RBP Diesel System Cleanse

Diesel Fuel Additive

Technical Data

Tests performed by:

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Introduction

Diesel System Cleanse is a premium diesel fuel additive that offers a large number of performance benefits. It also can be tailored to meet individual marketers' needs.
Diesel System Cleanse has been extensively tested both in the laboratory and in the field with impressive results. This report highlights some of this testing and many of the benefits. The benefits of Diesel System Cleanse include:

- Excellent injector cleanliness as shown by the Cummins L10 and Peugeot XUD-9 tests for injector deposits
- Lower operating costs due to improved fuel economy
- Reduced exhaust emissions compared to base fuel
- Superior corrosion protection
- Excellent fuel stability in storage
- Exceptional lubricity for reduced fuel system wear
- Reduces water entrainment and prevents stable emulsion formation
- Excellent anti-foaming characteristics

There are clear and measurable advantages to incorporating a multifunctional diesel fuel additive into diesel fuel. The end user of Diesel System Cleanse treated fuel will appreciate the differences in terms of:

- Improved driveability
- Reduced combustion noise
- Longer component life
- Reduced Operating costs

RBP Inc, can also add performance components such as cetane improvers and cold flow improvers to Diesel System Cleanse .

Test data presented in this report utilized Diesel System Cleanse at 310 ppm.

Cummins L10 Depositing Test

Background

Cummmins had a field problem that occurred in some fleets. Certain engines developed injector deposits that led to a noticeable decrease in power. Cummins analyzed the driving patterns of the affected fleets and a laboratory test method was developed to simulate these deposits. The test can be used to discriminate fuel/fuel additive quality. (Reference SAE paper No. 912331.)

Test Summary

- Two L-10 Cummins Engines in tandem
- 2300 RPM, 50-60 HP
- 15 second cycle – one engine driving, the other being driven. The roles are reversed for each subsequent 15-second cycle.
- 125 hour duration
- Rating
  - Percent flow loss
  - CRC Visual rating of plunger deposits

Cummins Criteria

Acceptable -	CRC Rating <25+SD Flow loss <5%
Superior -	CRC Rating < 10+SD Flow loss <5%

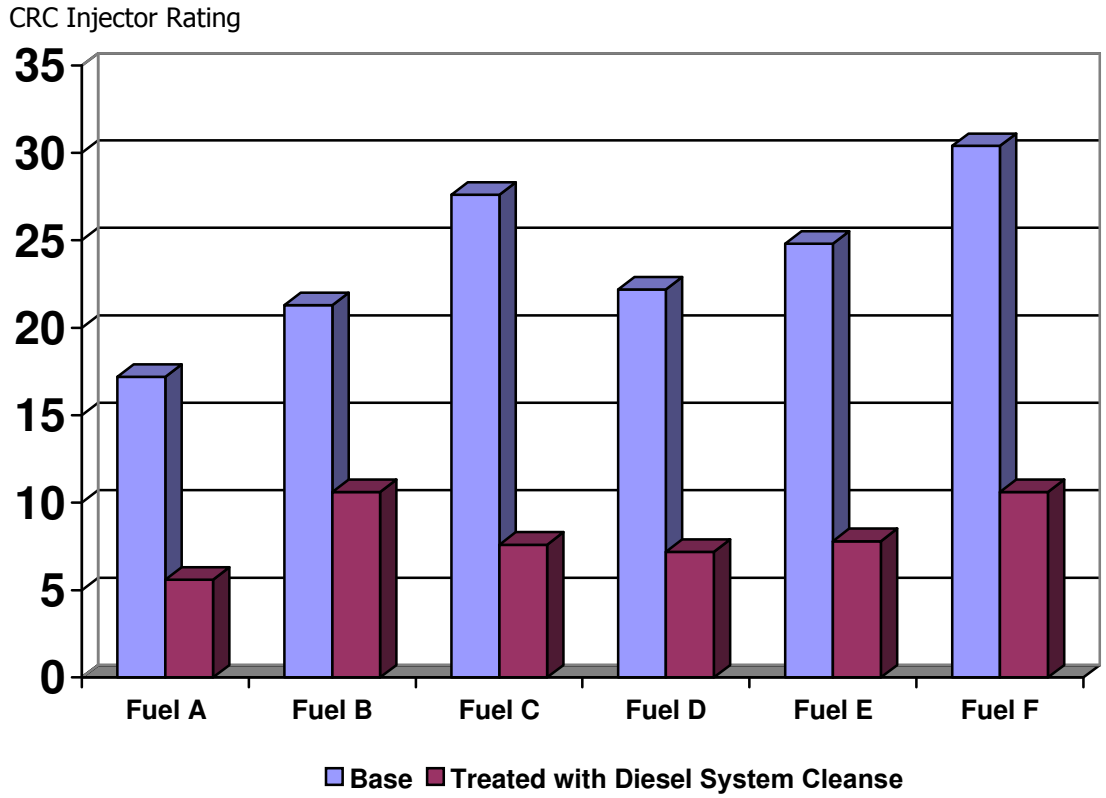
(CRC rating goes from 0 to 100 with 0 being totally clean.
Standard Deviation (SD) = 2.0.)

Test Results

Attached in table and graphical form. Diesel System Cleanse @310 ppm shows excellent results.

Cummins L10 Depositing Test

Diesel System Cleanse
Diesel Fuel Performance



125 Hour – Tandem Engine

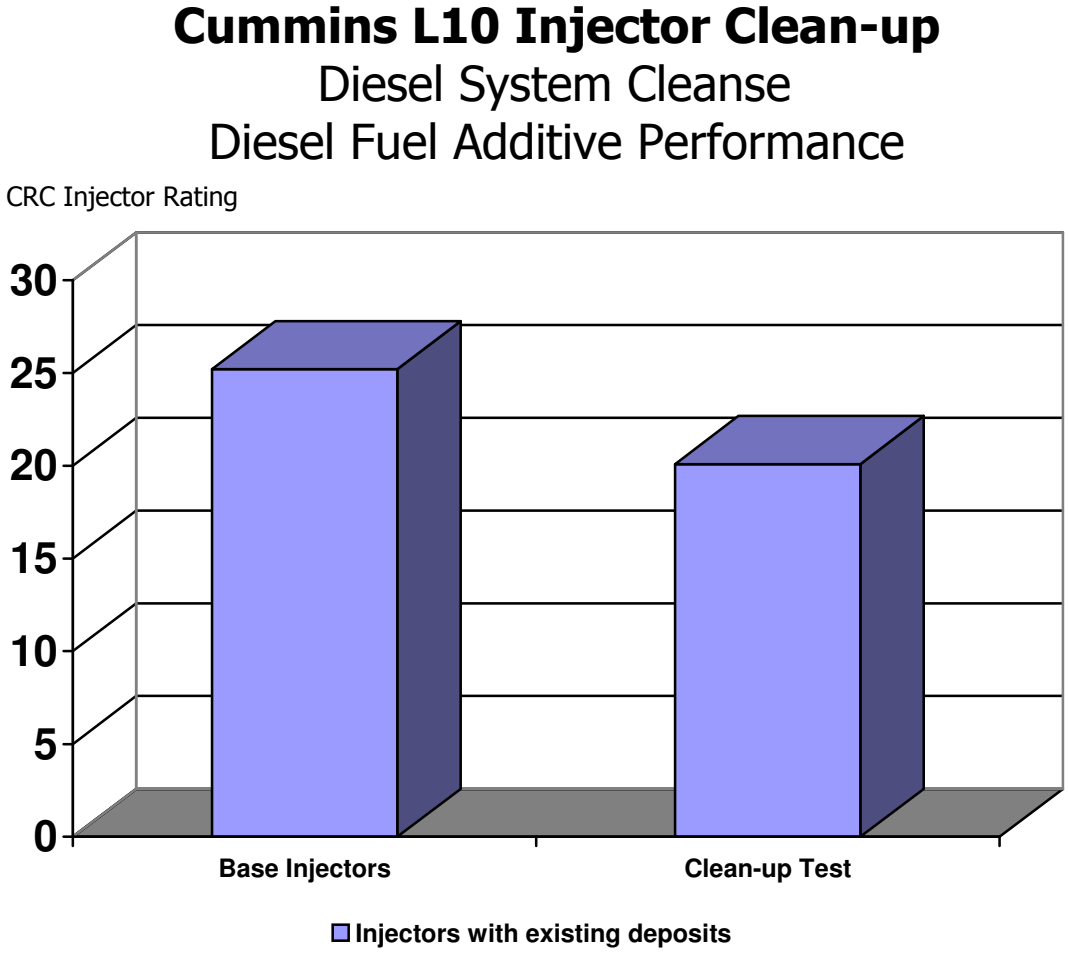
Diesel System Cleanse Performance Summary

Plunger Ratings – CRC Visual Ratings

Fuel	Base Fuel	Treated Fuel	% Improvement
A	17.2	5.6	67
B	21.3	10.6	50
C	27.6	7.6	72
D	22.2	7.2	68
E	24.8	7.8	69
F	30.4	10.6	65

Injector Clean-up Data

The ability of Diesel System Cleanse to clean up existing injector deposits was evaluated through the use of the Cummins Injector Depositing Test Cycle. A set of injectors were run in the Cummins L10 Injector Depositing Test Cycle using untreated Cat 1-H fuel and then rated. The same injectors were rerun in the Cummins L10 Injector Depositing Test Cycle using Cat 1-H fuel treated with Diesel System Cleanse. This test showed a reduction in average injector deposits of 20.3 percent.

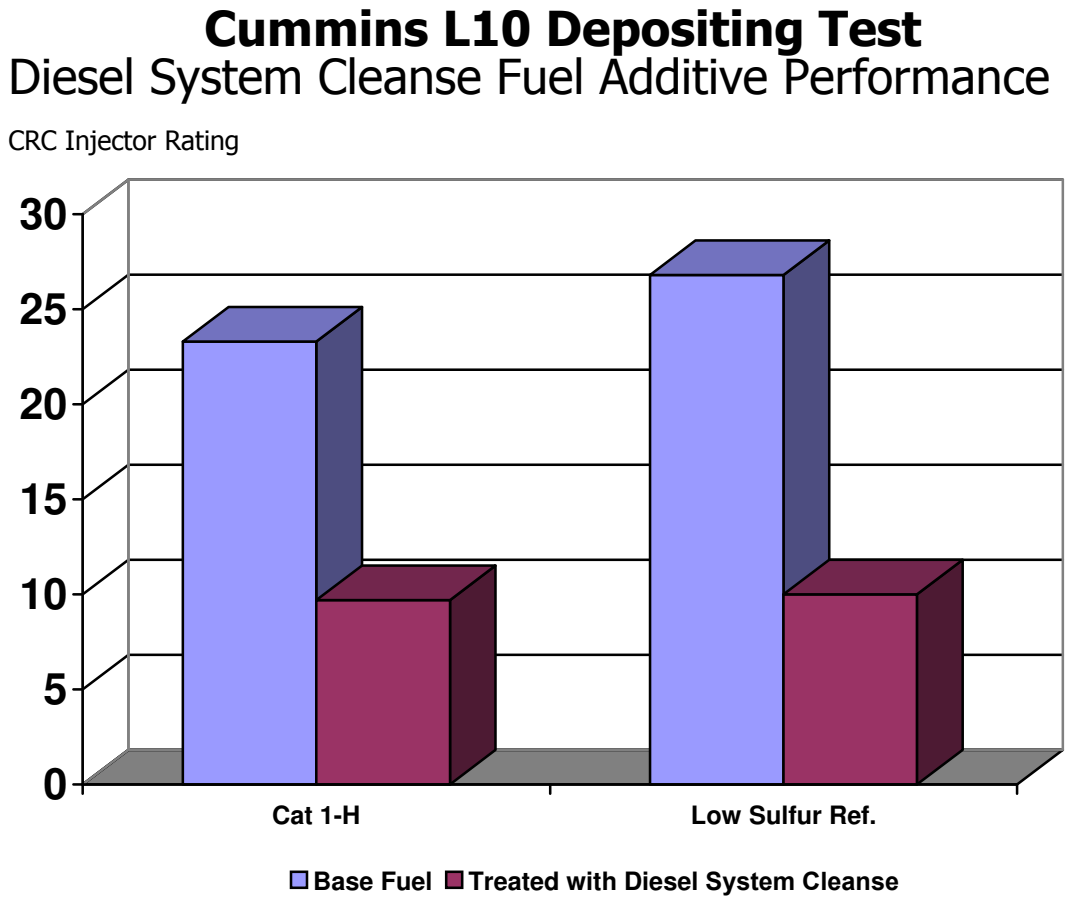


Testing run in Cat 1-H Reference Fuel @310 ppm

Cummins L10 Injector Depositing Test Cycle	CRC Rating (Avg.)
Initial dirty-up base line Cummins L10 test (untreated fuel)	25.2
After Cummins L10 with Diesel System Cleanse	20.1

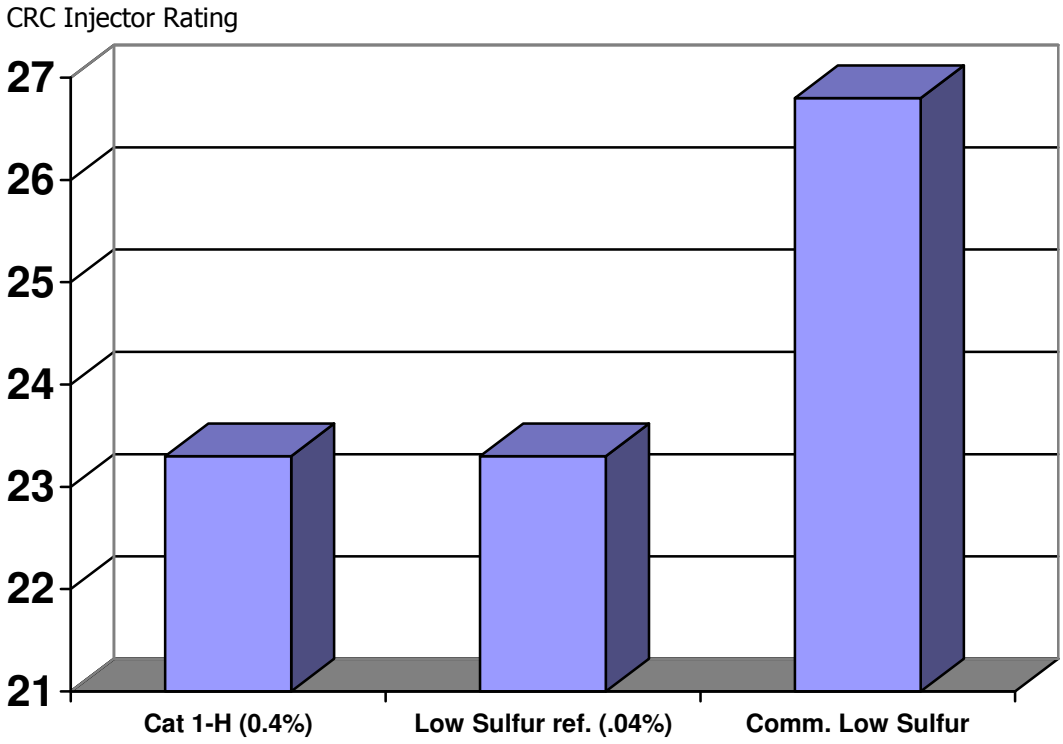
Fuel Sulfur Effects

The effects of fuel sulfur on base fuel performance in the Cummins L10 Injector Depositing Test is currently being investigated. Preliminary Additives, Inc. data indicates that low sulfur fuels may be more severe in this test. Base Fuel results are graphed in the following graphic. Diesel System Cleanse has successfully passed the Cummins L10 test in fuels with a range of sulfur content including the new low sulfur reference fuel.



	Base Fuel	Diesel System Cleanse
Cat 1-H	23.3	9.7
Low Sulfur Reference	26.8	10

Cummins L10 Injector Depositing Test
Fuel Sulfur Effects



125 Hour – Tandem Engine Stand

	Cat 1-H (0.4%)	Low Sulfur Ref. (.04%)	Comm. Low Sulfur
Fuel Sulfur Effects	23.3	26.8	39.1

Peugeot XUD 9 Nozzle Coking Test

The Peugeot XUD 9 Nozzle Coking Test is recognized as an industry evaluation of deposits in an indirect injected passenger car diesel engine. It was developed in Europe by Group PF26 of the CEC.

Test Parameters

Engine	Peugeot XUD-9
Cylinders, swept volume	4, 1.9L
Speed	3000 rpm
Load	58 Nm
Duration	6 hours

Test/Criteria Summary

New nozzles are flowed with air and measurements are taken at lift points of 0.1, 0.2, 0.3, and 0.4 mm. The nozzles are reassembled in the engine. The engine is warmed up to test conditions and then run for six hours. Nozzles are then reflowed and compared to the initial flow rate.

The original procedure was developed by Group PF26, but they specified no pass/fail limits. A French OEM group, CFCA, has developed a pass-fail criteria of greater than 15% remaining injector flow as compared to original flow at 0.1 mm of pintle lift.

Results

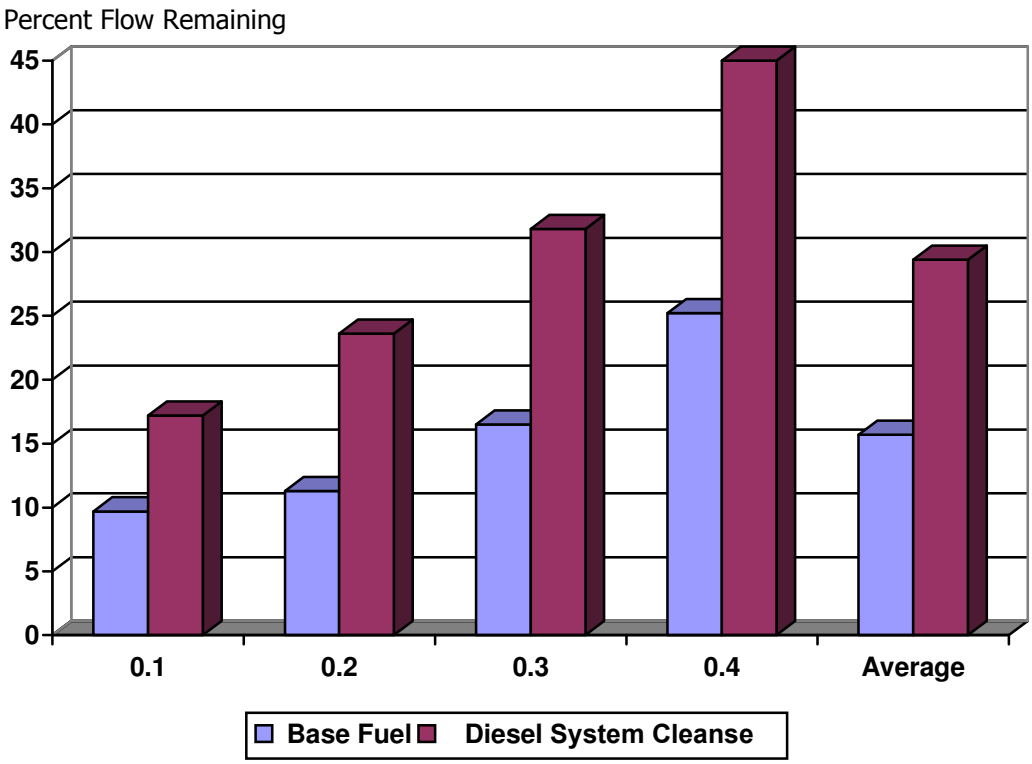
The following graph details the excellent results for Diesel System Cleanse. Diesel System Cleanse treated fuel gave an 87% improvement in Average Residual Flow and passed CFCA requirements. Combined with the excellent Cummins L10 results, this demonstrates Diesel System Cleanse performance versatility for DI and IDI engines.

Peugeot XUD-9 Nozzle Coking Test

Diesel System Cleanse

Diesel Additive Performance

Pintle Lift (mm)



CEC RF/03/A/84 Reference Fuel

Pintle Lift (mm)

	0.1	0.2	0.3	0.4	Average
Base Fuel	9.7	11.3	16.5	25.2	15.7
Diesel System Cleanse	17.2	23.6	31.8	45	29.4

Cummins N14 Corrosion Test

Background

Cummins had a field problem that occurred in some fleets in the Pacific Northwest. Certain engines experienced increased injector corrosion that led to a noticeable decreased fuel economy and injector life. Cummins analyzed the driving patterns of the affected fleets and a laboratory test method was developed to simulate these deposits. The test can be used to discriminate fuel/fuel additive quality and was reported at a Detroit Advisory Panel meeting.

Test Summary

- N-14 Cummins Engines
- 750 RPM, No Load
- 35 minute cycle – 30 minute at low idle then 5 full throttle snap accelerations to high idle
- 200 hour duration
- Rating
  - Percent flow increase

Cummins Criteria

Acceptable -	Flow Increase < 0.6%
Superior -	Flow Increase < 0.3%

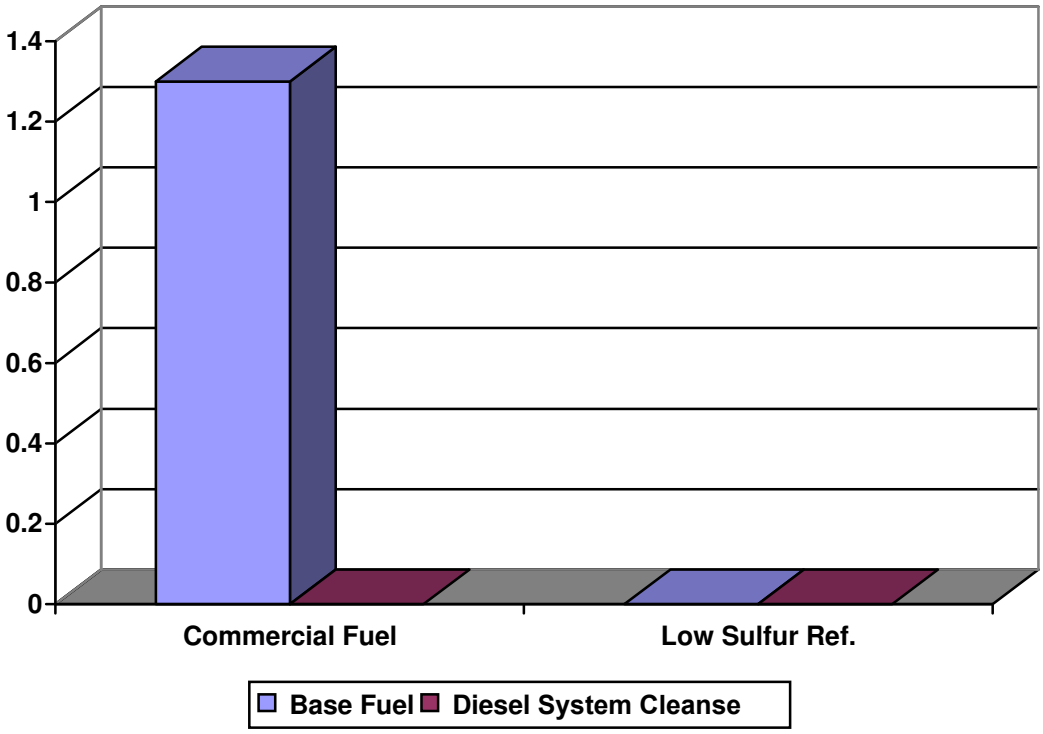
Test Results

Attached in table and graphical form. Diesel System Cleanse @310 ppm shows excellent results.

Cummins N14 Corrosion Test

Diesel System Cleanse

Diesel Additive Performance



	Commercial fuel	Low Sulfur Ref.
Base Fuel	1.3	0
Diesel System Cleanse	0	0

Laboratory Bench Tests

The following laboratory tests can also be used to evaluate diesel fuel quality and additive effectiveness. Below is a short description of each test. The following pages give test conditions, equipment schematics, and test results using Diesel System Cleanse. Diesel System Cleanse offers excellent wear protections, oxidation stability, corrosion protection, and water separation.

ASTM D 5001, BOCLE Test
Measure of a fuel's lubricity characteristic. (The Additive, Inc. scuffing test method is a modified BOCLE test that better simulates conditions in a diesel engine.)

ASTM D 2274, Fuel Oil Stability Test
Measure of the oxidative stability of a diesel fuel.

National Association of Corrosion Engineers (NACE) Rust Test
Measure of the anti-corrosion ability of a fuel.

ASTM 1094, Water Tolerance
Measure of a fuel's Ability to separate from water.

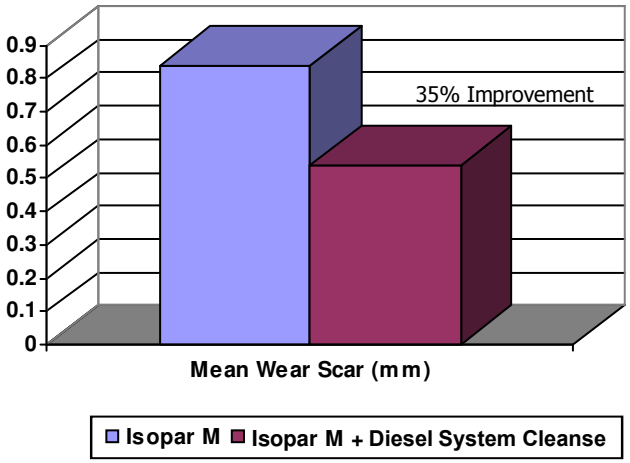
ASTM D 5001 BOCLE Test

Test Parameters

Base Fuel	Isopar M (50ml)
Temperature	25° C. (77° F)
Relative Humidity	10%
Test Conditions	Non-rotating ball applies 1000 g force to cylinder rotating @ 240 RPM
	30 minute duration
Performance Criteria	Measure wear scar on ball

Test Results

Fuel	**Mean Wear Scar (mm)**
Isopar M	0.838
Isopar M + Diesel System Cleanse	0.541



Conclusion

Diesel System Cleanse, when added to Isopar M reference fuel provides excellent anti-wear performance as measured by the ASTM D 5001 BOCLE Test (35% improvement).

The BOCLE test was developed to evaluate the lubricating properties of aviation fuels. The wear mechanism is corrosion related, which may not simulate the fuel wear mechanism in a diesel engine.

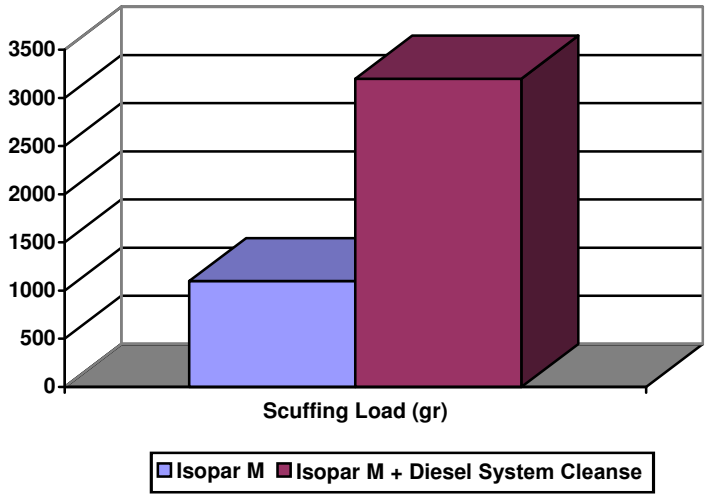
ASTM D 5001 BOCLE Test US Army Scuffing Method

Test Parameters

Base Fuel	Isopar M (50ml)
Temperature	25° C. (77° F)
Relative Humidity	**50%**
Test Conditions	Non-rotating ball applies **variable** force to cylinder rotating @ **525 RPM**
	1 minute duration
Performance Criteria	Measure 8 gram load to scuffing

Test Results

Fuel	**Scuffing Load (gr)**
Isopar M	1100
Isopar M + Diesel System Cleanse	3200



Conclusion

Diesel System Cleanse, when added to Isopar M reference fuel provides excellent anti-wear performance as measured by the US Army Scuffing Modification of the ASTM D 5001 BOCLE Test.

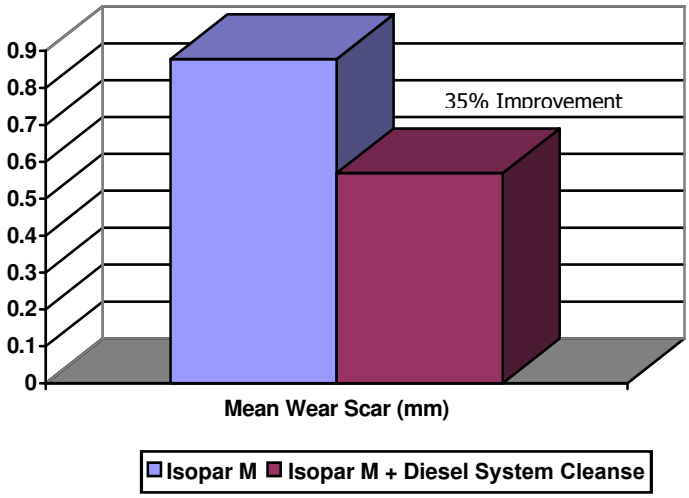
ASTM D 5001 BOCLE Test Additives, Inc. Scuffing Method

Test Parameters

Base Fuel	Isopar M (50ml)
Temperature	25° C. (77° F)
Relative Humidity	**50%**
Test Conditions	Non-rotating ball applies **7000 g** force to cylinder rotating @ **300** RPM
	2 minute duration
Performance Criteria	Measure wear scar on ball

Test Results

Fuel	**Mean Wear Scar (mm)**
Isopar M	0.878
Isopar M + Diesel System Cleanse	0.569



Conclusion

Diesel System Cleanse, when added to Isopar M reference fuel provides excellent anti-wear performance as measured by the Additives, Inc. Scuffing Modification of the ASTM D 5001 BOCLE test.

As sulfur levels are decreased in diesel fuel through more severe refining techniques, the inherent lubricating properties of the fuel decrease. Additives can be incorporated to enhance the wear protection of fuel system components and Additives, Inc. Scuffing Method results are a good determinant if additives are necessary.

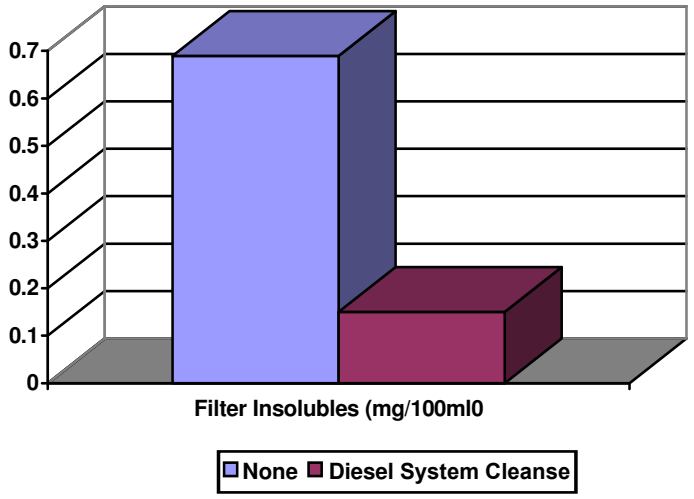
ASTM D 2274 Stability

Test Parameters

Base Fuel	Commercial No. 2 Diesel Fuel
Temperature	95° C. (203° F)
Test Time	16 Hours
Test Conditions	Oxygen is bubbled through the sample at a rate of 3 liter/hour
Performance Criteria	Amount of insolubles and the fuel color change.

Test Results

	ASTM Color		Filter Insolubles
Additive	**Initial**	**Final**	**(mg/100 ml)**
None	L0.5	L1.5	0.69
Diesel System Cleanse	L0.5	L0.5	0.15



Conclusion

In the ASTM D 2274 Fuel Oil Stability Test, Diesel System Cleanse provides excellent stability as illustrated by the 78% reduction in fuel insolubles and strong color stability. Oxidation of diesel fuel can cause the formation of gums, which can increase the formation of deposits and increase the chance of filter plugging. Diesel System Cleanse protects against oxidation.

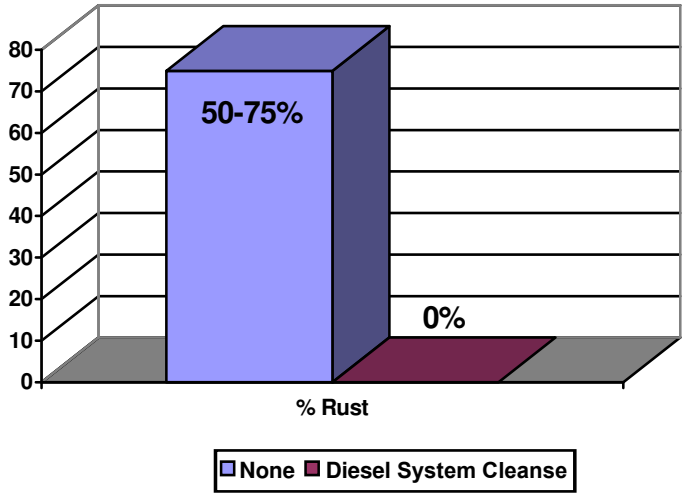
NACE Rust Test

Test Parameters

Base Fuel	Depolarized ISO-Octance
Temperature	37.8° C. (100° F)
Water Phase	Distilled
Fuel Water Contact	Stir fuel 30 minutes, stop, introduce water – stir 3.5 hours.
Steel Spindle	Polished, cold rolled SAE 1020, ½"
Performance Criteria	Visual evidence of rust

Test Results

	NACE	%
Additive	**Visual Rating**	**Rust**
None	D	50-75%
Diesel System Cleanse	A	0



Conclusion

Diesel System Cleanse provides superior anti-corrosion protection in Depolarized ISO-Octane fuel. This characteristic ensures superior anti-rust protection to storage facilities, fuel handling systems, and end users of diesel engines.

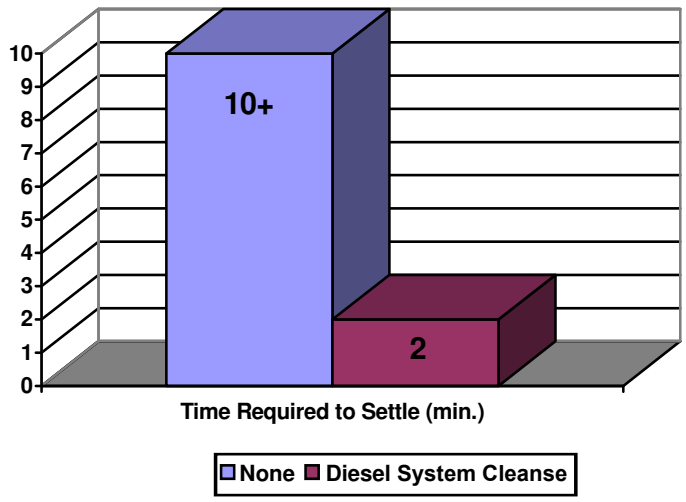
ASTM D 1094 Water Tolerance

Test Parameters

Base Fuel	Commercial No. 2 Diesel Fuel
Temperature	25° C. (77° F)
Water Phase	Distilled
Fuel/Water Contact	Hand shaken for 2 minutes (80 ml of fuel, 20 ml of water)
Settle Time	5 minutes
Performance Criteria	Degree of fuel/water separation, clarity of phased, interface rating

Test Results

	Rating after 5 minute		Time Required
Additive	**Interface**	**Separation**	**To Settle (min.)**
None	3	3	10+
Diesel System Cleanse	1	1	2



Conclusion

Diesel System Cleanse improves the fuel/water separation performance of base fuels to insure trouble free handling after any contact with water. Diesel System Cleanse will ensure that emulsions will not readily form, thus not causing driveability and rusting concerns.

Diesel System Cleanse

Fleet Test

Summary

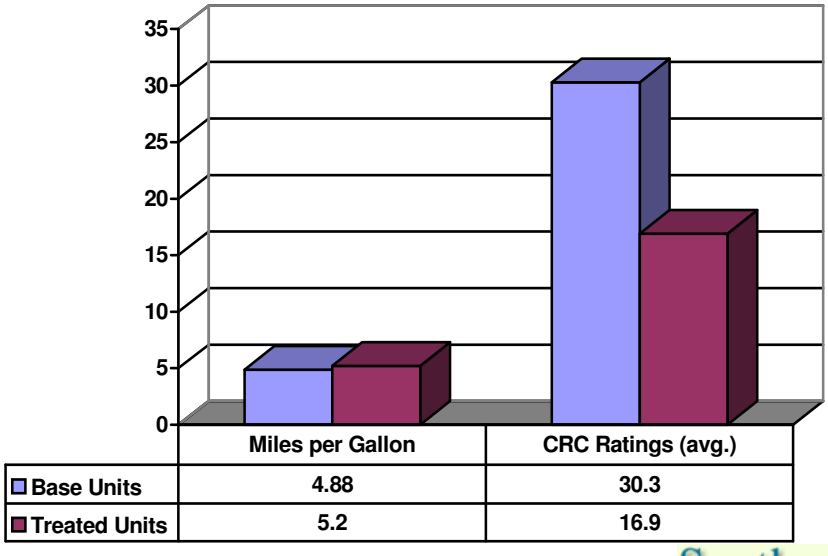
Diesel System Cleanse Fleet Test Overview

Fleet 1

Location	Charleston, SC
Fleet	Cement Trucks
No. of Units	22 Total 11 Base 11 treated
Engines	Cummins L10
Total Miles	400,000
Average Service	18,200 miles & 2,300 hours
Objective	The fleet was chosen in cooperation with Cummins Engine company and Engineering Test Services to closely match the L10 test cycle in service. (Engineering Test Services is a division of Cummins Engine Company.)
Test	The fleet was equipped with new injectors and monitored for one year. The injectors were then rated.
Conclusion	At the end of the test, the treated units had injectors that were 44% cleaner than the base unit injectors. The treated units also had more horsepower and better fuel economy.

Test Results

	Miles per Gallon	CRC Ratings (avg.)
Base Fleet	4.88	30.3
Treated Fleet	5.2	16.9

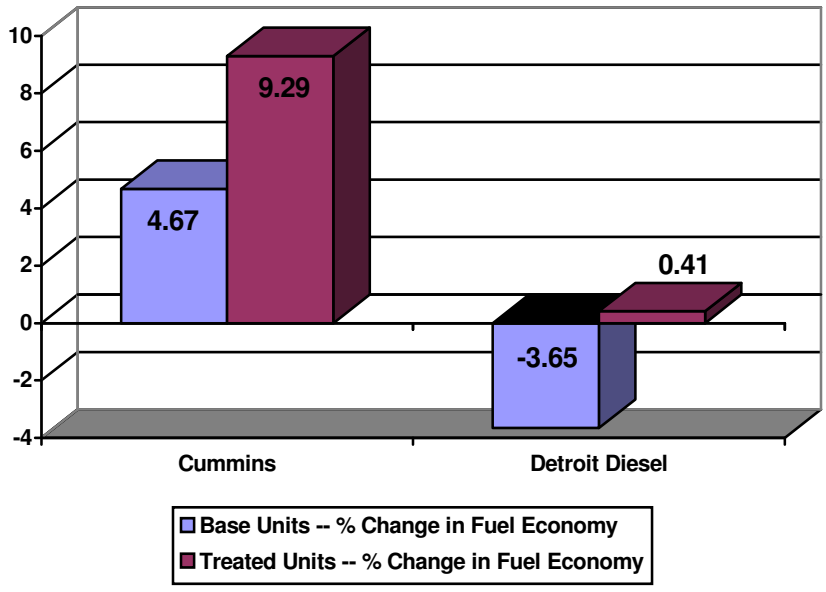


Fleet 2

Location	Charleston, SC
Fleet	Class 8 Line Haul
No. of Units	59 Total 31 Base 28 treated
Engines	Cummins L10, Detroit Diesel Series 60, Mack E6
Total Miles	2,750,000
Average Service	48,500 miles
Objective	The fleet represented a wel maintained line haul distribution fleet. This test monitored long term additive effects including injector cleanliness and fuel economy over a wide array of engines.
Conclusion	Data showed no fuel system related problems in the treated fleet and the treated fleet has experienced an improvement in over-the-road fuel economy.

Test Results

	Cummins	**Detroit Diesel**
Base Fleet – % Change in Fuel Economy	4.67	-3.65
Treated Fleet – % Change in Fuel Economy	9.29	0.41



Diesel System Cleanse

Emissions and

Power Data

Emissions Program

Test Sequence

- Run Cummins L10 Injector Depositing test with base fuel and fuel additized with 310 ppm of Diesel System Cleanse.
- At the conclusion of the test, remove injectors and place them in another L10 engine.
- Run the engine on the transient emission cycle. (The test is considered representative of real world driving conditions.) This cycle is used for on-highway certification of trucks in the USA and it has four phases that simulate driving in:
  - New York City highway
  - New York City urban
  - Los Angeles highway
  - Los Angeles urban
- Emissions, fuel consumption, and power are measured. Results of these tests are graphically represented on the following pages.

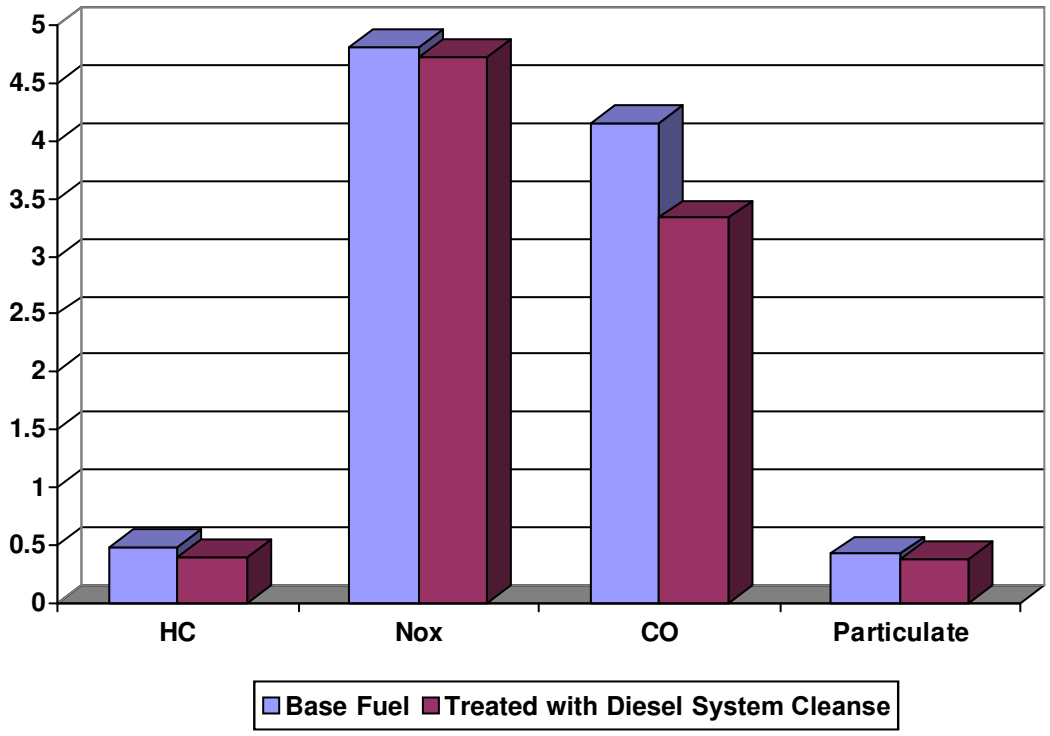
Conclusions

- Diesel System Cleanse significantly reduces emissions compared to unadditized fuel.
- Diesel System Cleanse provides excellent cleanliness within the engine, which leads to increased fuel economy.
- Diesel System Cleanse cleanliness and lubricity properties help to maintain engines in "like new' condition, which maintains power.

Composite FTP Emissions

Diesel System Cleanse
Diesel Fuel Performance

Emissions (G/BHp-Hr)



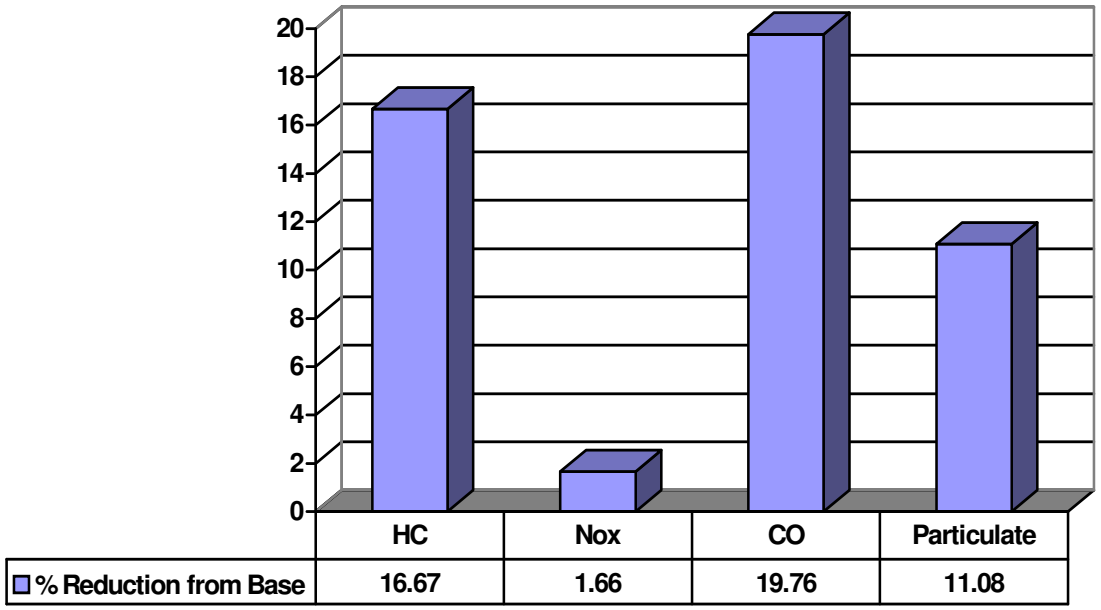
Emissions Test Cycle Run After Cummins L10 Test on the Injectors

	HC	NOx	CO	Particulate
Base Fuel	0.48	4.81	4.15	0.424
Diesel System Cleanse	0.4	4.73	3.33	0.377

Composite FTP Emissions Improvement

Diesel System Cleanse
Diesel Fuel Performance vs. Base

Percent Reduction from Base



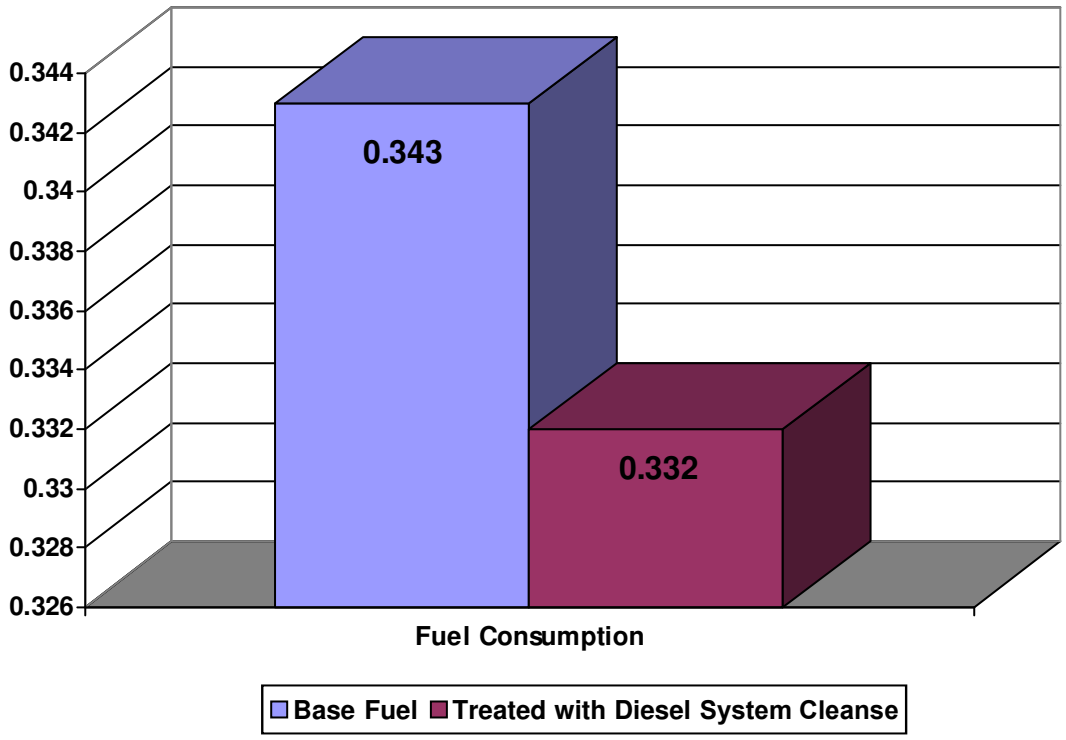
Emissions Test Cycle Run After Cummins L10 Test on the Injectors

	HC	NOx	CO	Particulate
Improvement - % Reduction from Base	16.67	1.66	19.76	11.08

Composite FTP Emissions

Diesel System Cleanse
Diesel Fuel Performance

LB/BHp-Hr



Data at Rated Load and Speed

	Fuel Consumption
Base Fuel	0.343
Diesel System Cleanse	0.332