

# ELECTRONIC FUEL INJECTION FOR DIESEL LOCOMOTIVES



13 August, 2011

Diesel Loco Modernisation Works, Patiala

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## A Milestone in Green Initiatives by Indian Railways

Hon'ble MR had announced in her Budget Speech in February 2011 that the Year 2011-12 would be the “**Year of Green Energy**”. Within just a few months of the declaration, Indian Railways have achieved the first major milestone in this direction for its fleet of Diesel Locomotives.

### Introduction

The first Diesel Locomotive equipped with “**Electronic Fuel Injection (EFI)**” was turned out by the Diesel Loco Modernisation Works (DMW), Patiala on August 13, a befitting gift to the nation on the occasion of the 64<sup>th</sup> Independence Day. **This is he first ever retrofitment of EFI on the ALCo locomotive in the world.** It also ranks among very few such efforts on large diesel engines.

Just as the Automotive technology has progressed from carburetted engines to MPFI and CRDi made possible by advances in microelectronics and control systems, the Mechanical Directorate of Engine Development in RDSO has taken up projects of modernisation of our fleet of over 4000 diesel locomotives. EFI is the first major step in this direction. Next step, already underway, is of CRDi, which will be the first outside North America.

### Collaborative Efforts of RDSO and IIT/Kanpur



Achieved purely indigenously due to collaborative efforts of **RDSO and IIT/Kanpur** at DMW, this landmark event heralds “greening” of diesel traction in the true sense. It also marks the culmination of the synergic teamwork of industry and academia previously unseen on Indian Railways and opens the doors to numerous such possible collaborations in the future.

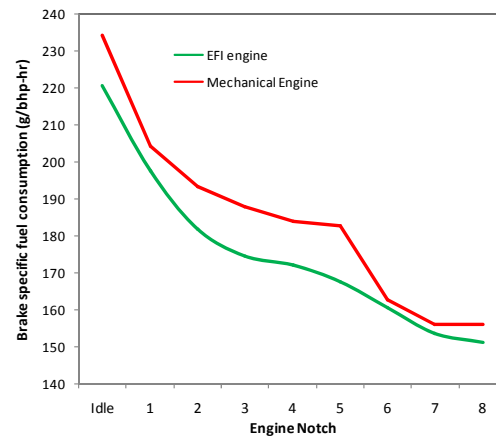
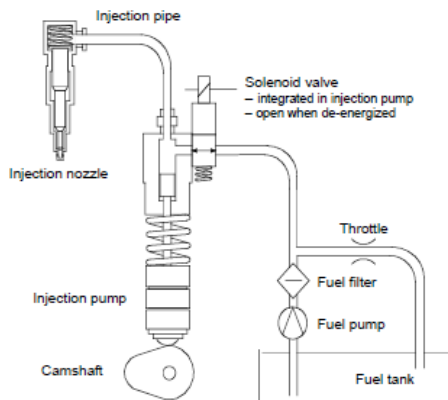
### Benefits of EFI

1. Electronic Fuel Injection, unlike the widely used mechanical injection system, makes precise injection of fuel possible to match the demand of load, optimize fuel consumption and cuts down emissions.
2. **Saving of 4% of High Speed Diesel** over the duty cycle of the diesel locomotive. This is over and above that achieved due to upgrades already made on the locomotives. **The potential saving is enormous, considering the Indian Railways consume nearly 250 Crore litres of fuel costing approximately Rs 10,000 Crores.**
3. Complete elimination of black smoke. This not only saves the environment, but also saves fuel since black smoke is caused by incompletely burnt fuel.

4. Elimination of hot engine failures
5. Elimination of large number of mechanical components, reduction in maintenance and increase in reliability
6. Better control and diagnostics

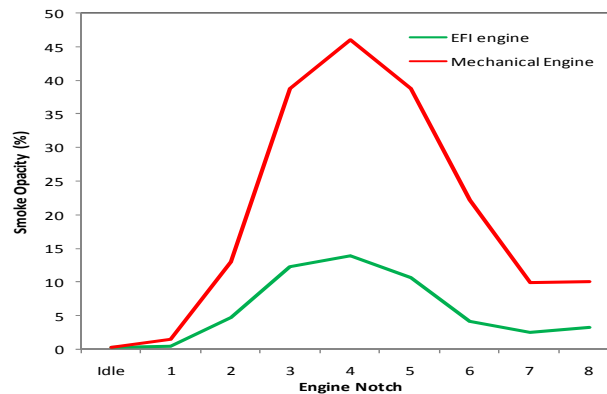
### How is it Achieved?

1. Such savings and improvements are made possible by matching of fuel consumption of the diesel engine to demand and speed at every notch. Previously such optimization was possible only at the maximum power level, since mechanical systems, did not permit intermediate optimizations.



### FUNDAMENTALS OF EFI

### SPECIFIC FUEL CONSUMPTION



### REDUCTION IN SMOKE OPACITY

2. An Engine Control Unit (ECU) sits between the Locomotive Controller Computer and the Fuel Delivery mechanism (Injection Pump and Injector) monitoring the need of fuel on a real time basis. It advances or retards fuel injection based on engine speed as well.
3. The actuation of solenoid valves controlling fuel happens in milliseconds as compared to seconds on mechanical systems thus preventing wasteful burning of fuel.

4. The research and development work includes hundreds of hours of trials and mapping of fuel requirements. EFI offers options exist to maximize power, optimize fuel consumption, minimise emissions and optimise engine response. This is preceded by hundreds of hours of simulation on computer and specialized software.

### **Expenditure**

Expenditure per loco on scales of production will be approximately Rs 24-25 lakhs. Considering the fuel expenditure of Rs 10,000 Crores on IR and average fuel consumption by each loco at Rs 25 Crores, the payback for the retrofit @savings of 4% is less than six months.

### **Challenges Faced and Overcome by the RDSO Team**

1. ECU Calibration was a totally new area. There was no expertise/ knowledge how to interface the EFI Electronic Control Unit to the Locomotive microprocessor.
2. Lack of knowledge about control systems, non-availability of any controls lab in RDSO posed a big problem
3. Industry was approached. But they expressed either inability, or mentioned very long lead times and quoted high costs.
4. Understanding of extensive documentation by the supplier posed a challenge.
5. An MOU was signed with IIT, Kanpur.

### **Roles and responsibilities**

#### ***Engine Development Directorate, RDSO***

- Overall project management and delivery
- Procurement of all parts
- UG modeling for design of headers, harness paths, layout etc.
- Engine simulation studies
- Calibration of the ECU to establish various limits
- Engine testing at RDSO, Diesel Shed Alambagh and final fitment at DMW

#### ***IIT Kanpur***

- Interfacing of the EFI system to the Test Cell controller
- Interfacing of the EFI system with the Locomotive Traction control computer
- Overall integration of the EFI electronics with the Locomotive electronics