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A Study On Fuel Injection Pumps And Nozzle In A Diesel Locomotive In Diesel Loco Shed Visakhapatnam, Andhra Pradesh India

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Abstract:

India being developing country transportation is important aspect of it to be one of the developed countries in future. Thus a comfortable transportation is important for its growth. Trains contribute major transportation facilities among India in majority like transport of goods, raw materials, posts, couriers, services sometimes, and passengers to carry on their journey. These results in effective transportation with less capital to government and to people, which is only possible India's present young engineers. Locomotive being the major part of train to work the detailed study of locomotives is must these locomotives are of various types and various principles involve in them. This works only with external force in the form of fuel. Fuel is the important ingredient for locomotive to work. Hence the fuel managing systems are of the vital importance. These fuels are of various types including conventional and non conventional resources. The major fuel used in India is diesel. This particular paper throws light on the fuel injection pumps and nozzles in a diesel locomotive. This study enlightens various parts, functions, assembling, disassembling testing working of nozzles and pumps.

This project wouldn't have been successful if we haven't received help from the members of the Diesel Loco Shed Visakhapatnam, Andhrapradesh, India. We thank each and every member of it for making our mission successful.

We are grateful to Sri S.R. Sethi, Sr. Divisional Mechanical Engr., Sri G. Shankar Reddy- Asst Divisional Mechanical Engr., Mr. T.R.S. Babu Junior Engineer Cum Our Project Guide And All Staff Members Of Diesel Loco Shed (VSKP) for giving us the opportunity to educate ourselves on diesel locomotives.

1.Introduction

1.1.Visakhapatnam Diesel Loco Shed

Diesel Locomotive Shed, Visakhapatnam (DLS/VSKP) was established on 2nd May 1965 with a holding of 13 WDM1 Locomotives to meet the traffic needs in transportation of mainly Iron Ore from Bailadilla Mines to Visakhapatnam Port Trust for further export to Japan. Since then 45 years have passed and the holding of the shed kept on increasing. At present, the shed is the biggest Diesel Shed in Indian Railways with a holding of 203 diesel locomotives and 3 Rail buses.

Year of Establishment	**1965**
Road No./ Type of the first loco homed in Shed	BG / WDM 1
Details of any heritage Locos in Shed on pedestal or otherwise	Nil
ISO Certicification Year	2006 9001 14001 18001
Type - wise holding:-	WDM3A 40 WDG 3A 110 WDM 23 8 WDM 2S 5 WDS 6 10 Rail Bus 3 **Total 206**
Maximum Holding (Year/Number of Locos)	2010 / 206
Present Loco link	32
Homing Capacity	160

Augmentation Plans	NIL
Other History (Not more than 4 lines)	Chief Guest was a very senior retired Railway IRSME officer Shri M. G. Sripathi of SCRA-1957 batch who had worked as Sr.DME(D) of this Diesel shed during the shed celebrated its 45th foundation day on 08.05.2010 in which period June-1977 to March-1981

Table 1

1.2.Vital Statistics

1) Sanctioned Strength 1333

2) On Roll Strength 1079

3) No. of Officers 9

4) No. of Supervisors 112

5) Total Area 100 Acres (approx)

6) Covered Area 5.19 Acres (approx)

7) % age of Staff housed in Railway Quarters 32.32%

8) Power Consumption 80,000 KWH per month

9) Water Consumption 1Lakh Gallons per day

10) Educational Profile of Staff

up to 8th	> 8th	10th Pass	10-12th	I T I	Graduate
1.37%	4.40%	5.95%	14.38%	55.13%	18.77%

11 Age Profile of Staff

< 30 yrs	30-40	41-50	51-55	56-60
13.64%	29.94%	29.21%	9.70%	17.50%

12) MPR as circulated by E & R Dte:-

1.3.Performance Parameters (2009-10)

1 SFC (Liters per 1000 GTKM)

2 LOC (Liters per 100 EKM)

FREIGHT	PASSENGER
2.31	4.35
3.08	3.08

3 Shed consumption of fuel 1,09,776 Liters per month (average)

4 Kms. Earned by Shed Locos/month 17,59,857 Earned Kilometers per month

1.4.Important Innovations

It is the first Diesel shed in which the prototype intelligent low idling equipment was fitted for trial on locomotives No. 36267 WDS6 on 30.07.2009 as per instructions RDSO in association with M/s. Lotus Wireless Technologies Private Limited, Visakhapatnam. Since there was substantial savings of fuel oil, RDSO has issued instruction bulletin No. MP. IB.EC.05.22.10 dated 30.04.2010 for implementation of intelligent low idling equipment on all WDS6 locomotives fitted with Woodward Gov

2.Loocomotive

A locomotive is a railway vehicle that provides the motive power for a train. A locomotive has no payload capacity of its own, and its sole purpose is to move the train along the tracks

figure 1

3.Types Of Locomotives

- A STEAM LOCOMOTIVE is a locomotive that produces its power through a steam engine
- A GASOLINE LOCOMOTIVE is a locomotive that produces its power through a gasoline engine
- A DIESEL LOCOMOTIVE is a locomotive that produces its power through a diesel engine
- A ELECTRIC LOCOMOTIVE is a locomotive that produces its power through a electric engine
- Besides locomotives which use only a fuelled power source (e.g. an internal combustion engine), and an electrical engine, there are also HYBRID LOCOMOTIVES that additionally use a battery. Here, the battery acts as a temporary energy store, allowing e.g. the implementation of regenerative braking and switching off the hydrocarbon engine when idling or stationary (as used in automobiles such as the Toyota Prius).
- A GAS TURBINE-ELECTRIC LOCOMOTIVE, or GTEL, is a locomotive that uses a gas turbine to drive an electrical generator or alternator.
- A locomotive which uses fuel cell and electricity for power generation is FUEL CELL LOCOMOTIVE
- A SLUG OR DRONE LOCOMOTIVE is a non-powered unit attached to a diesel-electric locomotive to provide additional traction and braking capability. The slug has traction motors but no engine, power being supplied by the attached locomotive (known as a 'mother'). At slow speeds, a diesel-electric prime mover can potentially produce more power than can be usefully used by its own traction motors; a slug increases the number of traction motors available to use the power more effectively.

3.1.*Advantages Of Locomotives*

There are many reasons why the motive power for trains has been traditionally isolated in a locomotive, rather than in self-propelled vehicles.

3.1.1.Ease

Should the locomotive fail, it is easy to replace it with another. Failure or maintenance of the motive power unit does not require taking the entire train out of service.

3.1.2.Maximun Utilization Of The Power Cars

Idle trains waste costly motive power resources. Separate locomotives enable costly motive power assets to be moved around as needed.

3.1.3.Flexibility

Large locomotives can be substituted for small locomotives where the grades are steeper and more power is needed. A 'passenger' locomotive can also be used for freight duties if needed, and vice versa.

3.1.4.Obsolescence Cycle

Separating the motive power from payload-hauling cars enables one to be replaced without affecting the other. At times locomotives have become obsolete when their cars were not, and vice versa.

3.1.5.Safety

In case of an accident, the locomotive may act as buffer zone for the rest of the train. If an obstacle is encountered on the line, the heavier mass of a locomotive is less likely to be deviated from its normal course. Also it may be safer in the event of fire especially with diesel locomotives.

3.1.6.Noise

A single source of tractive power, which means only motors in one place, means that the train will be quieter than with multiple unit operation, where one or more motors are located under every carriage. The noise problem is particularly present in

4.Engine

An engine or motor is a machine designed to convert energy into useful mechanical motion. Motors converting heat energy into motion are referred to as *engines*.

4.1.Types Of Engines

4.1.1.Combustion Engine

Combustion engines are s driven by the heat of a combustion process.

4.1.1.1.Internal Combustion Engine

Combustion of fuel takes place outside the cylinder. Such engines are called external combustion engines

Ex:-diesel, petrol, gas engines

4.1.1.2. External Combustion Engine

In other classes of heat engine combustion takes place inside the cylinder, so that the product of combustion acts directly on the piston. These types of engines are called internal combustion (I/C) engines

Ex:- steam engines , steam turbines

4.1.2.Non Combustive Heat Engine

Some engines convert heat from non combustive processes into mechanical work, for example a nuclear power plant uses the heat from the nuclear reaction to produce steam and drive a steam engine, or a gas turbine in a rocket engine may be driven by decomposing hydrogen peroxide. Apart from the different energy source, the engine is often engineered much the same as an internal or external combustion engine.

4.1.3.Diesel Engines

A diesel engine (also known as a compression-ignition engine and sometimes capitalized as Diesel engine) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel, which is injected into the combustion chamber during the final stage of compression. The diesel engine is modeled on the Diesel cycle. The engine and thermodynamic cycle were both developed by Rudolf Diesel in 1897. The diesel engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) often have a thermal efficiency which exceeds 50 percent.

Figure 2

4.2.Cycle Of Operations

A cycle may be defined as series of events through which a machine must pass to attain a definite end. In diesel engine a cycle consists of:

- Admission of air
- Compression of air
- Injection of fuel into cylinder
- Automatic ignition and subsequent combustion of fuel
- Expansion of hot gases
- Exhaust of burnt gases

If an engine requires 4 strokes of piston to complete the cycle engine, it is termed as four stroke cycle engine.

4.3.Four Stroke Cycle

Four strokes of a four stroke cycle engine are

4.3.1.<u>Suction Stroke</u>

During this stroke the inlet valve remains open and the piston moves from TDC to BDC. The exhaust valve remains closed. Fresh air is admitted into the cylinder during this stroke

4.3.2.<u>Compression Stroke</u>

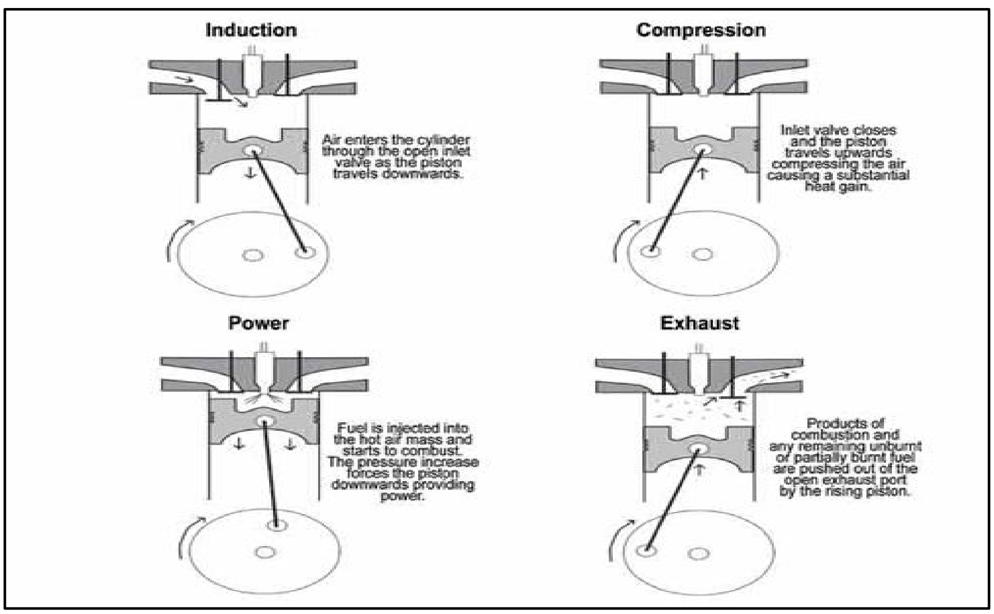
During third stroke the inlet and exhaust valves remains closed. Piston moves from BDC to TDC. Air is compressed as the piston moves upwards. Due to compression of air its temperature and pressure increases. Almost at the end of the stroke charge of oil is injected through the nozzle. The oil ignites as soon as it mixes with air into the cylinder without any presence of spark

4.3.3.Power Stroke

During this stroke the inlet and exhaust valves are closed. Piston moves from TDC to BDC, pressure created by the burning of fuel forces the piston downwards. This causes the crankshaft to rotate, delivering power to crankshaft. The gas continues to exert force on the piston until the piston reaches BDC. At about this time exhaust valves are open.

4.3.4.Exhaust Stroke

During this stroke exhaust valve remains open and inlet valve is closed. Piston moves from BDC to TDC. Burnt gases are thrown out of the cylinder during this stroke. Intake starts again and cycle is repeated.



FOUR STROKES OF THE DIESEL ENGINE

Figure 3

5.Principle Of Diesel Engine Locomotive

The diesel engine and the diesel electric locomotive is the prime mover to rotate a crankshaft which in turn drives generator to generate high voltage current (700-780 DC volts). This current when supplied to traction motor fitted on individual wheel axle causes movement of locomotives, since the traction motors armature are geared to the wheel axle through pinion and drive gears.

The traction motor consists of movable coils called armature and fixed coils called field coils when current is supplied the armature rotates due to like and unlike polarities causing attraction and repulsion between armature and field a pinion is fitted on the armature side which is mesh's to the drive gear is press fit on the axle. So armature rotates and the wheels also rotate to cause the locomotive movement

6.Properties Of The Diesel Engine Locomotive

SL NO	PROPERTIES	WDG
1	Total weight	123.0 T
2	Weight transfer to wheels	Side bearers(8)-100% Side bearers(2nos)adjacent to centre pivot-60% The other two side bearers-40%
3	Axle load	20.5T
4	Horse power generated	3100
5	Input to traction motor	2750HP
6	Compression ratio	12.5
7	Tractive effort	37884kg
8	Engine make &type	DLW 251B(up rated)
9	Engine RPM at 8^{th} notch	1050
10	Over speed trip setting(OST)	1200-1220
11	Max. permissible speed	100kmph
12	Service	goods
13	Gear ratio	74/18
14	Total length	19,15

SL NO	PROPERTIES	WDG
16	Total height	4162mm
17	Fuel tank capacity	6000lts
18	Lube oil sump capacity	1450lts
19	Lube oil for consumption	600lts
20	Turbo super charger	ABB VTC 904-V915/3100 HP Napier NA 295 IR 3100 HP
21	Bogie	Co-Co fabricated
22	Suspension bearing cap oil sump capacity	8 lts
23	Motor arrangement	LLL/RRR
24	Electrical transmission type	AC/DC
25	Generation through	Alternator & rectifier
26	Transitions	1
27	No load voltage setting at 8^{th} notch	1100-1140 V
28	Cranking done by	Exciter and auxiliary gen. Both working as motors
29	Brake system	IRABI
30	No of tractions motors	6
31	Wheel diameter	Max: 1092 mm Min: 1016mm(P) 1010 mm(G)

Table 2

- POWER TAKE OFF END: the generator eng of the engine is known as power take off end
- FREE END: turbo supercharger end of the engine is known as free end of the engine
- RIGHT AND LEFT SIDE: right and left side of the engine is determined by viewing the engine from the power take off end. When viewed from power take

off end, right side of is right side of the engine and left side is the left side of the engine

- CYLINDER LOCATION: location of the cylinder is count started from the free end side
- LOCATION OF APPARAT**US:** for convience in remembering, the different components of diesel loco may be divided into eight sections.

- short hood compartment
- engineman room or cab room
- control panel
- generator room
- engine room
- compressor compartment
- radiator compartment
- truck

7.Compartment In Short Hood Compartment

VA1 control valve, VA2 release valve, GD80 filter, volume reservoir, 1"combined cut out cock, A1 differential pilot air valve, oil pressure a witch(OPS), N1 reducing valve pressure gauges for lube oil, fuel oil, booster air,

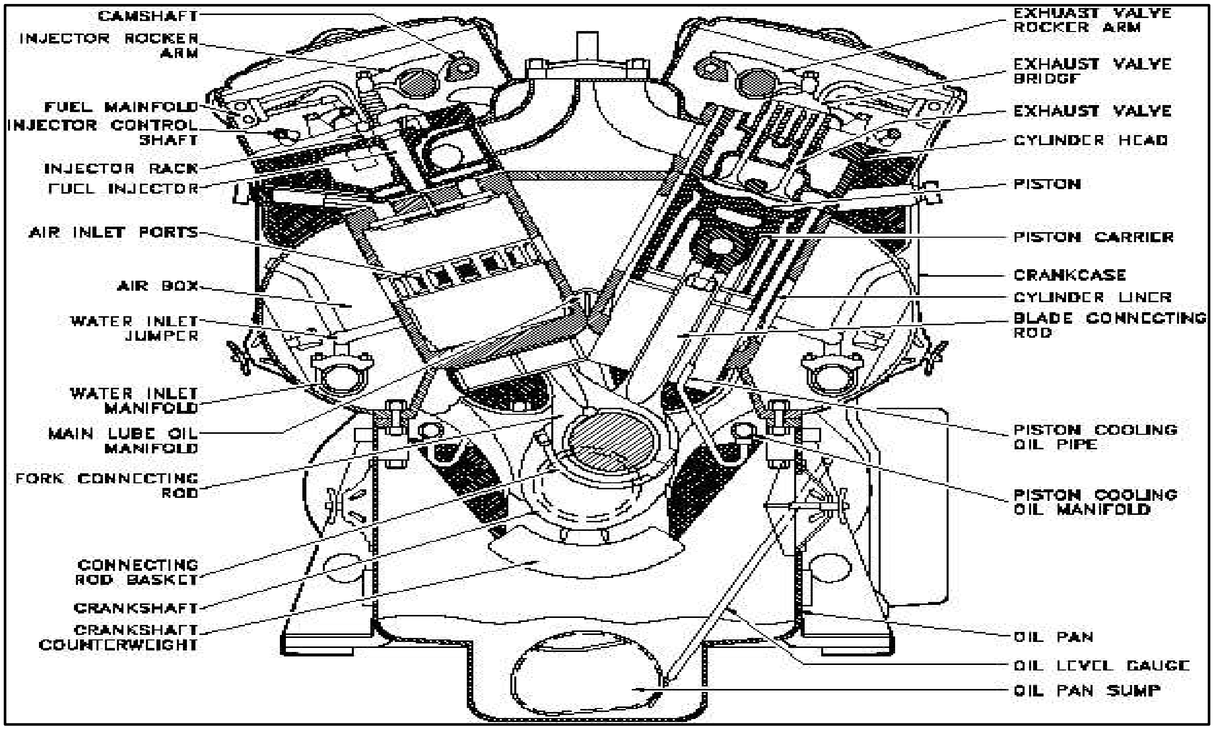


Figure 4

8.Alco Engine Variants

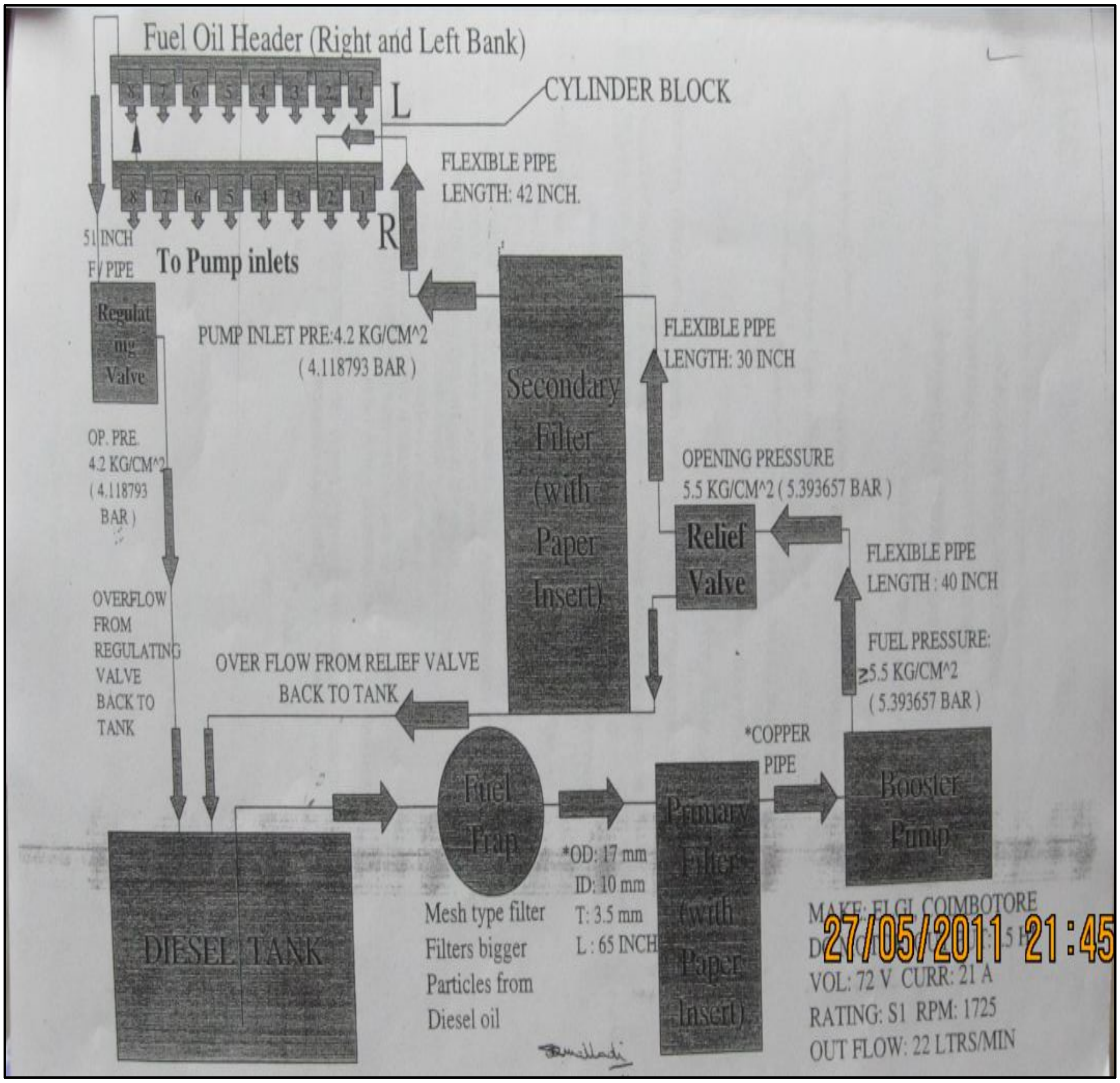
Engine Type	**251B / 251 D**			
Engine Power (HP)	2600	3100	3300	3600
Power (HP)/cyl	162.50	193.75	206.25	225.00
Cubic Capacity (Liters)	175	175	175	175
No of Cylinders	16	16	16	16
Application	Locomotive	Locomotive	Locomotive	Gensel/loco?
Customer	DLW	DLW	DLW	DLW/NHPC
Pump end Pressure(bar)	980@1050min-1	1050@1050min-1	1180@1050min-1	1187@1050min-1
SFC (Average Value)	175g/kWh	175g/kWh	No data	

Table 3

9.Engine Data -16 Clinders

1)	Application	Rail traction diesel engine (Indian railways, broad gauge)
2)	Engine type	DLW built 251-engine
3)	No. of cylinders	16
4)	configuration	'v'
5)	cycle	4 stroke
6)	bore	9"(2228.6mm)
7)	stroke	10.5"(226.7mm)
8)	Compression ratio	12.5
9)	Ratio of cam rod length to crank radius	4
10)	Fuel injection(at full load) spill port closing duration of injection fuel injection rate a) Pumps b) nozzles	25.5 degrees CA before TDC approx 27 degrees CA approx. 0.032gm/degree CA. 17mm plunger dia, 20mm stroke 0.35mm dia, 9 holes, 145 or 157 degree spray angle
11)	Firing order	1R 1L 4R 4L 7R 6R 6L 8R 8L 5R 2R 2L 3R 3L
12)	Valves(4 valve head) air inlet open air inlet close exhaust open exhaust close valve dia maximum valve lift port diameter	 80.1 degrees CA before TDC 35.4 degrees CA after BDC 57.7 degrees CA before BDC 57.7 degrees CA after TDC 7.62cm 2.04cm 7.40cm
13)	Turbo charger	One per engine
14)	After cooler	Single/twin, water cooled

10.Layout



11.Fuel Injection

Fuel injection is a system for mixing fuel with air in an internal combustion engine. It has become the primary fuel delivery system used in automotive petrol engines, having almost completely replaced carburetors in the late 1980s.

A fuel injection system is designed and calibrated specifically for the type(s) of fuel it will handle. Most fuel injection systems are for gasoline or diesel applications. With the advent of electronic fuel injection (EFI), the diesel and gasoline hardware has become similar. EFI's programmable firmware has permitted common hardware to be used with different fuels.

Carburetors were the predominant method used to meter fuel on gasoline engines before the widespread use of fuel injection. A variety of injection systems have existed since the earliest usage of the internal combustion engine.

The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on low pressure created by intake air rushing through it to add the fuel to the airstream.

The fuel injector is only a nozzle and a valve: the power to inject the fuel comes from a pump or a pressure container farther back in the fuel supply.

12.Objectives

The functional objectives for fuel injection systems can vary. All share the central task of supplying fuel to the combustion process, but it is a design decision how a particular system will be optimized. There are several competing objectives such as:

- power output
- fuel efficiency
- emissions performance
- ability to accommodate alternative fuels
- reliability
- drivability and smooth operation
- initial cost
- maintenance cost
- diagnostic capability
- range of environmental operation
- Engine tuning
- Various injection schemes
    1) Single-point injection
    2) _Continuous injection
    3) _Central port injection (CPI)
    4) _Multi-point fuel injection
    5) _Direct injection

- _Diesel engines
- _Petrol/gasoline engines

13.Fuel Is Done By Two Types Of Devices They Are

- PUMP
- NOZZLE/INJECTOR

14.Pump

A pump is a device used to move fluids, such as liquids, gases or slurries. A pump displaces a volume by physical or mechanical action. Pumps fall into three major groups: direct lift, displacement, and gravity pumps. Their names describe the method for moving a fluid.

15.PF-PUMP

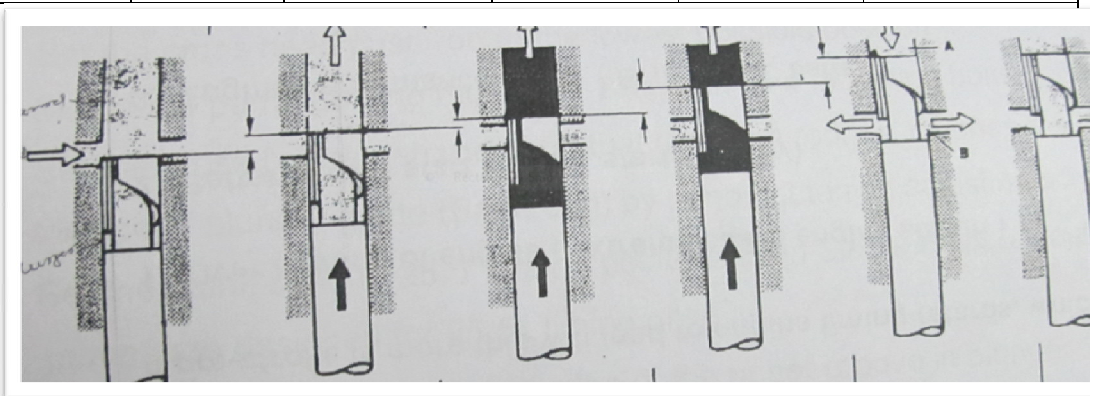
Pumps without a built in camshaft are called pf pumps.
First pf pump of series production started in 1927.

16.PF-PUMP PRESTROKE

Pre stoke =port closing = actual start of fuel delivery
The distance travelled by the plunger from BDC till it fully covers the barrel inlet port by the top edge of the plunger. The total stroke3 of the plunger is constant and consists of the following-

17.Phases Of The Plunger Stroke

- BDC position- zero position
- Port closing – prestroke
- D.V.opening – retraction stroke
- Active pumping –effective stroke
- TDC position- retraction stroke
- TDC clearance – clearance stroke

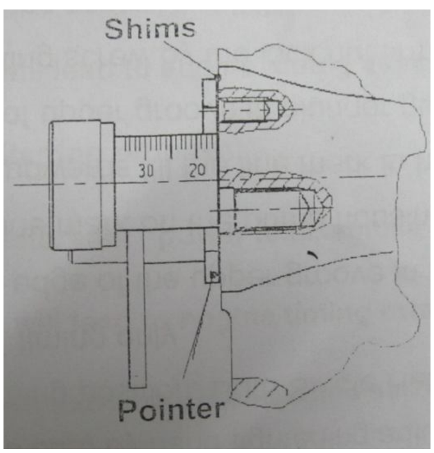
Bottom dead centre fuel inlet	Pre stroke	Retraction stroke	Effective stroke	Residual stroke	Top dead centre
					
Fuel flows from the suction gallery of the injection pump into the high pressure chamber of the plunger-and-barrel assembly.	Movement of the pump plunger from bottom dead centre to the closing of the inlet ports by the top edge of the plunger (variable depending on plunger – and – barrel assembly).	Movement of the pump plunger from the end of the prestroke to the opening of the delivery valve.	Movement of the pump plunger from the opening of the delivery valve to the opening of the inlet port by the helix (overflow).	Movement of the pump plunger from the opening of the inlet port (end of delivery) to TDC.	Reverse movement of the pump plunger.

19.Squence Of Steps To Be Follwed For Mounting The Fuel Pump On Engine

- Ensure camshaft/crankshaft is at BDC position
- Set the cross head/ push rod to the lowest possible position
- Mount the pump guiding the spigot and tighten all four mounting bolts uniformly.

- Set cross head or push rod such that the push rod just touches the bottom surface of the plunger guide by hand tightening adjusting screw
- Set the crank shaft to 25.5 ^{o} timing position. Both single and double helix pumps are designed for 25.5^{o} timing only
- Check and confirm that the lower edge of the upper groove in plunger guide is below the line mark on the pump housing timing window
- Move the cross head/ push rod upwards till the line mark in the housing timing window coincides with the lower edge of the upper grove in plunger guide.
- Lock the push rod height adjusting screw by the lock nut firmly
- Connect the fuel inlet, outlet and the control rod link appropriately

20.Delivery Adjustment By Using Shims



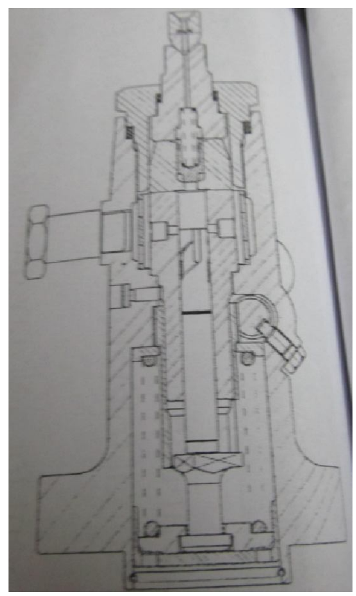


Figure 5

- Shims are required to adjust the delivery quantity at particular control rod position
- Delivery variation at setting point : ---- due to dimensional tolerance of components of FIP
- Similar arrangements for delivery quantity adjustment are available in other types of FIP (viz. eccentre, control rod marking, shims, oblong slot ect…)

- To achieve setting tolerance at particular CRP shims are required(max. 4mm)
- Addition of shims to adjust delivery quantity is practiced since inception of the pump

21.Fip For 2600 Rated Engines

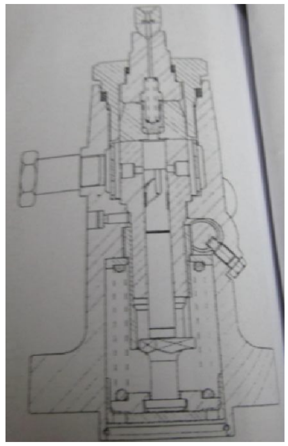


Figure 6

22.Features

- Plunger diameter : 17mm
- DV execution : normal GRV
- Relief volume : 300mm^3
- BDC : 6.5mm
- Lift : 20mm

Pump end pressure: 980 bar

23.Plunger And Barrel- Function

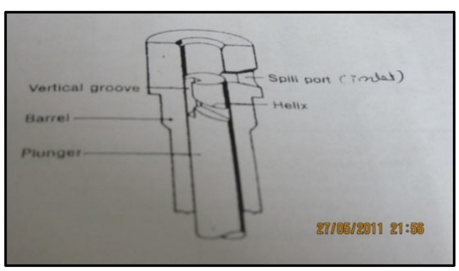


Figure 7

Delivers fuel under required pressure. Delivery of fuel can be varied from 0 to maximum. Ensures the required rate of injection.

24.Delivery Valve- Functions

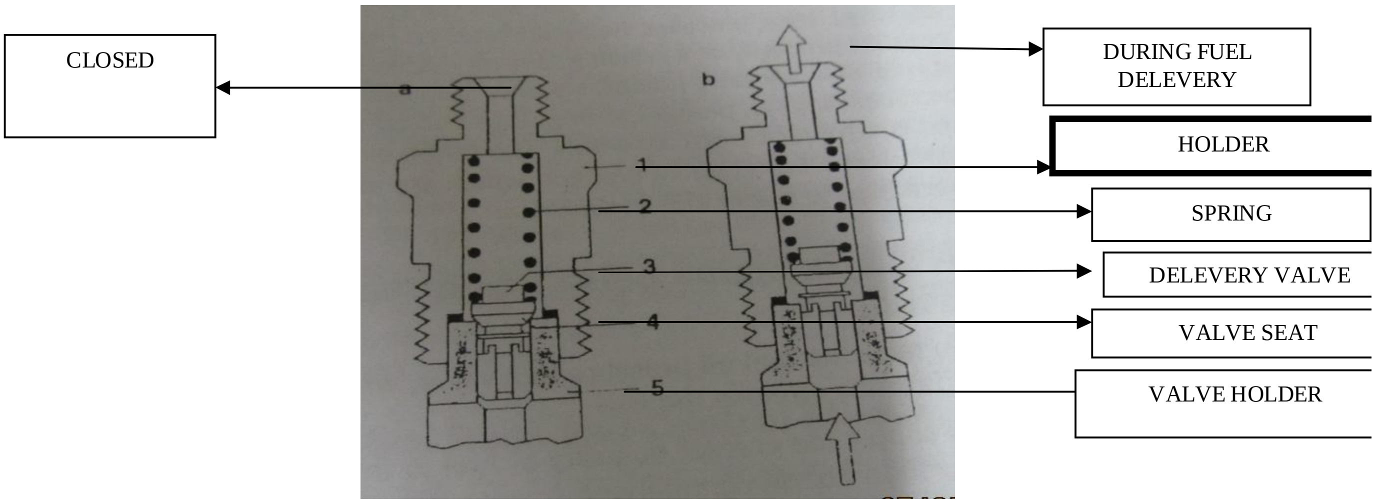


Figure 8

Acts as unidirectional valve. Ensures sharp end of injection. Controls residual pressure in the high pressure line.

25.Delivery Valve Pin

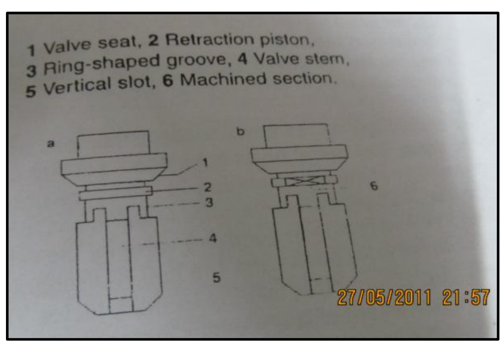


Figure 9

26.Fuel Injection Pump

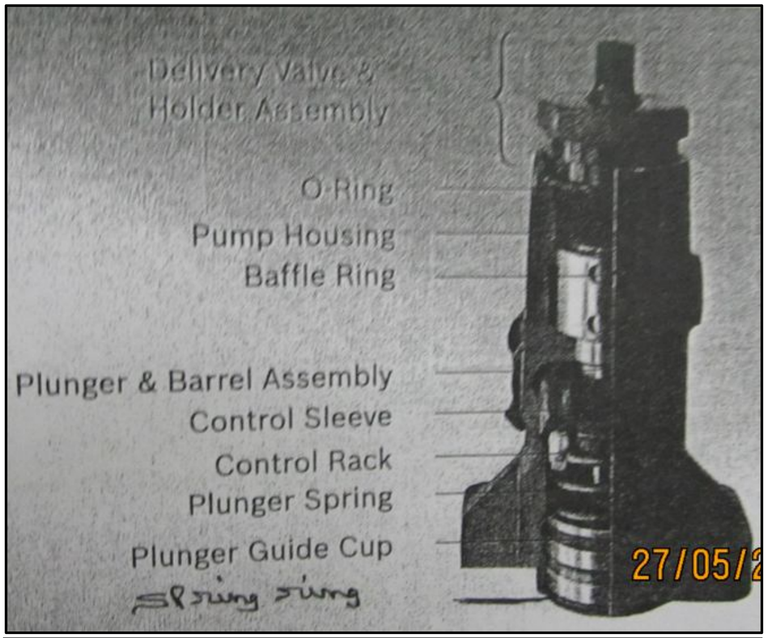


Figure 10

Fuel injection pumps are of single acting, constant stroke and plunger type
With effective working stroke, however, being adjustable. The pump consists primarily of a housing, delivery valve and spring, delivery valve holder, element (plunger and barrel assembly), plunger spring, a geared control sleeve and control rack assembly.

27.Functions

- To raise the fuel oil pressure to a valve, which will efficiently atomize the fuel
- To supply the correct quantity of the fuel to the injection nozzle commensurate with the power and speed requirement of the engine.
- To accurately the delivery of the fuel efficient and economical operation of the engine.

28.Working

Fuel oil enters the pump from the fuel oil header and fills the sump surrounding the plunger barrel. When the plunger is at the bottom at its stoke, fuel flows through the barrel ports filling the space above the plunger and the cut away area of the helix.

As the plunger moves upwards, fuel is pumped back to the sump until barrel ports are closed. Further upward movement of plunger raises the pressure of the trapped fuel. When pressure is sufficient to overcome the force exerted on the delivery valve by the valve spring, the delivery opens and the fuel is discharged into the high pressure pipe, leading to the injector. Further upward movement of the plunger increases fuel pressure to enable the injection to occur. Delivery of the fuel ceases when the plunger helix opens the barrel ports.

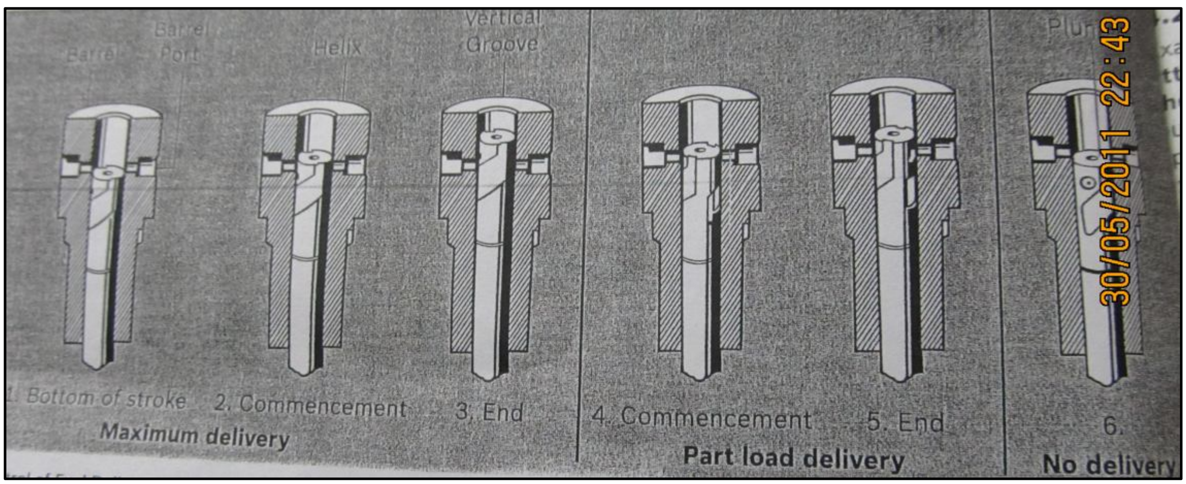


Figure 29

29.Parts

The following are the main parts of a fuel pump

PUMP HOUSING		PLUNGER AND BARREL		BUFFER RING	
CAP NUT		DELIVERY VALVE BODY		DELIVERY HOLDER	
DELIVERY SPRING		CONTROL SLEEVE		UPPER SPRING PLATES	
PLUNGER SPRING		LOWER SPRING PLATE		GUIDE UP	

SPRING ADJUSTMENT SHIM		CONTROL RACK	

30.Partwise Assembling Of Thed Pump

- PUMP HOUSING
- JUMPER BOLTING
- PLUNGER AND BARREL ON DOUBLE PIN
- BUFFLE RING

- DELIVERY RING
- DELIVERY VALVE BODY
- SPRING
- DELIVERY VSLVE HOLDER WITH ORING
- HOUSING ORING
- CAP NUT

BACK SIDE (BOTTOM OF THE PUMP) OF THE PUMP

- CONTROL SLEEVE
- SPRING PLATE
- PLUNGER SPRING
- PLUNGER
- LOWER SPRING
- PLATE GUIDE
- CUP
- SNAP RING

31.Control Rack Bush Rings

Place the pump housing on an arbor press, press in one busing at a time with a suitable tool like a locating pin. After both the bushings have been instead, ream the bushing to valve between 18.25 and 18.27mm. Use the reamer with the suitable guide. After reaming, thoroughly clean bushing and pump housing.

32.Cautio

Reaming is to be done only when the bushes are replaced; and not in a new pump housing.

33.Plunger And Barrel

Examine the barrel seat in the pump housing. Don't attempt to refinish the barrel seat but remove dirt, if there any. The barrel seat must be tight, so that during pump operation, fuel will not leak past the seat into the spring chamber place pump housing in dismantling fixture in an upright position. Insert element barrel into pump housing.

]

34.caution

Protection sleeve have to place in between plunger van and the barrel to avoid damage to the plunger top. Damage to the plunger top can cause seizure/ stickiness of the pump.

35.Control Rack And The Control Sleeve

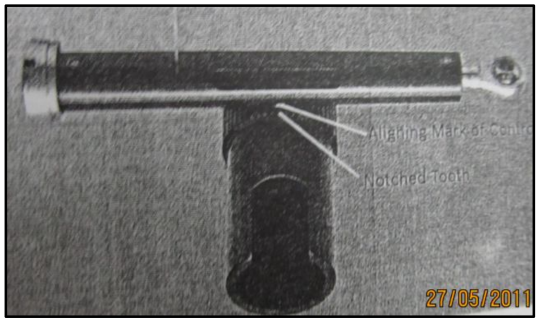


Figure 20

Place the pump in the dismantling fixture in an inverted position. Slide the control rack into its busing, and rotate it until the notched tooth is visible trough the bottom opening of the pump. Screw in the control rack stop screw and engage it to the slot in the rack. Tighten the stop screw and put the lock wire.

36.Adjusting Shims

The adjusting shims for the control rack pointer are available in various thicknesses.

37.Caution

Adjusting fitted in new fuel injection pump should not be disturbed during fitting to the locomotive.

38.Pump Mounting Procedure

39.1.Sequence Of Steps – Mounting The Fuel Pump On Engine

- Ensure camshaft/crankshaft is at BDC position
- Set the cross head/ push rod to the lowest possible position
- Mount the pump guiding the spigot and tighten all four mounting bolts uniformly.

- Set cross head or push rod such that the push rod just touches the bottom surface of the plunger guide by hand tightening adjusting screw
- Set the crank shaft to 25.5 ^{o} timing position. Both single and double helix pumps are designed for 25.5^{o} timing only
- Check and confirm that the lower edge of the upper groove in plunger guide is below the line mark on the pump housing timing window
- Move the cross head/ push rod upwards till the line mark in the housing timing window coincides with the lower edge of the upper grove in plunger guide.
- Lock the push rod height adjusting screw by the lock nut firmly
- Connect the fuel inlet, outlet and the control rod link appropriately

39.Tightening Torque For Pump

- Mounting bolt tightening torque ; 95 - 110 Nm
- Inlet connector tightening torque ; 38 -45 Nm
- Cap nut tightening torque; 750 – 800 Nm
- HPP cap nut tightening torque ; 55 – 65 Nm

40.Pump Testing

To minimize energy use, and to ensure that pumps are correctly matched to the duty expected pumps, and pumping stations should be regularly tested. By supplying 50psi pressure for testing internal cracks

41.Types Of The Testing Machines

41.1.Manual Testing Machine

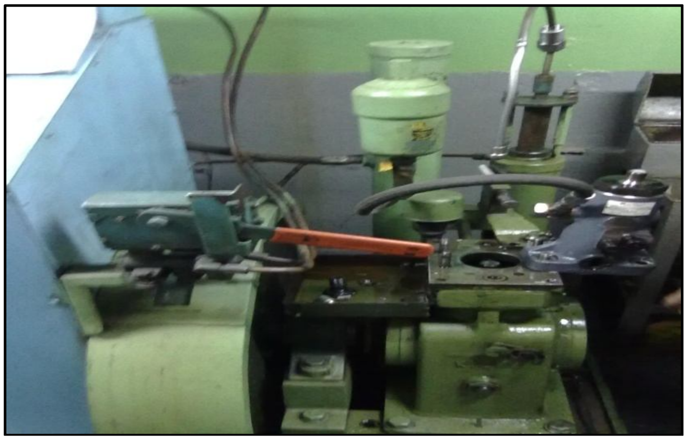


Figure 21

Figure 22

42.Pump Delivery

PUMP	RACK POSITION	IDLE POSITION	FULL FUEL	IDLE FUEL
15mm	30mm	9mm	340-355mm	30-35mm
17mm	28mm	9mm	370-408mm	40-45mm
18mm	28mm	9mm	370-408mm	40-45mm

43.Snuber Valve

43.1.Function

A Snuber assembly is fitted on the fuel injection pump at the top of the delivery valve holder using a tubing union sleeve and nut. It is basically a check valve that restricts fuel flow in the reverse direction trough a small orifice. Its function is to dampen the shock waves travelling through the high pressure line resulting from sudden closure of the delivery valve and the nozzle valve.

43.2.Inspectyion And Replacement Of The Snubber Valve

- Visually inspect for cracks.
- Check for free movement of the disk by shaking
- Examine the disc to see that it is not broken (by holding snubber valve assembly near a light source and looking through the snubber valve bore). Note that the orifice in the disc is considerably smaller than the bore in the snubber valve.
- The snubber valve should be replace if male and female cones are damaged/worn out and /or the valve disc is found broken. Replace complete snubber valve assembly as individual parts are not marketed.

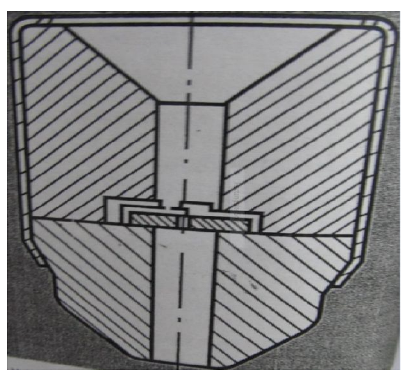


Figure 23

44.Injector (Nozzle)

A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe via an orifice. A nozzle is often a pipe or tube of varying cross sectional area and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them.

45.Parts Of The Nozzle

NOZZLE		IMPINGER		NOZZLE BODY	
NOZZLE CUP		PRESSURE SPRING		SEAT GUIDE	
PRESSURE SHIMS		NOZZLE ORING			

45.Partwise Assembly Of The Nozzle

- NOZZLE HOLDER
- ADJUSTING SHIMS
- SPRING
- SPRING SEAT

- INTERMEDIATE DISC NOZZLE CAP NUT (TORQUE TIGHT---94 TO 109 LENGTH BEFORE STRENGHT)
- HOUSING ORING

Figure 24

46.Cleaning Of Nozzle

If using a new nozzle, remove the preservative coating and wash the nozzle thoroughly in clean petrol. Dip the nozzle body and needle in filtered test oil and assemble. Nozzle needle and body is ‘match assembled’. Therefore they shouldn’t be interchange with those of other nozzles.

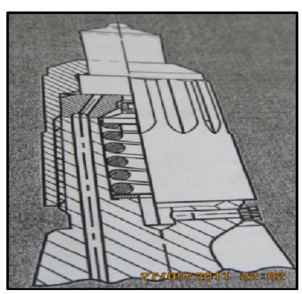


Figure 25

47.Testing The Nozzle

47.1.Slide Test

Dip the nozzle needle in filtered test oil and insert into nozzle body. Holding the nozzle body almost vertical, pull out the needle up to max. 1/3rd of its engaged (guide) length. When released, the nozzle should slide down to its seat by its own weight. Wash all the nozzle holder components thoroughly in clean test oil.

47.2.Functional Test

Mount nozzle holder body (1) in a holding fixture with 'nozzle end' upwards. Insert shims (2), spring seat (3) and spring (4) in the body. Keep spindle with guide bush (5) and intermediate disc (6) on the protruding end of the spring. Assemble nozzle over the intermediate disc. Screw on the nozzle cap nut by hand and centralize the nozzle. Tighten the nozzle cap nut to 130 - 150 Nm (13 – 15 kgf-m) torque with a suitable box spanner and torque wrench. Remove the injector from fixture and carry out the functional tests.

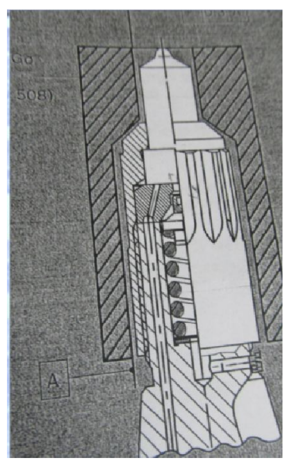


Figure 26

48.Fitment And Flushing

48.1.Opening Pressure Test

If the injector is new or new nozzle holder spring and the nozzle have been used, set the opening pressure to 275+10 kgf/cm^2. Resetting pressure for injector (with used nozzle spring and nozzle) is 260 – 270 kgf/cm^2.

Figure 28

49.Seat Tightness Test

Figure 29

50.Repetition (Chatter) And Spray Pattern Test (For New Nozzle)

Test for good repetition in the entire range of attainable lever speed. Lowest test speed is downward stroke/ second. Occasional / small non repeating ranges are of no significance and shouldn't be the criteria for rejection. At fast lever speeds, good repletion is indicated by well atomized spray.

51.Spray Pattern/Atomozation

At lower test speeds the atomization is coarse (non homogeneous). At fast lever speeds the spray is compact and finely atomized.

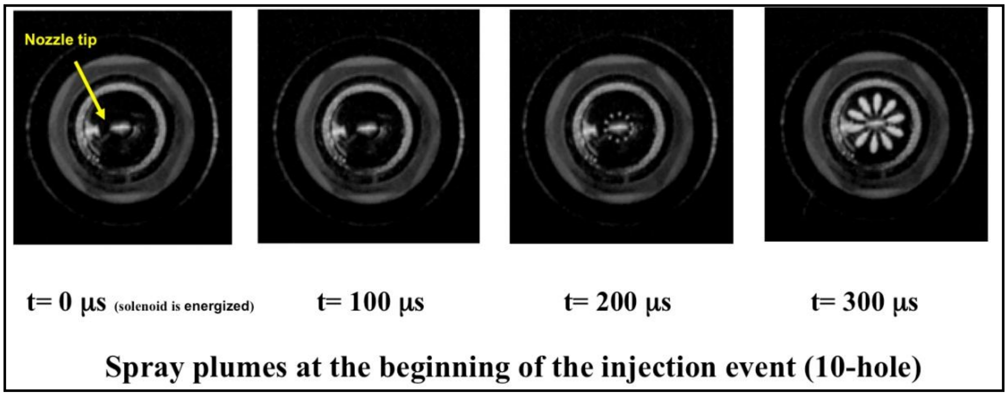


Figure 30

52.Instalation Of Injector On Engine

- Clean nozzle hole in cylinder head
- Position the rubber 'o' ring around the nozzle holder
- Place injector in cylinder head and position it with the locating dowel
- Apply the injector retraining clamp so that the clamp barring surface is directly over the central line of the nozzle holder. Tighten the clamp nuts, hand tight until the clamp is parallel to the head surface.
- Insert fuel injection tube at the side, make sure that upset cone enters conical seat on the side of the nozzle holder body. Tighten the fuel tube clamp screws to torque of 100Nm. And tighten high pressure fuel line at the pump end.
- Tighten the retaining clamp nut, next to the exhaust manifold, to 70 Nm.

52.Centering Of Nopzzle And Checking True Running

It is very important that during the assembly of the injector, care is taken that nozzle is centralized. To achieve a true running of 0.3mm, the center sleeve has been used. Further, the using the true running gauge checks the true running of the nozzle.

53.Caution

Failure to follow the above procedure can lead to side trust on the nozzle, which can lead to the breaking of the nozzle.

54.Test Specifications

54.1.Test Equipment

Test branch	Mico /bosch make
Cam box	824211900
Test injector	0681343005(efep218)
Nozzle	0681443016
High pressure pipe	311523674 8*2*950mm (Outer diameter*wall thickness*length).

Table 3

54.2.Test Conditions

Inlet pressure for calibration	0.5±o.1
Oil temperature	40±2^{0}c
Test oil	F002 S3E001

Table 4

55.Calibration Values

PUMP TYPE	TEST INDICATOR OPENING PRESSURE kgf/cm^2	CONROL RACK POSITION (mm)	MIN^{-1} (rpm)	DELIVERY QUANTITY (cm^3/300 strokes)
PFIWV 150/5	172+3	9 30	500 500	70.5-76.5(64.5-82.5) 399-411(387-423)
PF1WV 170/6	172+3	9 28	500 500	90-100(86-104) 465-489(462-492)

Table 5

56.Note

- Values given in brackets are over checking values.
- Applicable only for mico/bosch test benches.

- Max. shims at pointer to be 4mm

58.Caution

It is absolutely essential to ensure maintenance of BDC dimension both on the calibration test bench as well as on the pump mounting block on the engine. Failure to adherence will result in:

- Damage to the housing by way of spigot brakeage if the BDC dimension is more.
- Damage to the control sleeve/element it is less

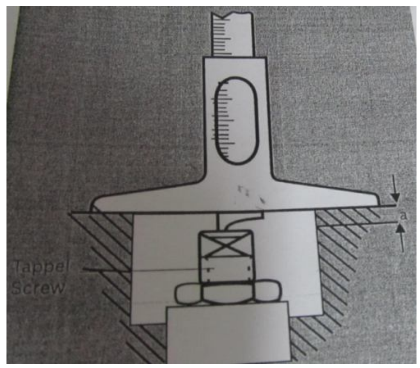


Figure 31

59.Injector

- NOZZLE WITH HOLE TYPE NOZZLE AND HOLDER ASSEMBLY:-

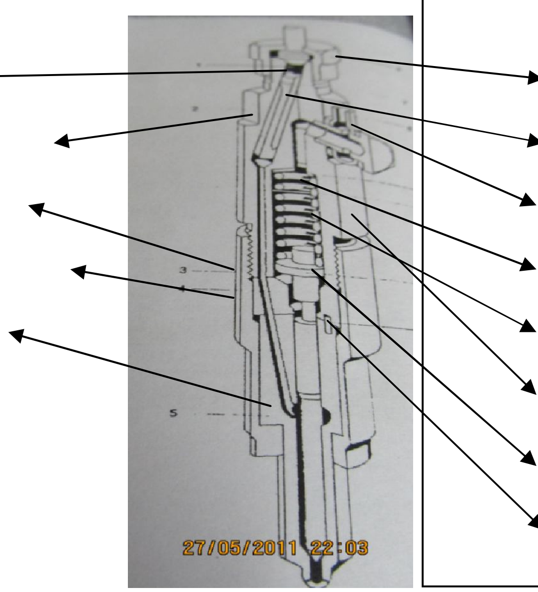


Figure 32

60.Funtions Of Injector Componets

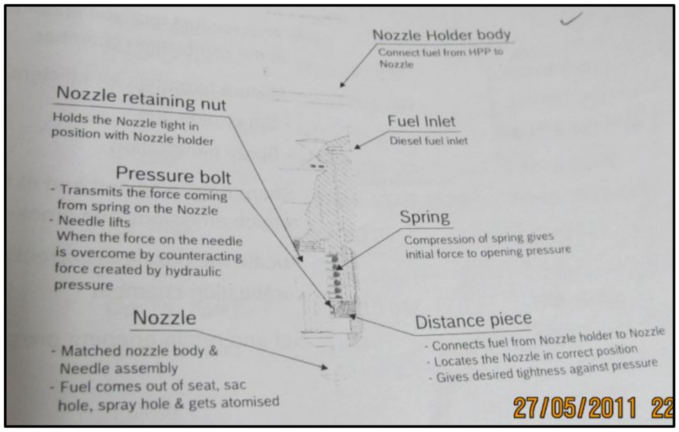


Figure 33

61.Functions Of Injector

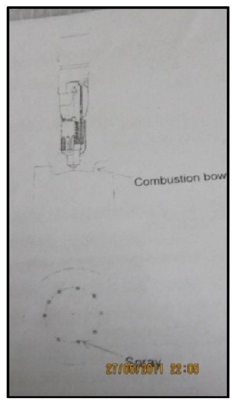


Figure 34

- Atomized fuel received under high pressure in the combustion chamber
- Mixture formation of efficient combustion

  Spray direction

  Spray penetration
- Sharp beginning and end of fuel injection to reduce emissions and smoke
- Locate the nozzle in correct position in the combustion chamber
- Set and retain opening pressure

62.Injector Feauters

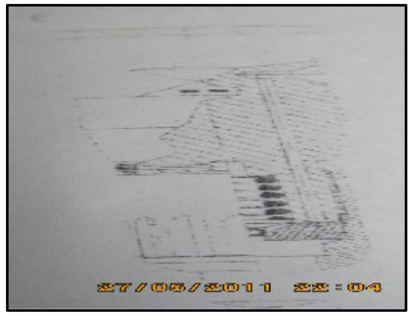


Figure 35

Application	251B	251D
Injector no.	9 430 032 130	9 430 032 131
Nozzle holder	9 430 031 302 HB-KBA 242 T10	9 430 031 302 HB-KBA 242 T10
Nozzle	9 430 033 300 HB-DL 157T1134	9 430 033 301 HB-DL157T1141
Spindle hole	9×⌀0.35	9×⌀0.38
Pressure stage	7×4	7×4
Opening pressure(bar)	275+10 bar	275+10 bar
identification	-------------------	GREEN

Table 6

62.Nozzle Features

Application	251B	251B
Nozzle	9 430 033 300 HB-DL 157 T 1134	9 430 033 301 HB-DL 157 T 1141
Spray hole	9×⌀0.35	9×⌀0.38
Pressure stage	7×4	7×4
Needle tip form	60^{O}	60^{O}
Sac hole ⌀, mm	1.8	1.8
Spray hole length	2.2	2.2
Stroke, mm	0.4	0.4
Stroke, mm maximum pressure, bar	1200	1200

Table 6

63.Reference

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4. V. Ganeshan (2007). Internal Combustion Engines. New Delhi: The Mc Graw Hill
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