

Issued by: Director/ED/RDSO	<b>ENGINEERING DESIGN PERFORMANCE SPECIFICATION</b>	No: TS/ED/2013/71, revision-2 Issued: March-2015
Approved by: Sr.ED/ED(CNG) RDSO	Engine Development Directorate Research Designs and Standards Organisation, Manak Nagar, Lucknow	First issued: June-2013 Supersedes: TS/ED/2013/71, rev.-1 of April-2014
Subject	Electronic Fuel Injection Pump (16mm plunger dia.)	
Affects Models	DLW built 16 cylinder 3100/3300/3600 hpALCo 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 a non-return valve and also controls pressure waves inside the fuel line.

## 2. GENERAL OPERATING CONDITION

### 2.1 Adjustment Features

- Free adjustment of begin of delivery within cam related borders depending on engine demand (load and speed)
- Pump/cylinder individual control of delivery possible if ECU is capable

### 2.2 Emergency Stop

Immediate stop of delivery by non-energizing of solenoid (magnet) valve to prevent over-fuelling in case of sudden load drop.

### 2.3 Environment

- EFI pump is to be fitted on each fuel injection pump (FIP) support of the engine block, the temperature around the engine block is to be around 100 °C.
- Lubrication between barrel and plunger is to be provided by diesel fuel available inside the EFI pump.
- 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 Bureau of Indian Standards (BIS), specification number IS 1460:2005, fifth revision or latest.

## 2.5 Fuel Filtration

As per RDSO's specification MP.0.2600-25 of December 2008 (Rev.00).

## 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 (Annexure 1)

S.No	Parameter	Value
1.	Plunger diameter	16 mm
2.	Plunger stroke	20 mm
3.	Pump BDC dimension and other mounting dimensions	6.5±0.2 mm
4.	High pressure line- Minimum inner diameter Maximum length	2.72 mm 557 mm
5.	Thread connection	7/8"-14 UNF-2B
6.	Pump mounting	4 X M14 bolt mounting with maximum contact pressing underneath bolt 400 N/mm <sup>2</sup>
7.	Push rod	Diameter to pump 19 mm guided in engine structure with spherical radius on contact with pump plunger Angular deviation of 0.45° from pump axis

#### 4.1.2 Functional Data

S.No.	Parameter	Value
1.	Maximum System Pressure	1300 bar
2.	Maximum pump output	1450 mm <sup>3</sup> /stroke
3.	Rated pump speed	525 rpm
4.	Maximum pump speed	600 rpm

#### 4.1.3 Low Pressure fuel circuit

S.No.	Parameter	Value
1.	Nominal inlet pressure to pump	4-6 Bar
2.	Fuel supply flow	44 liter/minute
3.	Fuel supply temperature	Up to 60° 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 serialnumber.

## 4.2 GDV (delivery valve) holder Assembly (Annexure 2)

### 4.2.1 Delivery valve carries out the following functions:

- Maintains 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.

### 4.2.2 Instructions for manufacturing and fitment:

- 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	Parameter	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.	Parameter	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 $\mu$ s
6.	Boost current	12A
7.	Hold current	5-10 A
8.	Hold in duration	10 ms
9.	Free air Inductance	0.410 $\pm$ 0.06 mH
10.	Winding wire	0.643 mm (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. The pumps will be returned

to OEM for reconditioning. 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.

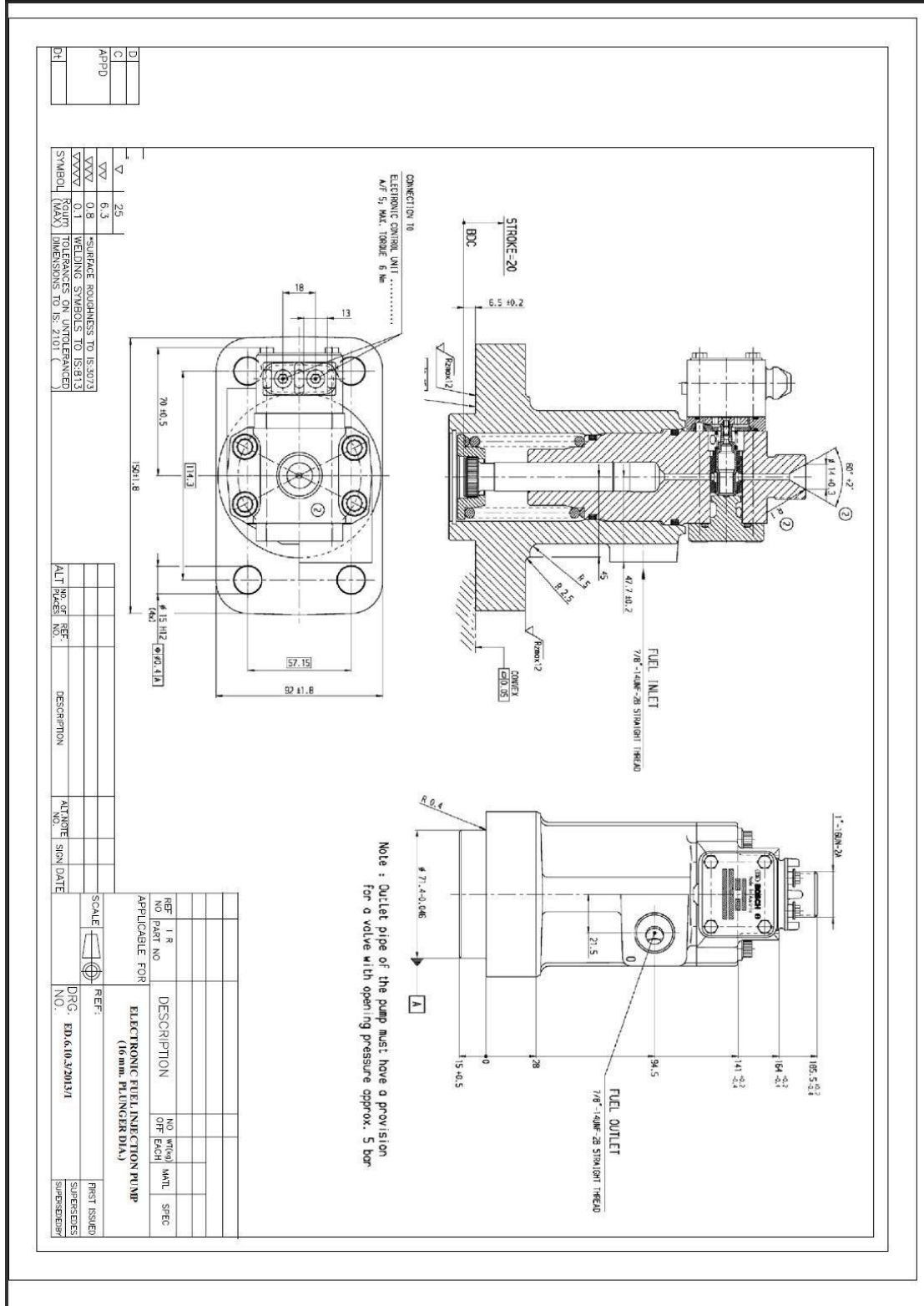
## 6. RELIABILITY DEVELOPMENT OF THE EFI SYSTEM

- a. In case of first supply of the EFI pumps, the same have to be first qualified for system optimization/tuning/performance testing on the Engine Test Bed in Engine Development Directorate at RDSO. During the engine validation tests on the Engine Test beds at RDSO, the supplier will be associated and will carry out necessary design modifications and replacement of parts / systems with the modified ones as may be required. These tests will have to ensure 500 hrs of testing and will be completed within six months from the date commencement of tests.
- b. After successful completion of the basic validation testing on the Engine Test Beds in the Engine Development Directorate at RDSO, 10 sets will be tested on Diesel locomotives for Reliability Verification Testing (RVT) (including the set tested on the Engine Test Bed as in (a) above. This test will be for duration of one year on a population of 10 EFI fitted diesel locomotives. During this period, all the failure modes experienced during the operation of the diesel locomotives will be documented and the supplier will carry out the necessary trouble shooting jointly with Indian Railways (RDSO and the Diesel sheds). The supplier will carry out the necessary design/ manufacturing modifications and introduce modified components on the locomotives so as to ensure that the Reliability of the EFI pumps is proven. At the end of the one year period it is understood that all possible failure modes will be identified and corrective and preventive action introduced by the supplier (for Design and Manufacturing issues) and Indian Railways (RDSO and Diesel Sheds for the Maintenance issues) will be completed. During the RVT period the supplier will ensure operation for minimum 2000 hours or one year whichever is later, from the date of start of tests.
- c. In supply beyond the 10<sup>th</sup> loco set EFI pumps will incorporate all modifications as implemented during the Reliability Verification Testing (RVT). Supply beyond the 10<sup>th</sup> EFI system will be construed as Series supply and standard stores warranty of Indian Railways shall be applicable.

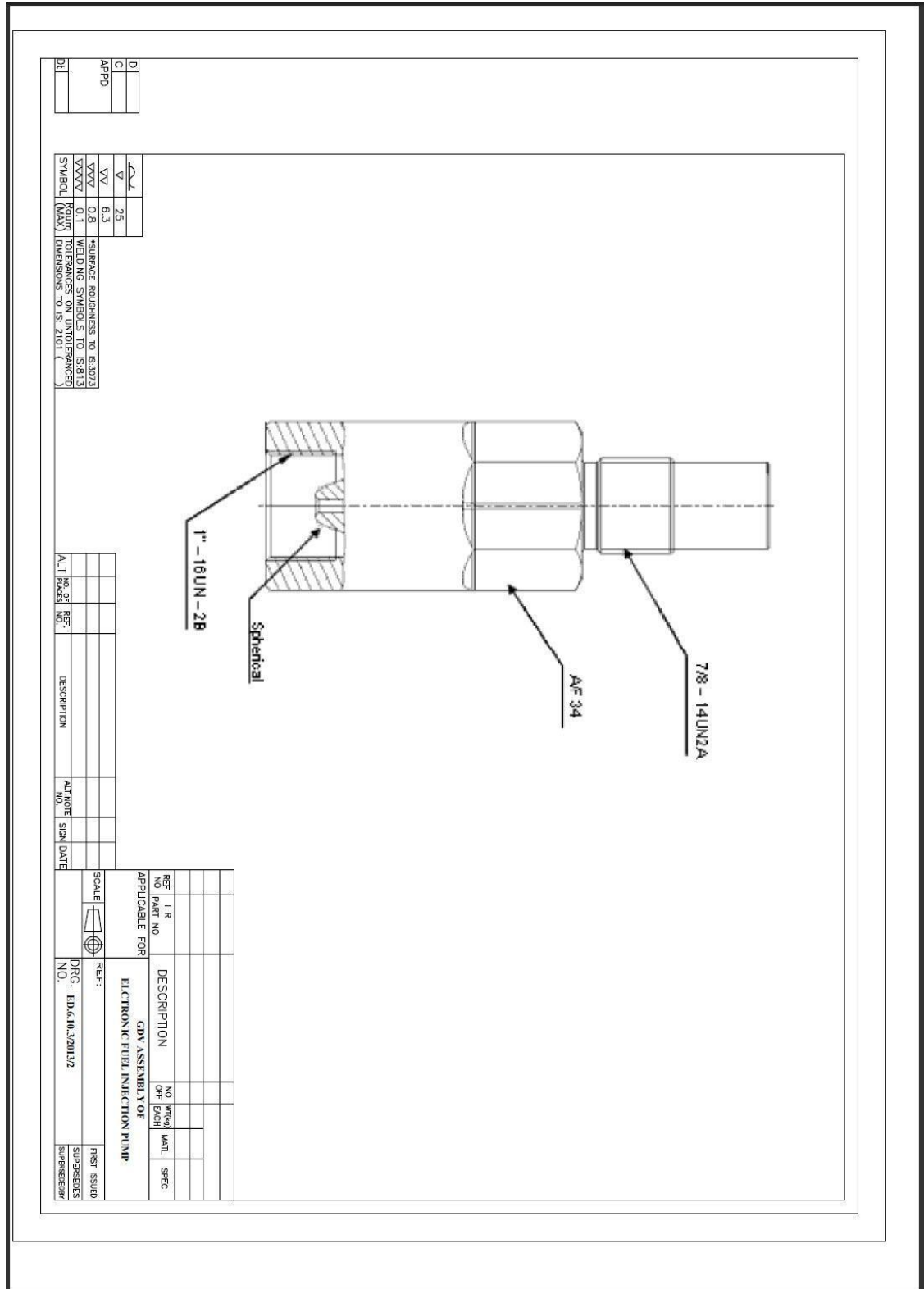
## 7. PRODUCTION INSPECTION FOR QUALITY ASSURANCE

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.

Annexure-1  
EFI Pump Drawing



Annexure-2  
GDV Drawing



D	
C	
APPD	
DL	

√	25
∇	6.3
∇∇	0.8
∇∇∇	0.1
SYMBOL	ROUND BARRIERS TO IS: 2191

\*SURFACE ROUGHNESS TO IS:3073  
TOLERANCES ON DIMENSIONS TO IS:813  
WELDING SYMBOLS TO IS:813

ALT	NO. OF	REF.	DESCRIPTION	ALTNOE	SIGN	DATE

SCALE	REF.	DRG. NO.	FIRST ISSUED SUPERSEDES
1:1		ED/4.10.3201/2	
APPLICABLE FOR	DESCRIPTION	NO. WITH OFF EACH	MATL SPEC
	GDV ASSEMBLY OF ELECTRONIC FUEL INJECTION PUMP		