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Approved by:	Engine Development Directorate Research Designs and Standards Organisation, Manak Nagar, Lucknow	First issued: May-2013 Supersedes:
Subject	Electronic Fuel Injection Pump (16mm plunger dia.)	
Affects Models	DLW built 16 cylinder 3100/3300/3600 hp ALCo locomotives	
Ref. Drawings	ED.6.10.3/2013/1 & ED.6.10.3/2013/2	
Originator		
Supplier	The following information is the property of Engine Development Directorate of Research Designs and Standards Organisation , Manak Nagar, Lucknow and must be treated as privileged communication between suppliers and Indian Railways	

1. INTRODUCTION

Electronic Fuel Injection (EFI) pump is a constant stroke solenoid valve operated fuel injection pump installed on each cylinder of DLW built 16 cylinder ALCo engines. It is operated by camshaft working through a lever and roller arrangement. The amount of fuel injected and the time of injection is controlled by the Engine Control Unit (ECU) through a solenoid valve fitted on the EFI pumps. Low pressure fuel is delivered to the EFI pump by a fuel booster pump. Excess quantity of inlet fuel is returned to the fuel tank through return header after cooling the solenoid valves of EFI pumps. High injection pressure is developed by the pumping action of the pump barrel once the ports are closed. Fuel is delivered to the injector through a delivery valve fitted above the EFI pump. Delivery valve is working a non-return valve and also controls pressure waves inside the fuel line.

2. GENERAL OPERATING CONDITION

2.1 Adjustment Features

2.1.1 Free adjustment of begin of delivery within cam related borders depending on engine demand (load and speed)

2.1.2 Pump/cylinder individual control of delivery possible if ECU is capable

2.2 Emergency Stop

Immediate stop of delivery by non-energizing of valve to prevent over-fuelling in case sudden load drop

2.3 Environment

2.3.1 EFI pump is to be fitted on each FIP support of the engine block, the temperature around the engine block is to be around 100 °C.

2.3.2 Lubrication between barrel and plunger is to be provided by diesel fuel available inside the EFI pump.

2.3.3 Solenoid valve is to be cooled by the diesel fuel circulated through the solenoid valves.

2.4 Fuel Specification

Fuel is to be as per Automotive Diesel Fuel specification no. IS 1460:2005 fifth revision or latest.

2.5 Fuel Filtration

Two stage, 10µm primary and 5µm secondary.

3. EXPECTED PERFORMANCE

- 3.1 Maximum acceptable failure rate in two years, including all failure mode is 0.25%.
- 3.2 Maximum allowable change in calibrated fuel delivery per stroke in two years is 2.0%.

4. DESIGN SPECIFICATIONS

4.1 Electronic Fuel Injection Pump

4.1.1 Geometric Data

S.No.	EFI Characteristic data	Value
1.	Plunger diameter	16 mm
2.	Plunger stroke	20 mm
3.	Pump BDC dimension and other mounting dimension	6.5±0.2 mm
4.	High pressure line- Minimum inner diameter Maximum length	2.72 mm 557 mm
5.	Thread connection	7/8"-14UNF-2B
6.	Pump mounting	4XM14 bolt mounting with maximum contact pressing underneath bolt 400N/mm ²
7.	Push rod	Diameter to pump 19mm guided in engine structure with spherical radius on contact with pump plunger Angular deviation of 0.45 ⁰ from pump axis

4.1.2 Functional Data

S.No.	EFI Characteristic data	Value
1.	Max. System Pressure	1300 bar
2.	Max. pump output	1450 mm ³ /stroke
3.	Rated pump speed	525 rpm
4.	Max. pump speed	600 rpm

4.1.3 Low Pressure fuel circuit

S.No.	Characteristic	Value
1.	Nominal inlet pressure to pump	4-6 Bar (rel.)
2.	Fuel supply flow	19 litre/minute
3.	Fuel supply temperature	Upto 60 deg C
4.	Fuel supply connection with pump	7/8"-14UNF-2B

4.1.4 The EFI pumps is to be stamped in the specified manner by part number and

serial number.

4.2 GDV holder Assembly

- Maintain constant residual pressure in high pressure pipe at all speed.
- Reduce the danger of the cavitations in high pressure circuit.
- Pressure fluctuation is avoided.
- The delivery valve is to contain a non return valve to prevent cylinder pressure back flow.
- The valve spring is to be made of a high quality chrome vanadium steel.
- No assembly tool will be required to assemble the delivery valve other than a torque wrench for obtaining proper torque.
- The manufacturer will specify the proper tightening torque.
- No gasket is to be used at the EFI pump to the delivery valve seat
- Hydraulic tightening test: To check the sealing effectiveness with a supply pressure of 10 bar.

S. No.	Characteristic data	Nominal value
1.	GDV opening pressure return side	130 bar
2.	GDV opening pressure forward side	~30 bar
3.	GDV lift	0.30 mm

4.3 Solenoid Valves

S. No.	Characteristic data	Nominal value
1.	Operating voltage	24 V DC
2.	Voltage range	16-33 V DC
3.	Pull in voltage	5.56 V DC
4.	Pull in current	16-18 Amp
5.	Pull in duration	< 1100 μ s
6.	Boost current	12A
7.	Hold current	5-10 A
8.	Hold in duration	10 ms
9.	Free air Inductance	0.410 \pm 0.06mH
10.	Winding wire	0.643mm (Bare wire)
11.	Fly time	0.8 mS
12.	Working temperature range	-40 to 125 $^{\circ}$ C
13.	Protection grade	IP 66K

5. Maintenance

The pumps will require reconditioning after 18 months of usage. For this the pumps will be returned to OEM. Any intermittent repair will also be done by OEM. Centralized rate contract may be entered into by Indian Railways for repair and reconditioning of these pumps.

6. PRODUCTION INSPECTION FOR QUALITY ASSURANCE

The method of inspection and sample size shall be arrived at by mutual negotiations between the supplier and Indian Railways's quality control department and vendor quality assurance committee. All test procedures called out on any applicable Engineering Test Instructions must be followed. The manufacturer to indicate applicable engineering test instructions for their equipment.

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EFI Pump Drawing

The drawing includes the following views and dimensions:

- Front View:** Shows a cylindrical pump with a diameter of $\Phi 114.3$ and a length of 190 ± 0.8 . It features four injection ports, each with a diameter of $\Phi 15 \text{ H}12 \text{ } \Phi 10 \text{ T}14$. The top surface has a diameter of $\Phi 71.4 \pm 0.06$ and a height of 18.5 ± 0.2 from the top flange. The bottom flange has a diameter of $\Phi 114.3$ and a thickness of 1.8 .
- Side View:** Shows the pump's profile with a total height of 106.5 ± 0.4 . The fuel inlet is located 28 units from the bottom, and the fuel outlet is 94.5 units from the bottom. The top flange has a diameter of 114.3 and a thickness of 1.8 . A note indicates that the outlet pipe must have a provision for a valve with opening pressure approx. 5 bar.
- Cross-sectional View:** Shows the internal components, including the fuel inlet and outlet ports, and the internal plunger mechanism. The fuel inlet is labeled "FUEL INLET" and the fuel outlet is labeled "FUEL OUTLET". Both are specified as $7/8" \text{ } 14.6\text{M} \text{ } 28 \text{ STRAIGHT THREAD}$. The stroke length is 20 units. The fuel inlet has a diameter of $\Phi 14.6 \pm 0.3$ and a chamfer of $R 0.4$. The fuel outlet has a diameter of $\Phi 14.6 \pm 0.3$ and a chamfer of $R 0.4$.

CONNECTION TO ELECTRONIC CONTROL UNIT
M/F 5% MAX. TORQUE 6 Nm

Note : Outlet pipe of the pump must have a provision for a valve with opening pressure approx. 5 bar

APPENDIX

D	29	*SURFACE ROUGHNESS TO IS:3073
C	6.3	*WELDING SYMBOLS TO IS:813
APPD	0.8	ROUND DIMENSIONS TO IS:2101
DR	0.1	

REF. I.R. NO.	DESCRIPTION	NO. OF SETS	DATE

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ELECTRONIC FUEL INJECTION PUMP
(16mm PLUNGER DIA.)

SCALE: 1:1

REF: EDC-ED.6.10.3/2013/1

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GDV Drawing

