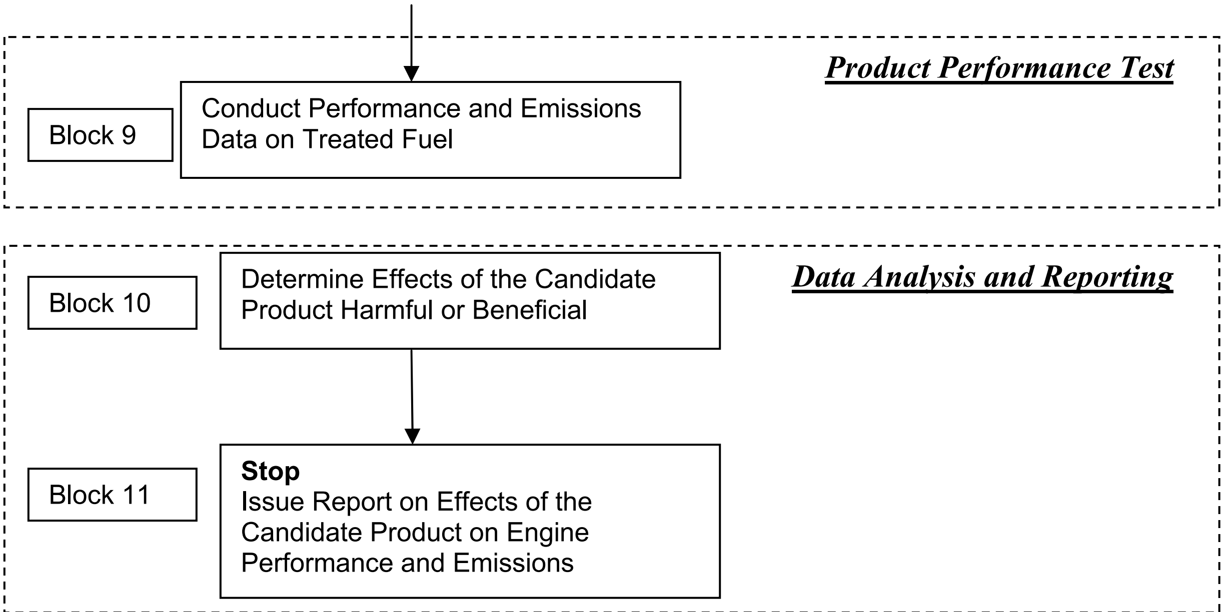


Figure 1: Evaluation test flow chart

2.2 Test Engine

The SCRE-251 is a four-stroke medium-speed diesel research engine with 9.0-inch bore and a 10.5-inch stroke. The engine specifications are as shown in Table 1.

Table 1: SCRE-251 specifications

Cylinder	1
Engine Stroke	4
Bore X Stroke	9.0 in. (228.6mm) X 10.5 in. (266.7 mm)
Displacement	668 cu. in. (10.9 L)
IMEP (max)	23 bar (334 psi)
Engine Speed (max)	1200 rpm
Idle Speed (Normal)	400 rpm
Compression Ratio	11.5: 1 (variable)
Fuel Injection Type	Direct Injection
Fuel Injector	9 holes × 0.40 mm × 145°
Fuel Injection Timing	27.5° CA BTDC (Variable)
Governing	Electronic

Figure 2: Single Cylinder Research Engine (SCRE)

2.3 Test Fuel

Regular low sulfur no. 2 diesel fuel was used as baseline fuel. Enerteck fuel additive was mixed at a ratio of 1:2500 with no. 2 ULSD diesel fuel and was used during preconditioning and performance parts of the test.

2.4 Engine Power and Fuel Consumption

The speed of engine is controlled by an electronic engine governor, measured by an electronic-magnetic speed pick-up with an accuracy of ±0.1% FS. The engine load is controlled and measured by a Schenck D1100 hydraulic dynamometer, which has an accuracy of ±0.5% FS.

Fuel is drawn from the fuel weighing tank by the engine booster pump which then passes it through a filter prior to the engine fuel pump, which incorporates a pressure relieve valve for directing returning excess fuel to the same weighing tank. The net fuel consumption rate is measured by using a single channel micro-processor based process monitor (Visipak VIP524W, ±0.01% FS accuracy) connected to a load cell carrying the weighing tank.

2.5 Exhaust Emissions Measurements

An emission sample probe was mounted in the exhaust stack to sample engine exhaust after a complete mixing of the exhaust gases in the surge tank. The gas samples were drawn from the engine exhaust stack via a high-flow pump assembly with an in-line water trap and particulate filter for proper conditioning prior to be analyzed by the electrochemical gas sensors of the ECOM AC+ analyzer. The analyzer detects concentrations of carbon monoxide (CO), oxygen (O_2), unburned hydrocarbons (HC), nitric oxide (NO), and nitrogen dioxide (NO_2), while also calculating carbon dioxide (CO_2). The accuracy of each of these sensors is within 2% of reading. Particulate matters were determined using a particulate emission measuring system, which was designed according with EPA 40CFR Part 92 specifications.

3. TEST RESULTS

3.1 Fuel Properties

Fuel properties, as shown in Table 2, for the baseline and the treated fuel for performance suggest non-significant changes of the treated fuel.

Table 2: Baseline and treated fuel properties

	Base Fuel	Treated Fuel
Ash, % mass	0.001	0.001
Cetane Index	53.5	51.5
Density @ 15 °C, kg/l	0.81	0.8103
Copper Strip Corrosion	1a	1a
Flash Point, °C	46.5	44.5
Cloud Point, °C	-20	-23
Pour Point, °C	-39	-42
Calorific Value, kJ/kg	45988	45971
Conradson Carbon Residue, % mass	0.014	0.016
Water & Sediment, % vol.	<0.05	<0.05
Distillation:		
Initial boiling point, °C	146	147
10%, °C	178	175
50%, °C	223	223
90%, °C	303	301
Final boiling point, °C	326	319
Viscosity at 40°C, Cst	1.87	1.87

3.2 Engine Operating Parameters

Engine operating parameters such as speed, load and coolant temperature were recorded during the baseline and performance test. The variations of these parameters are within the limits specified in SFAT protocol. The average values of the parameters were maintained as closely as possible as shown in table 3.

Table 3: Engine operating parameters of Baseline, Preconditioning and Performance

Test Mode	Engine Speed (rpm)	Engine Load (Nm)	Air Boost (psi)	Air Boost Temp (°C)	Fuel Temp (°C)
Full Load	1050	1696	32.5	85°C	28 - 32°C

3.3 Fuel Economy

Engine Brake Specific Fuel Consumption (BSFC) of the baseline and performance are as shown in table 4. A difference of +0.61% in performance was observed when compared with that of baseline. The difference is too small to be considered significant since it's in the error margin of 1% of the measuring instrument.

Table 4: Comparison between BSFC (g/kW-hr) of baseline and performance

Test Mode (RPM)	Average BSFC (g/(kW-hr))		Difference (%)
	Baseline	Performance	
1050	235.01	236.44	+0.61

3.4 Exhaust Emissions

The raw engine emissions were converted to brake specific values in g/kW-hr. Results are shown in Table 5. The differences between baseline and performance data for CO, NOx and THC aren't considered significant at +1.5%, -1.3% and +.7% since these values are below the 2% error margin of the test equipment. Particulate matter was diminished by 3% in the test and this value is considered significant since it's over 2%.

Table 5: Comparison between specific emissions results (g/kW-hr)

Emissions	Baseline	Performance	Percentile difference (%)
CO (g/kW-hr)	2.0898	2.1210	1.5
NOx (g/kW-hr)	16.5972	16.3735	-1.3
THC (g/kW-hr)	1.8578	1.8712	0.7
PM (g/kW-hr)	0.0598	0.0580	-3.0

3.5 Engine Deposit and Wear Observations

From borescopic investigation, it is observed that there are no adverse effects on engine components as shown in figures 3, 4, 5, 6. There were not any carbon deposits, engine wear, and no engine oil contamination was observed.

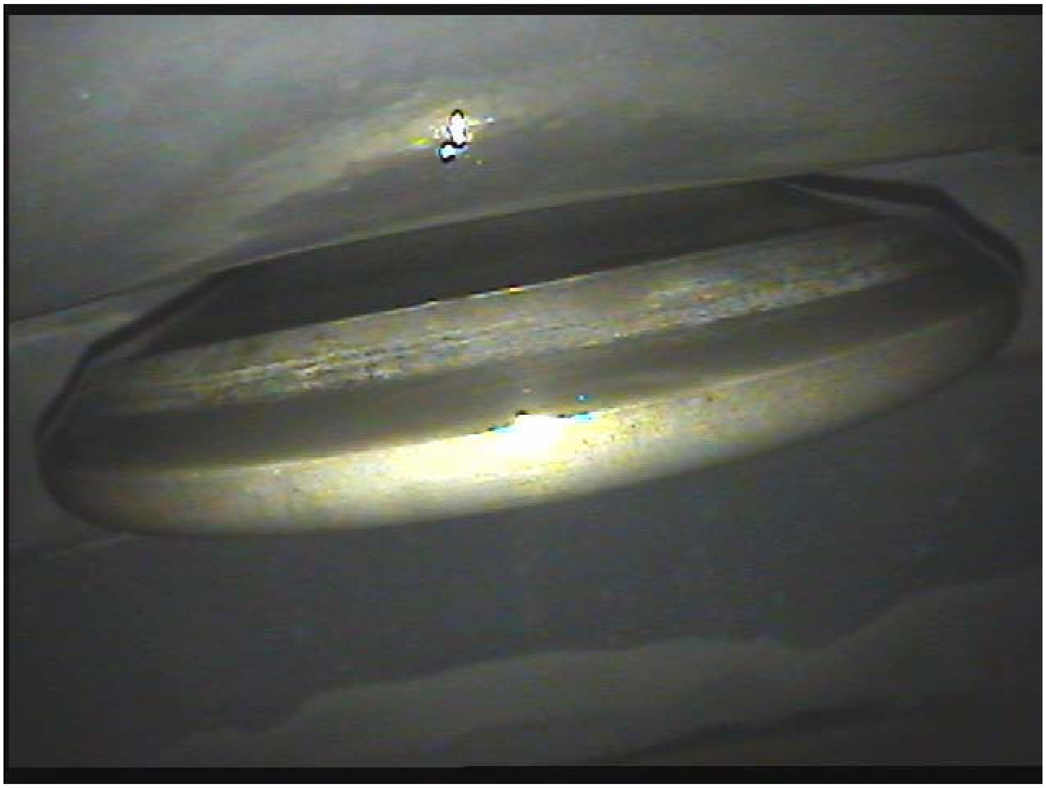


Figure 3: Intake valve

Figure 4: Surface of cylinder liner

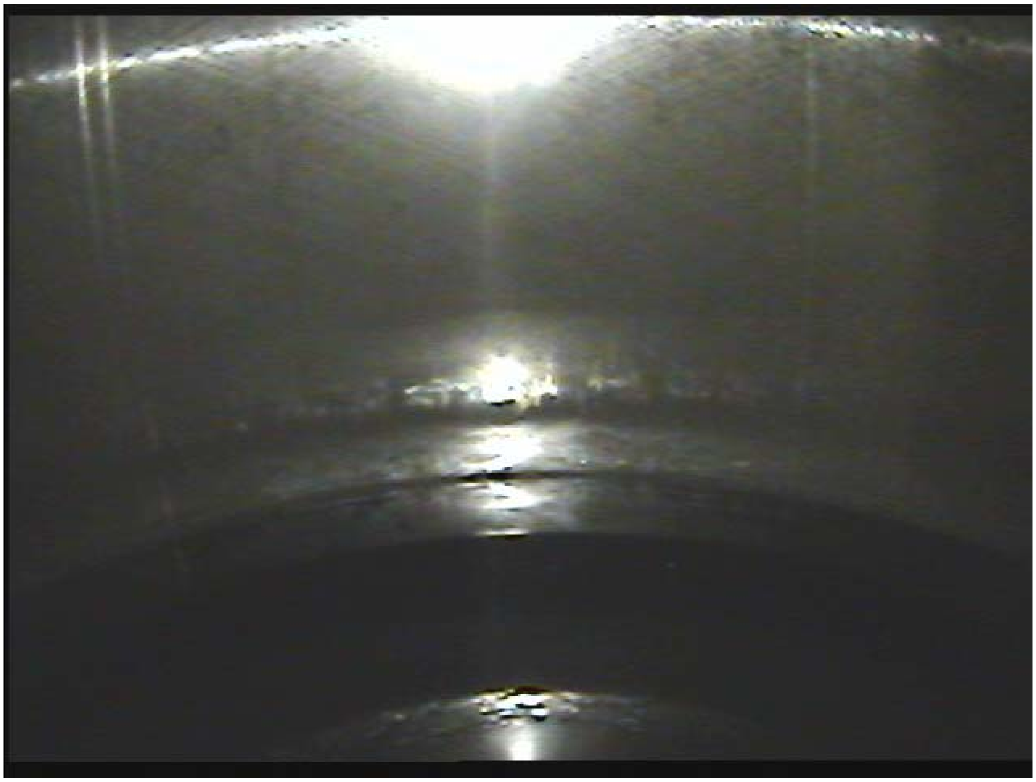


Figure 5: Surface of cylinder liner at BDC

Figure 6: Top of the piston surface

4. CONCLUSION

The main objective of this project was to evaluate the effects of Enerteck's fuel additive on fit-for-use engine performance, emissions and in-cylinder condition following the SFAT procedure.

After the addition of the diesel fuel additive, it was observed that BSFC at full load (1050 rpm and 250 hp) has worsened by 0.61%. This result is not considered significant since it is within the overall error margin of the measuring equipment which is fixed at 1%.

From emissions results it was observed that full load (1050 rpm and 250 hp); the brake specific values for CO increased by 1.5%, NOx diminished by 1.3%, THC augmented by 0.7% and PM decreased by 3.0% respectively. Since the error margin of the measuring instruments is fixed at 2% for the emissions, the only significant change in engine performance recorded is a diminution of particulate matter by 3%.

Investigation performed with a borescope show that there are no adverse effects on engine components when the fuel additive is added to the base fuel.

From over all evaluation of fuel consumption, emissions, and borescopic investigation it is observed that Enerteck's fuel additive does not have adverse effects on engine performance and presented no downsides compared to base fuel. In addition, it is suggested that further studies be done on additive mixing ratio.

5. REFERENCES

1) M. Payne, M.Vasquez, “Simplified Fuel Additive Test Phase I, II, III, IV”, Transportation Development Centre, Transport Canada.

2) B. D. Hsu, “ Practical Diesel-Engine Combustion Analysis”, SAE International.

3) J. Heywood, “Internal Combustion Engine Fundamentals”, McGraw-Hill, 1988