

DETAILS OF AN INJECTOR DEPOSITING TEST FOR EVALUATION OF DIESEL QUALITY

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Diesel engine emission control can be greatly improved by maintaining the integrity of the fuel injection system. While previous efforts have focused on mechanical design improvements, it is clear that fuel quality issues must also be addressed. Poor quality fuels promote deposit formation, corrosion, and inadequate lubrication, all of which deleteriously impact injector performance. Cummins' commitment to improved diesel fuel quality resulted in the development of an engine laboratory test to

evaluate injector deposit formation. It is the only known test to measure diesel injector deposits and has been included in the EMA Premium Fuel Specification. The 125 hour test utilizes an '88 Cummins L10 engine alternating between powering and motoring cycles with injector deposits visually rated at the end of the test. Deposit levels and composition correlate well with field measurements with reasonable repeatability.

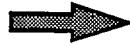
Details of an Injector Depositing Test for Evaluation of Diesel Fuel Quality

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University of California - San Diego

Introduction

- Diesel emission control improved by maintaining the integrity of the fuel injection system
- Fuel quality impacts:
 - deposit tendency
 - corrosivity
 - lubricity
 - filter plugging
- Cummins Engine Company committed to improved diesel quality worldwide



Injector
Performance



Overview

- Injector deposits have long history of occurrence
- Impact:
 - Engine performance
 - Emissions
- Hardware changes driven by emission regulations
- New focus: Diesel fuel quality



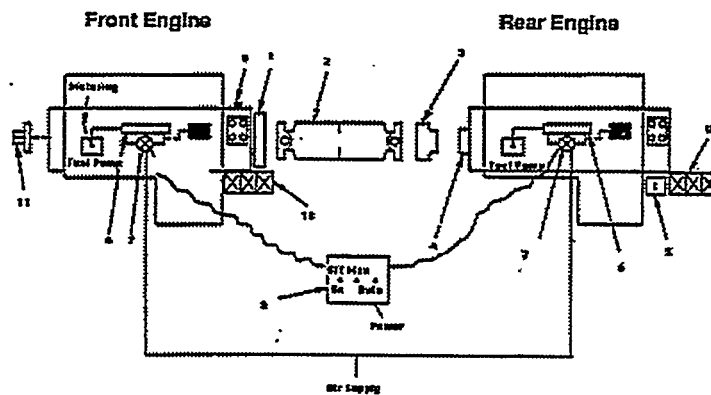
Background

- Performance loss due to deposit formation noticed by fleets operating in hilly areas
- Problem attributed to duty cycles with frequent periods of high speed driving and motoring
- Design change on the injector plunger provided a fix
- Fuel quality still an issue however



Test Development

- In response, Cummins developed an engine test to mimic the 'problem' duty cycle
- Cummins '88 L10 engine (6 cyl, DI, 300 HP)
Fixed time - PT fuel system
- Test cycle:
 - 2300 RPM/60 HP
 - 15 seconds driving/15 seconds driven (alternating)
 - 125 hours
- Tandem or dyno stand setup



Tandem Engine Schematic
L10 Injector Depositing Test



Injector Evaluation

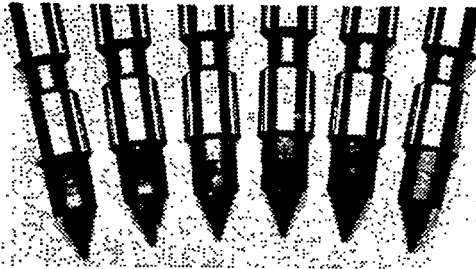
- Deposit rating
 - Visual rating of carbon and lacquer/varnish
 - Modified version of CRC piston deposit rating
 - Digital imaging method under development
- Flow
 - Injector flow measured before and after test



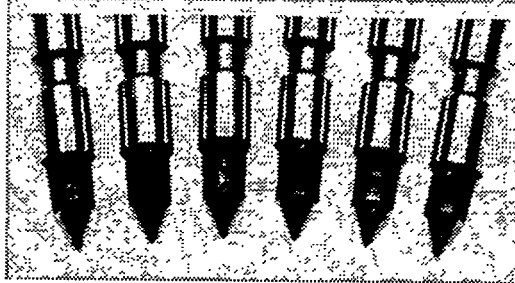
Test Stand Calibration

- Test stands referenced using specified fuel and additive
- Stands must reference within acceptance bands with a neat and additized fuel
- Neat fuel
 - Howell 0.4% Sulfur Diesel Test Fuel
 - Deposit rating: 21.2 - 28.6
- Additized reference fuel
 - Howell fuel with 200 ppm CRA-1





Reference Diesel Fuel Treated with 200 ppm CRA-1



Unadditized Reference Fuel



Test Stand Availability

- Qualified test stands established at five labs
 - 3 independent test labs
 - 2 additive suppliers
- 10 raters trained, workshops held periodically
- ASTM Surveillance Task Force formed
 - test standardization planned for '98
- Growing interest worldwide as test matures



Current Applications

- L10 IDT included in EMA's FQP-1
- Part of Cummins diesel fuel performance criteria
- Qualifying test for Thailand railroad diesel fuel
- Premium diesel increasingly prevalent in agricultural applications



Impact of Fuel Detergency

- Maintaining injector life means maintaining emission control capability and fuel economy
- Studies by Lubrizol, Paramins, Texaco demonstrate that prolonged use of treated fuels lowers:
 - fuel consumption
 - hydrocarbons
 - CO
 - particulates(as compared to fleets using untreated fuels)



Summary

- Cummins is devoted to improved diesel fuel quality worldwide
- An engine test is available to evaluate diesel detergency with reasonable precision
- Fuel detergency enhances the durability of the injection system...a positive for emission control and fuel economy

