MECHANIC DIESEL

TRADE PRACTICAL

NSQF LEVEL - 4

HANDBOOK FOR CRAFTS INSTRUCTOR TRAINING SCHEME

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

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A Comprehensive Training Program
under Crafts Instructor Training Scheme (CITS)
for Instructors

HANDBOOK ON TECHNICAL INSTRUCTOR TRAINING MODULES

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भारत सरकार
कौशल विकास एवं उद्यमिता मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
AND ENTREPRENEURSHIP

Foreword

In today's rapidly evolving world, the role of skilled craftsmen and women is more crucial than ever. The Craft Instructor Training Scheme (CITS) stands at the forefront of this transformation, shaping the educators who will train the next generation of artisans and technicians. This book aims to provide an in-depth understanding of the subject, exploring its significance, methodologies, and impact on vocational training.

The Craft Instructor Training Scheme was established with the objective of enhancing the quality of instruction in industrial training institutes and other vocational training institutions. By equipping instructors with advanced skills and knowledge, the scheme ensures that they are well-prepared to impart high-quality training to their students. This, in turn, contributes to the creation of a highly skilled workforce capable of meeting the demands of modern industry.

The initial chapters provide the importance of specialized instructor training. Following this, detailed chapters delve into the curriculum covering advanced techniques, safety protocols, and instructional strategies. Each section is designed to offer both theoretical insights and practical applications, ensuring a well-rounded understanding of the subject.

The book offers recommendations for overcoming obstacles and enhancing the effectiveness of the program, with the ultimate goal of producing highly skilled instructors capable of shaping the future workforce.

This book is intended for a diverse audience, including current and aspiring instructors, vocational training administrators, policymakers, and industry stakeholders. It serves as a valuable resource for understanding the intricacies of the subject and its pivotal role in vocational education.

I extend my heartfelt gratitude to all contributors who have shared their experiences and expertise, enriching this book with their valuable insights. Special thanks to the contribution of the development team, reviewers and NIMI that have supported this endeavor, providing essential data and resources.

It is my sincere hope that this book will inspire and guide readers in their efforts to enhance vocational training, ultimately contributing to the development of a skilled and competent workforce.

ATUL KUMAR TIWARI, I.A.S.
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MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
DIRECTORATE GENERAL OF TRAINING

FOREWORD

The Craftsmen Training Scheme (CTS) implemented by the Directorate General of Training (DGT) provides skill training to the youth and ensures a steady flow of skilled manpower for the industry. It aims to raise quantitatively and qualitatively the industrial production by systematic training, and to reduce unemployment among the youth by providing them with employable skills.

The Craft Instructor Training Scheme (CITS) is an indispensable part of the Craftsmen Training Scheme (CTS). It offers comprehensive training both in 'skills' and in 'training methodology' to the instructor trainees to make them conversant with techniques of transferring hands-on skills.

I congratulate NIMI for taking the initiative of preparation of the course content for CITS. This will help institutionalize the mechanism for imparting training to the trainers all across the ecosystem. I also extend my gratitude to the Instructors and Officials of National Skill Training Institutes (NSTIs) and the DGT for their invaluable contribution in preparation of the CITS course content.

As we navigate the complexities of a rapidly changing world and the technological disruptions, the significance of CTS and CITS has increased manifold. It not only empowers individuals with practical skills but also lays the foundation for a prosperous future. I am confident that this book will serve as a guiding light to all instructor trainees for skill development and nation-building.

Trishaljit

(Trishaljit Sethi)

PREFACE

The Craft Instructor Training Scheme is an indispensable module of the Craftsmen Training Scheme, which has been an integral part of the Indian skill development industry since its inception. This program aims to equip instructors with the necessary skills and teaching methodology to effectively transfer hands-on skills to trainees and promote a holistic learning experience. The first Craft Instructor Training Institute was established in 1948, followed by six more institutes across India in 1960. Today, these institutes, including the National Skill Training Institute (formerly Central Training Institute for Instructors), offer the CITS course, which is mandated by the Directorate General of Training (DGT).

The Craft Instructor training program is designed to develop skilled manpower for industries. The course aims to offer instructors an opportunity to improve their instructional skills, engage learners effectively, offer impactful mentoring, and make efficient use of resources, leading to a more skilled workforce in various industries. The program emphasizes collaborative and innovative approaches to teaching, resulting in high-quality course delivery. Overall, the Craft Instructor Training Scheme is a pivotal program that helps instructors grow in their careers and make a significant contribution to society. This program is essential for developing skilled manpower and promoting a robust learning environment that benefits both trainees and instructors alike.

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following experts to bring out this Instructional material **(Trade Practical)** for **CITS Mechanic Diesel (NSQF Level - 4)** under the **Automotive** Sector for **Instructors**.

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NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

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ABOUT THE TEXT BOOK

The Vocational Instructor Training Program is a comprehensive initiative designed to equip aspiring students with the necessary skills and knowledge to effectively teach in vocational education settings. This program encompasses a range of pedagogical strategies, instructional techniques, and subject-specific content tailored to the diverse vocational fields. Participants engage in coursework that covers curriculum development, assessment methods, classroom management, and the integration of industry-relevant technologies. Practical experience and hands-on training are emphasized, allowing participants to apply theoretical concepts in real-world teaching environments. Through collaborative learning experiences and mentorship opportunities, aspiring vocational instructors develop the confidence and competence to facilitate engaging and impactful learning experiences for their students. This training program aims to cultivate a new generation of educators who are not only proficient in their respective vocational fields but also adept at fostering the success and employability of their students in today's competitive workforce.

This text book covers communication, self-management, information and communication technology, entrepreneurial and green skills. It has been developed as per the learning outcome-based curriculum.

G C Rama Murthy,
Joint Director,
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CONTENT

MODULE 1: Work Shop Maintenance

EXERCISE 1.1: Practice 5S techniques

Objectives

At the end of this exercise you shall be able to

- practice 5S techniques.

Requirements

Tools/Equipments/Materials

- Cleaning solution
- Cotton waste
- banian cloth
- Name plates (or) Name stickers
- Plastic buckets
- Dust bin
- Brooms
- Colour paints
- Brushes
- Vacuum cleaner
- Mop Stick
- Scrubber machine
- Cleaning trays
- Tools board
- Shelves
- Air compressor

Procedure

Definition

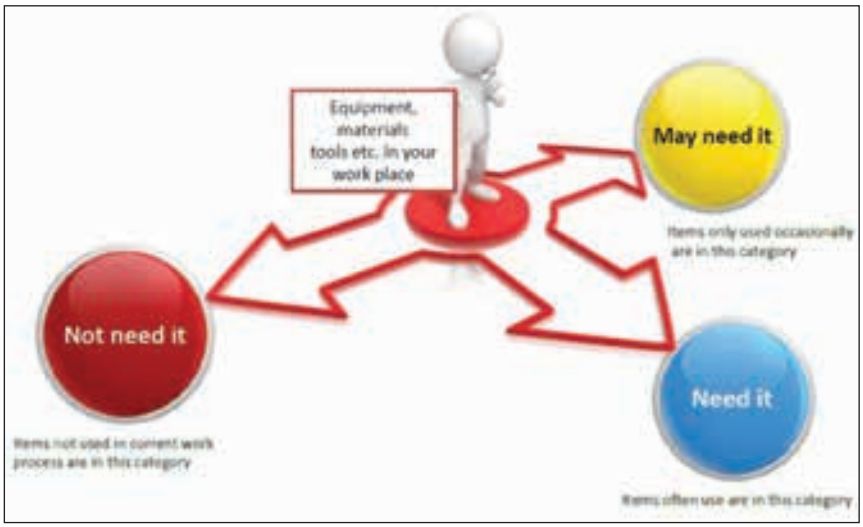
5S is defined as a house keeping technique in order to achieve high levels of quality, safety, productivity and good working environment

List out 5S

- Sort out –seiri
- Systemize –seiton
- Shining –seiso
- Standardize –seiketsu
- Sustain -shitsuke

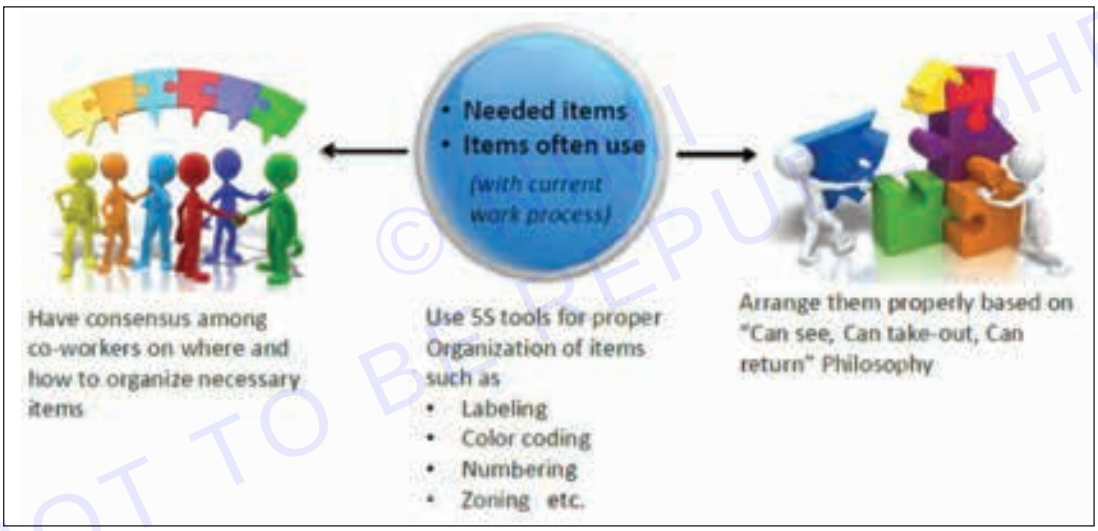
S1: Sorting activities

Equipment, material, tools files, furniture etc. can be categorized based on the frequency of use.



S2: Setting activities

Consider workflow and arrange 1 items.



S3: Shine

- Cleaning up one's workplace daily so that there is no dust on floors, machines or equipment.
- It will create ownership and build pride in the workers

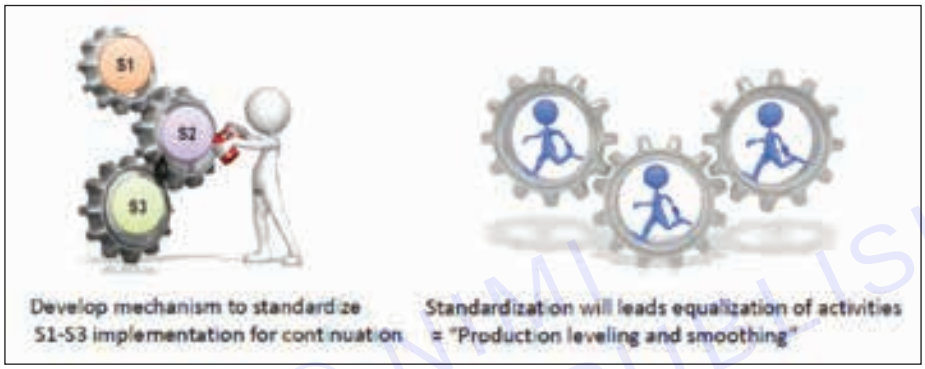
S3: Shining activities

- Clean floor, windows and walls.
- Clean and Maintain office automation machines, medical equipment and tools, office furniture
- Develop and follow regular cleaning and Maintenance schedule

S4: Standardize

- Maintain an environment where S1 to S3 are implemented in the same manner throughout the organiization.
- Give opportunities to employees to take active part in the development of these standards.

S4: Standardizing activities



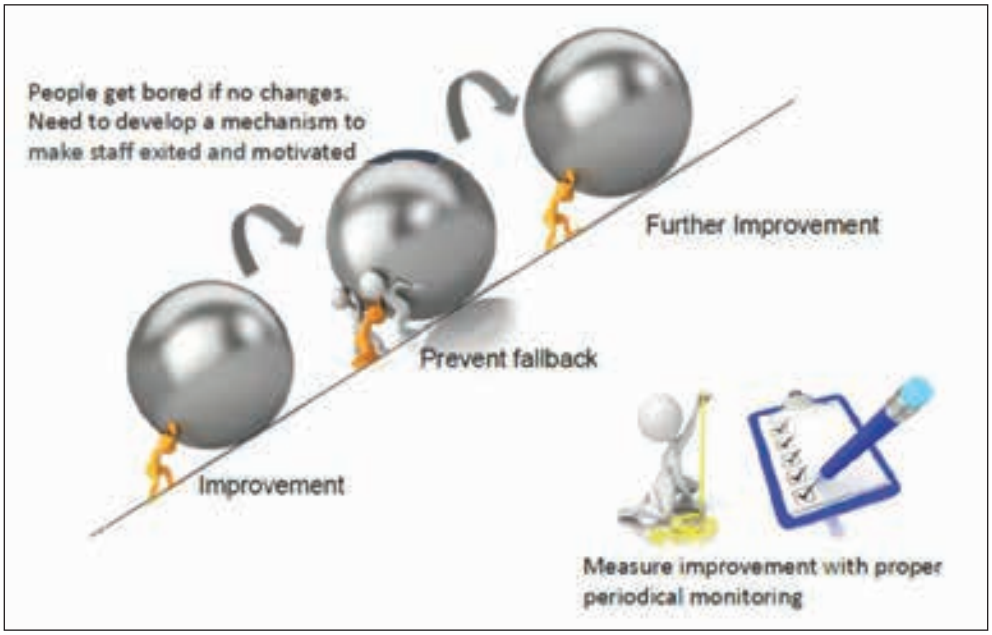
Standardization is useful for;

- Easy implementation of S1 to S3 activities
- Equalization process output
- Everyone's participation

S5: Sustain

- Maintain S1- S4 through discipline, commitment and empowerment
- It focuses on defining a new mindset and a standard in workplace

S5: Sustainability activities



Advantages

Targets of Five-S include:

- Zero changeovers leading to product/service diversification.
- Zero defects leading to higher quality.
- Zero waste leading to lower cost.
- Zero delays leading to on time delivery.
- Zero injuries promoting safety.
- Zero breakdowns bringing better maintenance.

EXERCISE 1.2: Safety precautions to be followed in the auto shop

Objectives

At the end of this exercise you shall be able to

- list out the types of shop hazards
- carry out the safety precautions to be followed in the auto shop
- list out the safety precautions to be followed while working with vehicle components.

Requirements

Tools/Equipments/Materials

- Materials like fuels, oils, consumables related to the trade
- Safety materials
- Fire extinguishers A,B,C & D type
- Exhausr scrubber
- Wheel chocks
- Steel horses
- Waste oil collectors

Procedure

Shop hazards

1 Flammable liquids such as gasoline and paint must be handled and stored properly in approved, closed containers.

2 Flammable materials such as oily rags must be stored properly in closed containers to avoid a fire hazard.

3 Batteries contain a corrosive sulphuric acid solution and produce explosive hydrogen gas while charging.

4 Loose sewer and drain covers may cause foot or toe injuries.

5 Caustic liquids, such as those in hot cleaning tanks, are harmful to skin and eyes.

6 High pressure compressed air can be very dangerous or fatal if it penetrates the skin and enters the blood stream. High pressure air released near the eyes cause eye injury.

7 Frayed cords on electrical equipment and lights may result in severe electrical shock.

8 Carbon monoxide from vehicle exhaust is poisonous.

9 Loose clothing or long hair becomes entangled in rotating parts on equipment or vehicles, resulting in serious injury.

10 Dust and vapors generated during some repair jobs are harmful. Asbestos dust, which may be released during brake lining service and clutch service, is a contributor to lung cancer.

11 Oil, grease, water or parts cleaning solutions on shop floors may cause someone to slip and fall. Resulting in serious injury.

Shop safety rules

1 Always wear safety glass and protective equipment where ever needed.

2 Do not wear loose or torn clothing.

3 Do not wear rings, watches or loose hanging jewelry.

4 Store oily rags and other discarded combustibles in covered metal containers designed for this purpose.

5 Operate all the shop equipment, including lifts, according to the equipment manufacturer's recommended procedure.

6 Do not run or engage in horse play in the shop.

7 Obey all fire, safety and environmental regulations.

8 Do not stand in front of or behind vehicles.

9 Collect oil, fuel, brake fluid and other liquids in the proper safety containers.

10 Be sure safety shields are in place on all rotating equipment.

11 Must wear proper foot wear.

Safety while working with the vehicles

1 Set the parking brake when working on a vehicle. If the vehicle has an automatic transmission, place the gear selector in park. When the vehicle is equipped with manual transmission, position the gear selector in neutral with the engine running, or in reverse with the engine stopped.

2 Always connect a shop exhaust hose to the vehicle tail pipe, and be sure the shop exhaust fan is running.

3 To operate the vehicle without exhaust hose, then open the large shop door to provide adequate ventilation.

4 Keep hands, clothing and wrenches away from rotating parts such as cooling fans.

5 Always leave the ignition switch off when it is not running.

6 Always place fender, seat, and floor mat covers on the vehicle before working on the car.

7 When one end of the vehicle is raised, place wheel chokes on both sides of the wheels remaining on the floor.

EXERCISE 1.3: Maintenance of garage equipments in the work shop

Objectives

At the end of this exercise you shall be able to

- operate the air compressor
- operate the hydraulic car hoist
- operate a car washer
- operate the mechanical/hydraulic jack and jack stand
- operate a grease gun
- operate an oil spray gun
- operate the mechanical press
- operate the hydraulic press
- operate the two post car hoist
- operate the four post car lift
- operate the engine hoist.

Requirements

Tools/Materials

• Trainee's tool kit	- 1 No's	• Air compressor	- 1 No.
• Measuring Tape	- 1 No's	• Cotton waste	- as reqd.
• Car	- 1 No.	• Soap oil	- as reqd.

Procedure

Air compressor (Fig 1)

1 Check the oil level.

2 Check the belt's (1) tension connecting the motor (2) and the compressor's pulley (3).

3 Ensure that the belt guard is fixed in its position.

4 Drain the water through the drain plug (4) and tighten the drain plug.

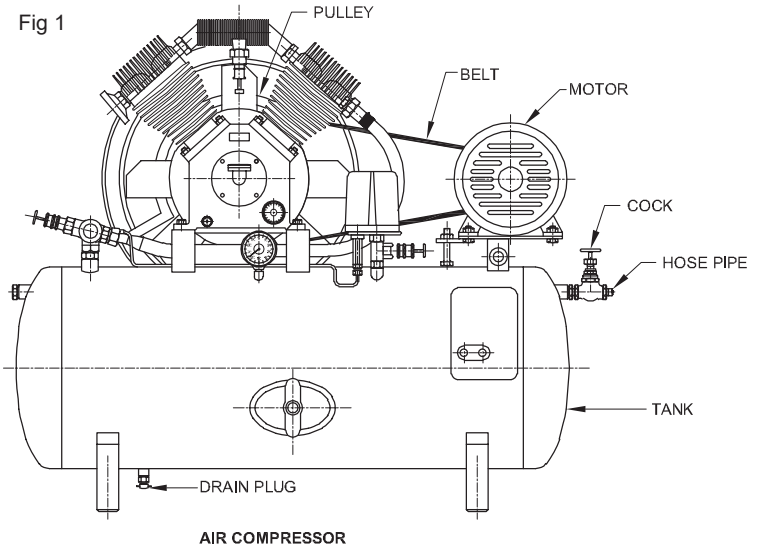
5 Inspect the electrical connections visually for looseness, disconnections or cuts.

6 Switch 'on' the compressor

7 Observe the sound of the compressor. If any abnormal sound is found, stop the compressor immediately. (Consult your instructor)

8 Switch 'off' the compressor.

Fig 1



AIR COMPRESSOR

9 Hold the hose-pipe (5) and open the cock (6). Use compressed air wherever needed.

10 Close the cock after using the compressed air.

Skill Sequence

Hydraulic car hoist

This shall help you to

- operate service station equipments.

Hydraulic car hoist (Fig 2)

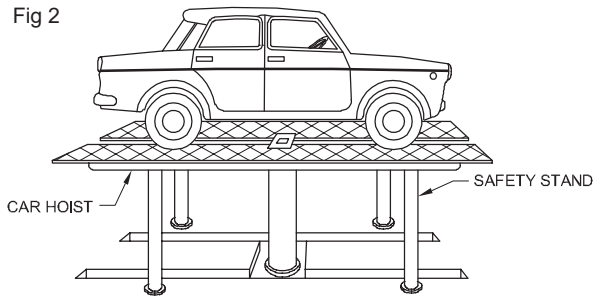
Park the vehicle in the centre of the car hoist.

Clamp the front and rear axle or check wheels

Open the air cock gradually and observe that the car hoist(1) is moving upwards.

Close the cock when it reaches the required height.

Fig 2



HYDRAULIC CAR HOIST

Provide safety stands(2)underneath the hoist. Open the outlet cock slowly so that the vehicle moves down without jerk. Ensure that the hoist side rail sits firmly on the stand.

After finishing the required job, slightly open the inlet cock and raise the car hoist slightly up. Close the inlet cock.

Remove the safety stands.

Ensure that nobody is present underneath the vehicle.

Open the outlet cock slowly so that the hoist comes down without disturbing the vehicle's position.

Remove the clamps/chocks and remove the vehicle from the hoist.

Car washer.

Check the oil level.

Check the belt tension.

Check the belt guard for its position.

Inspect the electrical connection visually for looseness, disconnections or cuts.

Open the water tank.

Check the water level.

Hold the gun before starting the car washer.

Switch 'ON' the car washer and adjust the pressure gauge for the required pressure.

Open the water gun.

Check the water jet and adjust for force and spray at an angle to body panel.

After completing the cleaning, stop the car washer.

Close the water intake cock (water supply).

Mechanical jack (Fig 3)/Hydraulic jack (Fig 4)

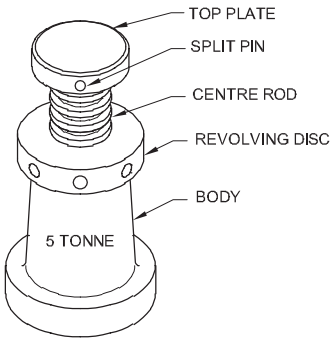
Park the vehicle on level ground.

In case of jacking up the front axle, chock the rear wheels and vice versa.

Check the free movements of threads in a mechanical jack by hand and in the hydraulic jack. Check the oil level and its operations.

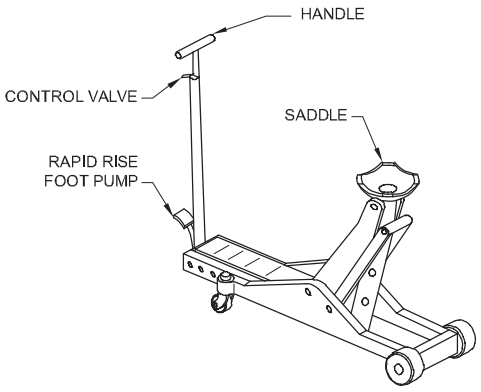
Place the jack under the vehicle in specified place.

Fig 3



MECHANICAL JACK

Fig 4



HYDRAULIC JACK

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Rotate the screw gradually with the jack lever and lift the vehicle and in the case of hydraulic jack move the jack's lever slowly so that the axle jacks up without any jerk.

Place the support/horses below the chassis frame/axle.

Lower down the jack and remove it.

After completing the specific job jack up again.

Remove the support/horses.

Lower down the jack and remove it.

Safety points

1 Never work under a vehicle supported only by a floor jack.

2 Lift saddles must be properly located and in secured contact.

3 Always check for equipments, parts or personnel beneath the car before lowering.

Jack stand (Fig 5)

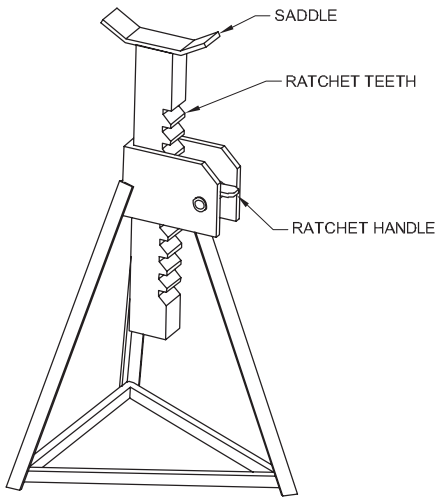
The height of the jack stand is adjusted by the ratchet adjustment.

Stands must be properly and securely placed.

Grease gun (Fig 6)

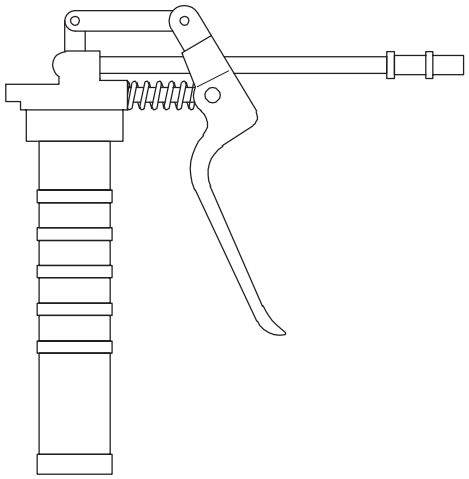
Select the grease gun nipple according to the vehicle. (Consult your instructor)

Fig 5



TYPICAL ADJUSTABLE JACK STAND

Fig 6



GREASE GUN

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Check visually, the grease nipple holder for any damage.

Fill up the gun with the specified grease.

Close the grease gun and operate the lever till the grease comes out continuously from the nipple with pressure.

Use the gun for the required purpose.

Oil spray gun

Check visually the oil spray gun nozzle, nozzle holder, operating lever, air hose for any damage.

Fill the spray gun with SAE20W/40 and kerosene mixture in the ratio of 1:20.

Connect the oil spray gun to the quick release coupler.

Operate the oil spray gun.

See that the oil is sprayed at pressure and spray over panel joints and moving part only.

Close the air-hose connections and takeout the oil spray gun.

Mechanical (Arbor) press (Fig 7)

Check for easy movement of the operating lever(1) and rack if necessary lubricate.

Select the plate(3)according to the work.

Place the component on the plate.

Press the work slowly and listen for abnormal noise.

Hydraulic press (Fig 8)

Clean the press.

Check the oil level(1) if necessary topup with hydraulic oil

Check the hydraulic press for its free function and leakage

Lock the cylinder plunger releasing knob(2).

Fig 7

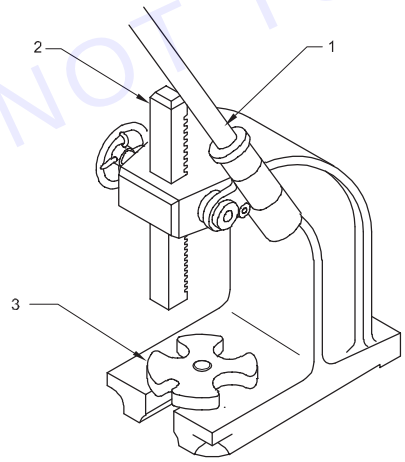
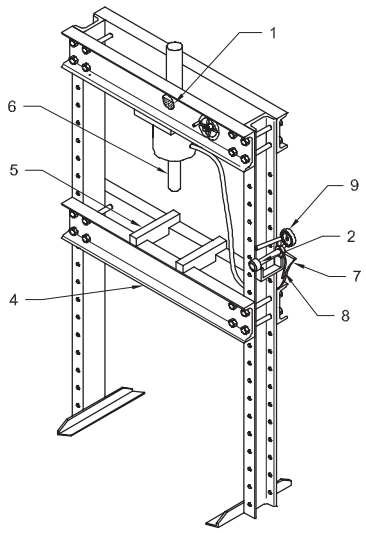


Fig 8



HYDRAULIC PRESS

Adjust the bed(4) to the required height so that, after placing the job, there will be 100mm clearance between the plunger (6) and the bed (4).

Align the anvil (5) according to the job.

Place the job on the anvil (5).

Select the distance piece in such a way that while pressing the shaft/bush, it does not touch the body (minimum 10mm gap to be given between the plunger (6) and the distance piece)

Place the distance piece on the shaft/bush. Ensure that it does not touch the body.

Operate the low pressure lever (7) and make the plunger (6) to have a contact on the job,

Operate the heavy pressure lever (8), observe the load on the gauge(9) and the job simultaneously. Ensure the job comes out gradually.

If the load exceeds more than the specified limit, stop the pressing.

Safety

1 Shield brittle parts such as bearings to prevent flying of parts.

2 After finishing the work loosen the plunger releasing knob (2).

3 Remove the job and clean.

Two post car hoist

Park the vehicle in the centre of the electro mechanical hoist.

Adjust and fix the telescopic two post lift lifting arm.

Use the automatic arms locking and releasing device while lifting and lowering.

Set safety mechanism to prevent uneven lifting.

Use the extra safety nut.

Check the chain drive and operate the lifting switch.

Use the anchoring bolts for safety (Fig 9).

Four post lift

Drive the vehicle on the leveled ramp of the four post lift.

Check the vehicle parked correctly are not on the romp & use wooden block as a stopper

Check the vehicle door and glasses are closed & pull up hand brake lever of vehicle.

Drive the hydraulic cylinder in stable & lowering.

Offering pull range mechanical protection by using safety block

Connected by using steel cables, Forced synchronized movement of the lift in order to effectively prevent the sloping of the vehicle

Ton with extended run way length for LCV and Bigger vehicle.

Fig 9

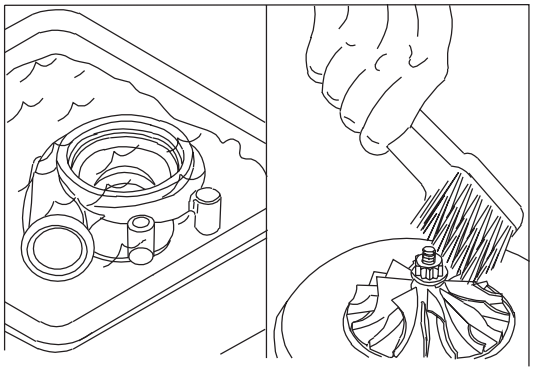
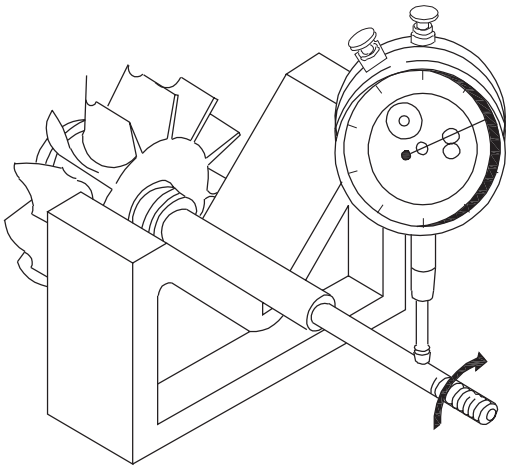


Fig 10



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Engine hoist

Keep the vehicle on level ground.

If firm ground is not there use big wooden block under the base of hoist.

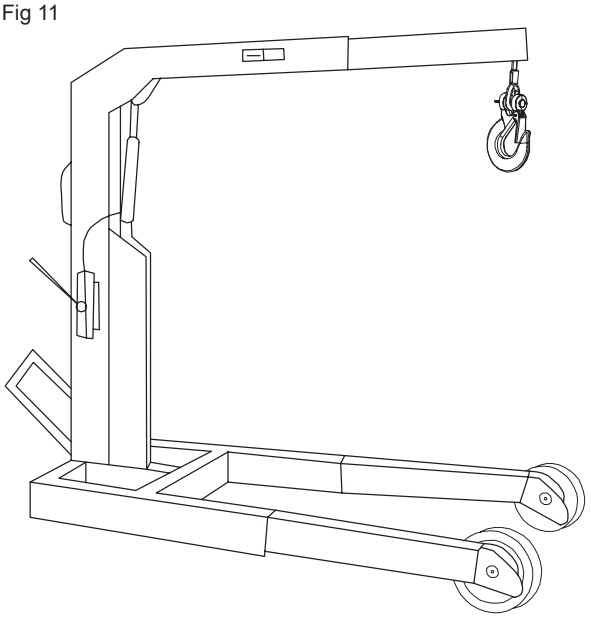
Pull up hand brake lever of vehicle.

Place the hoist on firm ground & fix a rope to such part of engine.

Lift the hoist slowly till free from the vehicle.

Slowly roll the wheel hoist and take hoist to work shop. (Fig 11)

Fig 11



EXERCISE 1.4: Preventive maintenance of a light motor vehicle

Objectives

At the end of this exercise you shall be able to

- check condition of the antifreeze
- check condition of the engine oil
- check condition of the brake fluid
- check condition of the wind shield washer
- check battery condition
- check pump belt tension
- check bearing steering and suspension components
- check underhood oil leaks
- check dash board indicators
- check electrical accessories
- check car a/c effect.

Requirements

Tools/Materials

- A running diesel engine
- Two or four post lift
- Multi meter
- Thermometer
- Refractometer
- Brake oil tester
- Coolant
- Distilled water
- Engine oil
- Brake oil
- Wind shield washer

Procedure

1 Park the vehicle in a level surface.

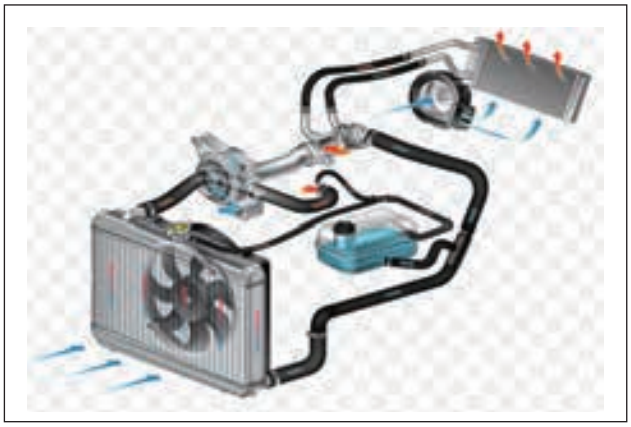
2 Apply hand brake.

3 Put the gear in reverse position.

4 Open the bonnet.

TASK 1: **Check coolant**

- Identify the anti freeze bottle.
- Check the level of the anti freeze.
- Remove the anti freeze bottle cap.
- Confirm colour of the antifreeze solution.
- Take a few drops of antifreeze.
- Put these drops in the refractometer.
- Check the quality of the antifreeze solution.
- Top the antifreeze solution if necessary.



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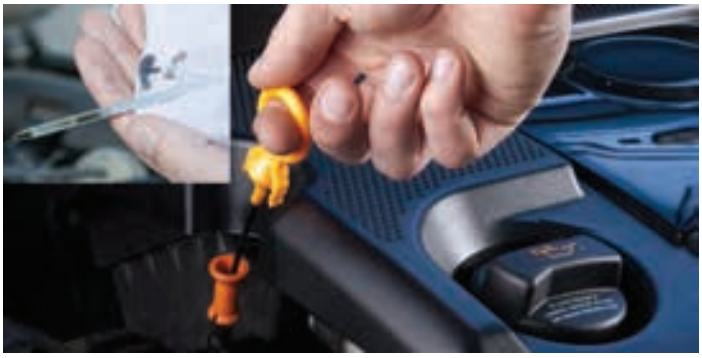
TASK 2: **Check engine oil**

- Remove dip stick
- Clean it Thoroughly
- Reinsert it fully
- Remove again
- Check the engine ail lord
- Open the oil cap and top up it necessary
- Reinsert dip stick



TASK 3: **Check brake oil**

- Identify the brake oil container.
- Check the level of the brake ail.
- Open the brake oil container cap.
- Insert the brake oil tester.
- Switch on/ the tester and check the condition of the brake oil. By the colour of the LED in tester.

TASK 4: **Check wind shield washer**

- Open the wind shield washer cap.
- Top up if necessary.

TASK 5: **Check battery condition**

- Check the battery voltage
- Crank the engine and check the cranking voltage
- Start the engine and raise the speed till the engine speed app. 3000 rpm. check the charging voltage

TASK 6: **Check pump belt tension**

- Identify the pump belt.
- Check the belt tension in between alternator and pump pulleys.

TASK 7: **Check steering and suspension system components**

- Lift the vehicle.
- Check the condition of the wheel bearings by rotating the wheels.
- Hold the wheel in horizontal direction firmly by hands and jiggle the wheels. If yes check steering system components for wear and deterioration.
- Hold wheel in vertical direction by hands firmly and jiggle the wheels. If you check the suspension system components for wear and deterioration.

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TASK 8: **Check under hood oil leaks**

- Lift the vehicle fully and do under hood inspection.
- Check any ail leaks in engine oil sump and bottom of the gearbox.
- Cheek exhaust leaks by starting the engine.
- Check should absorber oil leaks.

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TASK 9: **Check dash board indicators and switches**

- Switch on ignition.
- Check all dash board indicators are on.
- Start the engine.
- Apply foot brake.
- Release hand brake.
- Check all the indicators are off.

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TASK 10: **Check electrical accessories**

- Close all the doors and windows of car
- Switch on head lights and check.
- Switch on indicators an indicators and check.
- Switch on and cheek wiper mechanism.
- Apply foot brake and check its function.

— — — — —

TASK 11: **Check a/c condition**

- Place a thermometer in the AIC duct.
- Check the temperature of the A/C cut off.
- Stop the engine.

— — — — —

MODULE 2: Engine System

EXERCISE 2.1: Perform vacuum test

Objectives

At the end of this exercise you shall be able to

- installing vacuum gauge
- testing the vacuum in different stages
- concluding the results.

Requirements

Tools/Materials

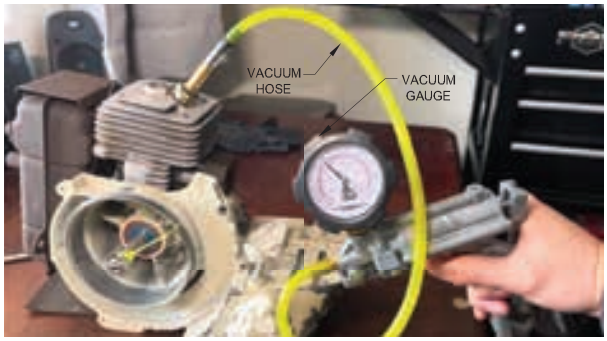
- A petrol vehicle in running condition
- Combination plier
- Vacuum gauge

Introduction

The vacuum test is performed in an engine to know the condition of the engine and with the results we can have a conclusion of whether the engine need reconditioning or not.

Procedure

- Place the vehicle in a level ground.
- Switch off engine.
- Open the bonnet.
- Locate the vacuum line in the engine intake manifold.
- Disconnect the vacuum connection from the component where it is connected and not from the intake manifold
- Connect the vacuum gauge with the vacuum line.
- Start the engine.
- Allow the engine to run idle.
- Note down the reading shown in the vacuum gauge.
- The vacuum of the engine during idle is _____ in- Hg.
- Slowly raise the engine till the engine speed reaches approximately 2500 rpm. And measure the vacuum again.



- The vacuum during 2500 rpm is _____ in-Hg.
- slow down the engine speed.
- Raise the engine speed suddenly and release it immediately.
- Note down the vacuum reading.
- The vacuum during sudden raise and release are _____ in Hg.
- Based on the readings obtained, conclude the condition of the engine.

EXERCISE 2.2: Perform compression test

Objectives

At the end of this exercise you shall be able to

- install compression gauge
- test engine compression in different stages
- conclude the results.

Requirements

Tools/Materials

- A diesel vehicle in running condition
- Compression gauge with necessary adopters
- Engine oil
- Oil can
- Trainees tool kit.

Introduction

The engine's compression is The results of condition Tested by the compression gauge. Compression gauge in different stage tell us the of the engine and with this we can decide whether the engine needs reconditioning or not.

Procedure

- Place the vehicle in a level ground .
- Apply hand brake.
- Switch oft engine.
- Open the bonnet.
- Identify the fuel pump relay and remove it.
- Run the engine till it stops. This action releases the fuel pressure.
- Remove the air filter assembly.
- Remove the injector connections from the common rail.
- Remove the injectors from all cylinders.
- Select correct size adopter and fit with the compression gauge.
- Install Compression gauge in first cylinder where injector fitted.
- Hold it properly.
- Crank the engine.
- Press the accelerator pedal fully.
- Observe needle the reading a the reading the engine for few seconds and allow the engine to crank till the compression gauge needle stalls.
- Stop cranking the engine.
- Note down the maximum reading obtained.
- The reading obtained during dry test is ___ kg/cm²
- Remove the compression gauge.
- Put few drops of oil in to the engine cylinder.
- Install gauge again compression gauge.
- Crank the engine and note down the readings.
- The reading obtained during wet test is _____ kg/cm²
- Do the same procedure for all cylinder.
- Conclude the condition of the engine from the readings obtained.

EXERCISE 2.3: Carry out cylinder leakage test

Objectives

At the end of this exercise you shall be able to

- clean the cylinder block and locate cracks distortion
- check cylinder block leakage.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Scraper - 1 No.

Equipments/Machines

- Engine cylinder block - 1 No.
- Multi cylinder diesel engine - 1 No.
- Air compressor, Water washer - 1 No.

Materials/Components

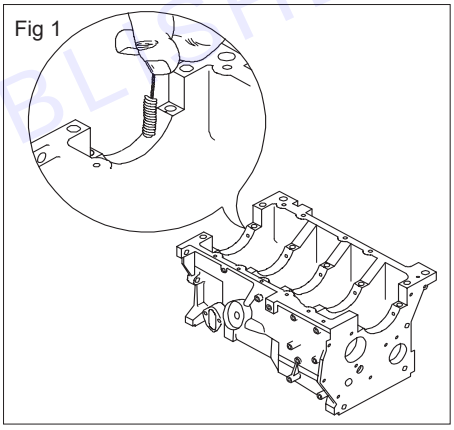
- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.
- Steel plate with rubber pad - as reqd.
- Hot water - as reqd.

Procedure

TASK 1: **Cleaning the cylinder block**

1 Put the cylinder block on wooden blocks (Fig 1)
2 Clean cylinder block with suitable solvent or steam.
3 Clean the oil passages of cylinder block with help of wire brush.
4 Remove all sludge of dirt and carbon deposits in crank case, cylinder walls and valve chambers.
5 Remove carbon deposits in cylinder block.
6 Use scrapper to remove hard carbon deposits and take care with out damage the highly finished surfaces.
7 Clean the cylinder block by using compressed air blast.
8 Visually check the cylinder block for cracks and damages.
9 Replace the cylinder block if any damage is found.

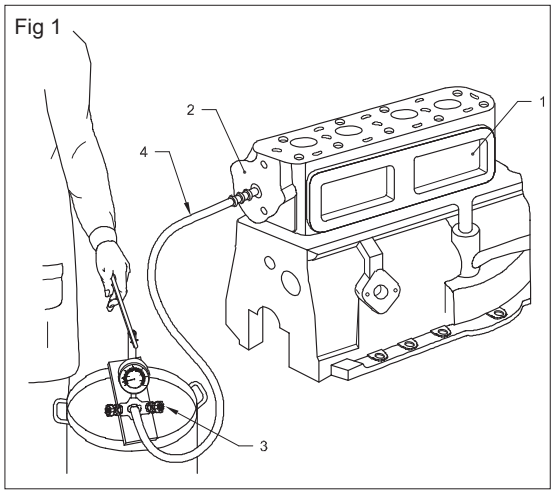
Fig 1



TASK 2: **Descaling water passages of cylinder block**

1 put the engine on two wooden block
2 Clean the engine block with suitable solvent
3 Descale water passages by injecting water with suitable solvent at high pressure.
4 Clean the cylinder block by using compressed air blast. (Fig 1)
5 Check engine block visually for cracks.
6 Fit steel plate (1) with rubber pads on cylinder block to close water jackets opening and also fit side sealing plate.
7 Fit sealing plate (2) with adapter on the front face of the block and connect rubber hose (4) to hand operated pump (3) dipped in a container of hot water of 70oC to 80oC temperature.
8 Pump water in cylinder block at approximate 5kg./cm2 and check cylinder block correctly for leakage.
9 If leakage found in cylinder block Repair/ replace it.
10 Clean the cylinder block oil gallery passages.
11 Clean the oil pipe lines of engine.

Fig 1



EXERCISE 2.4: Measure the cubic capacity of an engine

Objectives

At the end of this exercise you shall be able to

- calculate the cubic capacity of an engine
- calcuate the compression ratio of an engine.

Requirements

Tools/Instruments

- Mechanic tool kit
- Dial gauge with magnetic base
- Vernier gauge
- Flat Scrapper
- Telescopic gauge
- Inside micrometer

Equipments/Machines

- Multi cylinder diesel engine
- Vacuum cleaner
- Air Compressor

Materials

- Cotton waste - as reqd.
- Cotton cloth - as reqd.
- Emery sheet fine
- Cylinder bore gauge

Procedure

1 Clean the engine outside with compressed air and cotten waste.

2 Remove the battery terminals connected to the Engine.

3 Remove the fuel line, coolant line and other electrical connections to the engine.

4 Remove the air filter assembly.

5 Remove the water pump/alternator belt.

6 Remove the valve cover.

7 Remove the cylinder head bolts .

8 Remove the crank shaft pulley.

9 Remove the timing cover.

10 Remove the timing belt.

11 Remove the cylinder head.

Note: Follow the instructions of available engine Service manual for removal of cylinder head.

12 Clean the cylinder bore and piston head of each cylinder.

13 Remove the carbon deposits and wipe with clean cloths.

14 Use vernier depth gauge, measure the stroke length, when the piston is at B.D.C. That is, measure the distance between cylinder Top to piston head when the piston is at B.D.C.

15 Note down the reading of stroke length.

16 Use cylinder telescopic gauge inside micrometer cylinder bore gauge, measure the cylinder bore diameter.

17 Calculate the cubic capacity of an engine using the following formula

Cubic capacity = $\pi/4 \times (D)^2 \times L \times N$

Where, CC = Cubic capacity in cm

D = Diameter of the bore in cm

L = Stroke length in cm

N = Number of cylinders

18 Compare the cc value given by the engine manufacturer with measured cc value for any deviations.

Note: If any engine cylinder bore reconditioning work is done, check this engine displacement volume and then calculate compression ratio.

19 Calculate the compression ratio of the engine using the following formula

$$\text{Compression Ratio} = \frac{\text{The total cylinder volume when piston at BDC}}{\text{The total cylinder volume when piston at TDC}}$$

$$CR = \frac{Vs + Vc}{Vc}$$

Where,

Vs = Swept volume

Vc = Clearance volume

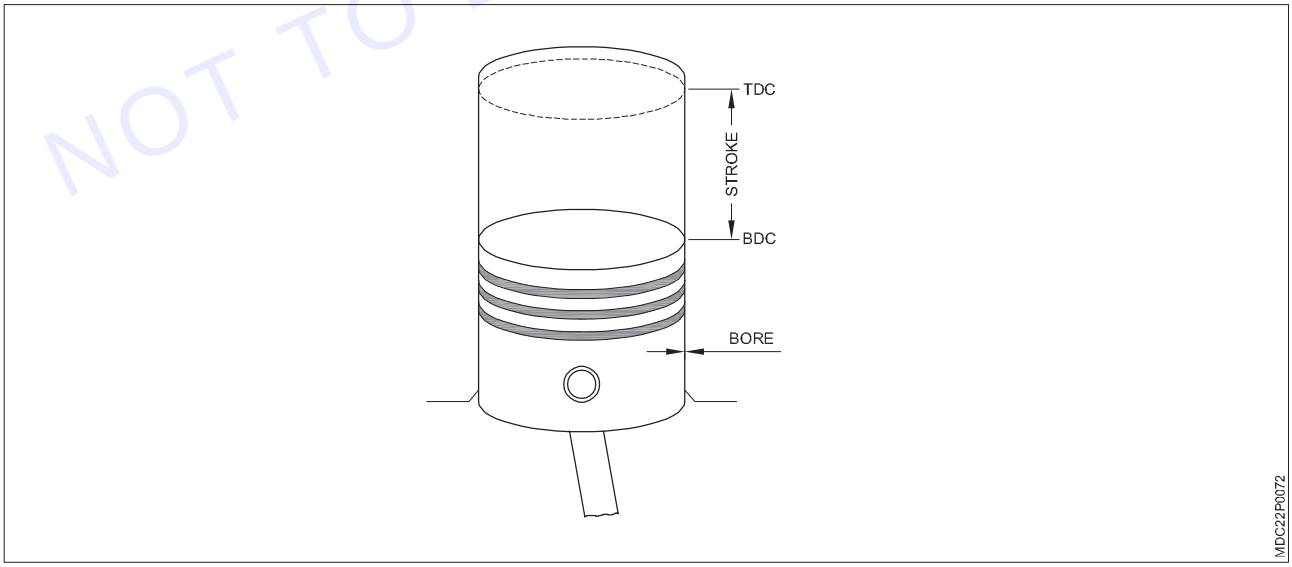
20 Compare the compression ratio with manufacturer's recommendation.

Note:

- **The volume of combustion chamber and cylinder head gasket thickness are to be added while calculating the cylinder volume.**
- **The volume of the head gasket is calculated by multiplying its thickness by the square at the bore and 0.7854.**

21 Refit cylinder head and other removed components

22 Reconnect fuel, coolant and other electrical connections.



EXERCISE 2.5: Removing the accessories from the engine

Objectives

At the end of this exercise you shall be able to

- dismantle the diesel engine.

Requirements

Tools/Instruments

- Tools/Instruments
- Trainee's tool kit - 1 No.
- Torque wrench - 1 No.
- Tray - 1 No.

Equipments/Machines

- Diesel engine vehicle (LMV) - 1 No.
- Engine lifting crane - 1 No.

Materials

- Cotton cloth - as reqd.
- Soap oil - as reqd.
- Kerosene - as reqd.
- Engine stand - as reqd.
- Wheel choke - as reqd.

Procedure

- Drain the oil (if provided)
- Drain the water (if provided)
- Remove the radiator (if provided)
- Disconnect electrical connections
- Disconnect the fuel pressure pipes (5) (Fig 1)
- Remove the fuel filter assembly (8)
- Remove the flywheel (6)
- Remove the fan belt (9)
- Remove the dynamo/alternator (10)
- Remove the self-starter (11). (Fig 3)
- Remove the water pump assembly (12)
- Remove the inlet (4) and exhaust (15) manifold
- Remove the valve cover (16). (Fig 2)
- Remove the timing cover.
- Remove the timing gear and chain (22). (Note down the timing marks)

Fig 1

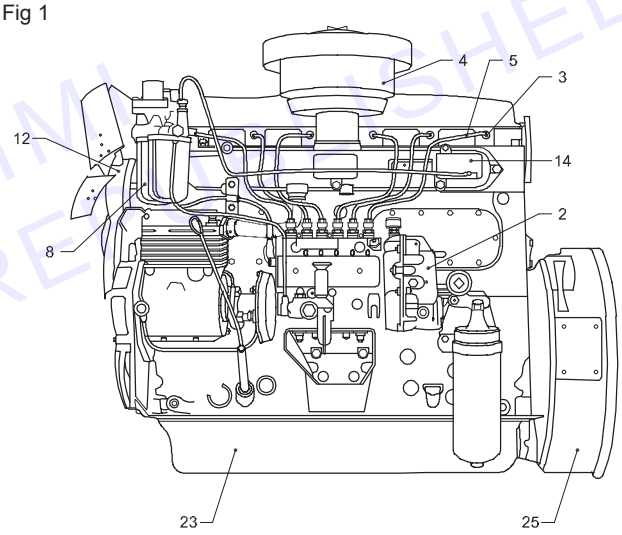


Fig 2

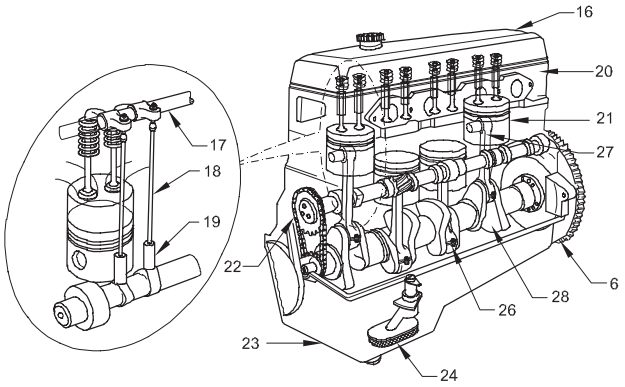
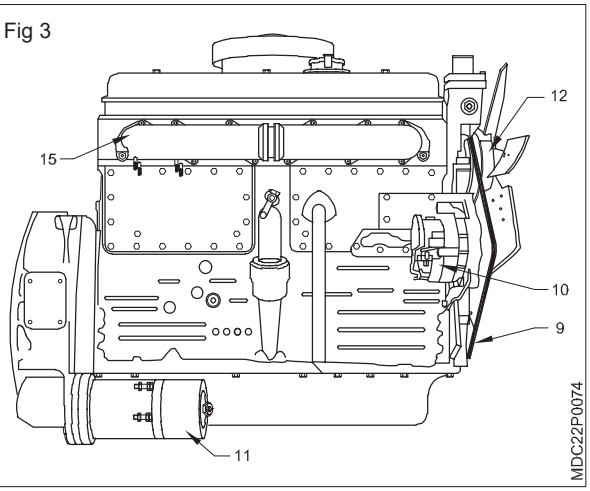


Fig 3



EXERCISE 2.6: Remove the check the vibration damper

Objectives

At the end of this exercise you shall be able to

- check the vibration damper defects.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Socket spanner for damper pulley - 1 No.
- Pulley puller - 1 No.

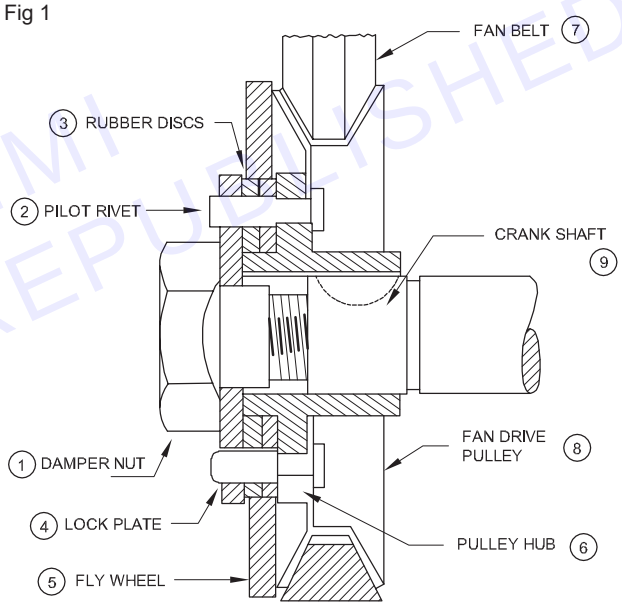
Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Vibration damper accessories - as reqd.

Procedure

- Remove the fan belt (7) (Fig 1) from the fan drive pulley
- Loose the damper nut (1) with help of socket spanner and remove the damper nut
- Fix the puller on fan drive pulley (8) and remove it
- Place the fan drive pulley on the tray
- Clean the vibration damper and fan drive pulley
- Visually check the rubber discs (3), pilot rivet (2) and lock plate (4) of vibration damper.
- Dismantle the vibration damper
- Plate the vibration damper, pilot rivet discs, pulley hub, fandrive pully, lock plate, damper nut on the work bench in tray.
- Clean all dismantled parts of the vibration damper
- Inspect the dismantled parts for wear and damages
- Select the damaged/ wearing parts and replace it with new parts.

Fig 1



VIBRATION DAMPER

- Assemble the all dismantled parts of vibration damper.
- Fit the vibration damper on the crank shaft.
- Ensure the vibration damper is properly installed with the fan drive pulley.

EXERCISE 2.7: Removing and checking the camshaft

Objectives

At the end of this exercise you shall be able to

- remove and inspect camshaft from the engine
- check cam shaft bend and twist
- inspect cam lobe and journal
- measure cam lobe height.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Mallet - 1 No.
- Feeler gauge, - 1 No.
- Outside micrometer - 1 No.
- Dial test indicator - 1 No.
- 'V' block - 2 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.
- Surface table - 1 No.

Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Procedure

- Remove the bolts (1) retaining the camshaft thrust plate and remove thrust plate (Fig 1)
- Support the camshaft and carefully slide the journals through each bearing. Avoid contact of the surface with cam lobe and pull out the camshaft. (Fig 2)

Fig 1

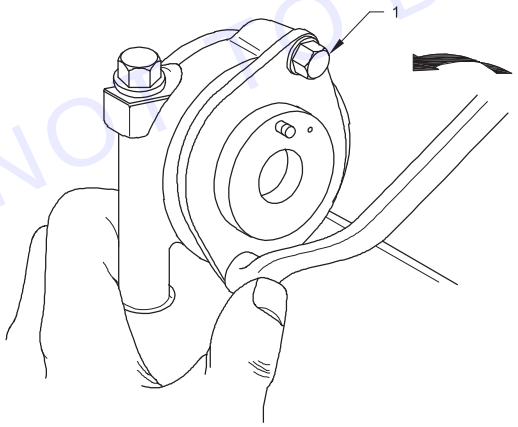
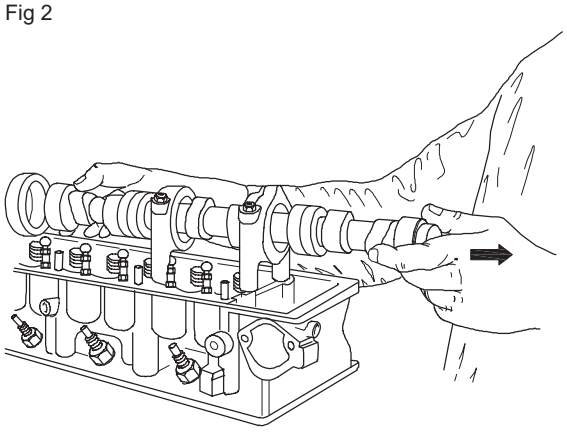


Fig 2



- Clean the camshaft thoroughly.
- Inspect the camshaft journals for scratches, grooves and pitting marks.
- Measure each journal for ovality, taper and wear.
- Check camshaft for bend and twist with dial test indicator
- Check cam lobes surface for wear. (Fig 3)
- Measure diameter of the base circle (1) of camshaft with a micrometer.

- Measure height (2) of cam lobe with micrometer.
- Difference between cam lobe height (2) and base circle diameter (1) is cam lift.
- Check oil pump drive gear for pitting, wear and damage.
- Check eccentricity for driving fuel pump.
- Check the cam shaft bearings. If any damages found, replace the bearing.
- Measure clearance between thrust washer (1) and camshaft's first journal (2). (Fig 4)
- Change thrust washer if clearance is not as per manufacturer's recommendation.

Fig 3

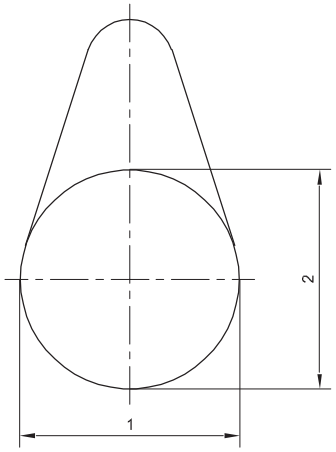
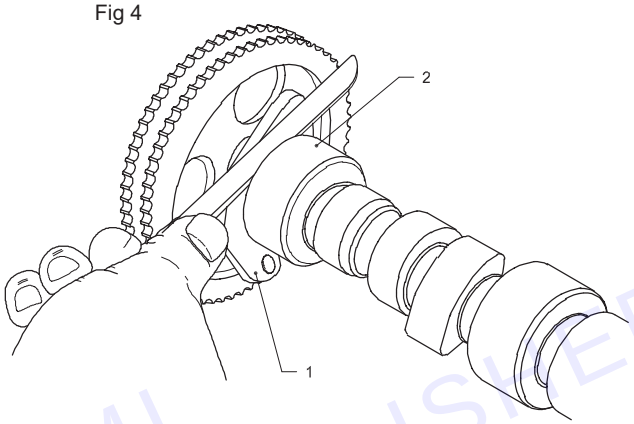


Fig 4



EXERCISE 2.8: Removing the cylinder head from the engine

Objectives

At the end of this exercise you shall be able to

- remove the cylinder head from the engine
- decarbonise the cylinder head.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Box spanner set - 1 Set.
- Torque wrench - 1 No.
- Wire brush, Scrapper - 1 No each.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.
- Zib crane/engine hoist - 1 No each.

Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.
- Wooden block - as reqd.

Procedure

- Remove the air cleaner and keep it in a vertical position on a plain surface to avoid spilling of oil.
- Remove the valve cover.
- Disconnect the fuel delivery lines. Hold the inner nut (1) with the help of a double end spanner (2), then loosen the outer nut(3) with the help of another double end spanner (4). Remove the pipe (5). (Fig 1)
- Remove the fuel pipes and the injectors.
- Loosen the fuel injection pump mounting nuts, by loosening each screw, two turns at a time. Ensure that these nuts do not fall anywhere.
- Remove the F.I.P. and keep it in a vertical position on a plain surface.
- Loosen nut (1) and pull the alternator (2) downwards till the fan belt becomes loose. Use a screw-driver (3) between the fan and pulleys or between any of the pulleys and remove the fan belt. (Fig 2)

Fig 1

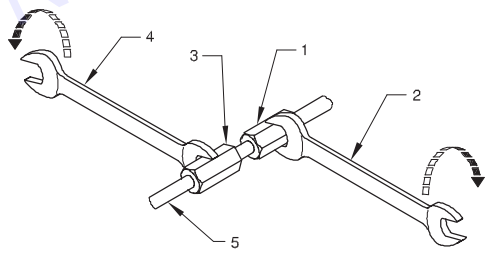
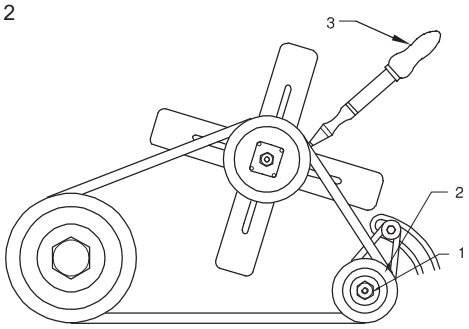


Fig 2



- Remove the fan assembly with the water pump pulley.
- Take out all the push-rods.
- Remove the tappet side cover and remove the tappets.
- Remove all the cylinder head nuts/bolts.
- Fix the lifting hooks (1) at both ends of the cylinder head (2). (Fig 3)

- Lift the cylinder head with the help of lifting hooks from the cylinder block (3).
- Ensure that the cylinder head is not tilted while removing, so as to avoid damage to the cylinder head studs.
- Place the cylinder head (2) on a workbench (4) over two wooden block stands (5). (Fig 4)
- Remove the cylinder head gasket and keep it in a safe place.

Fig 3

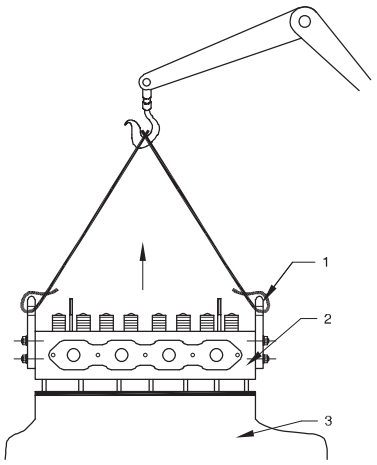
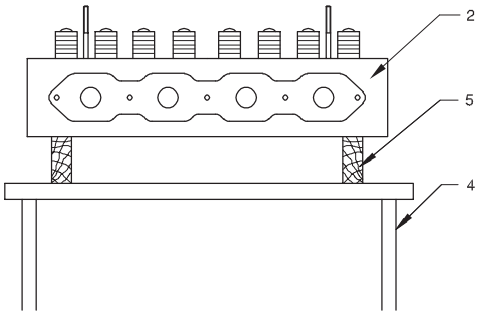


Fig 4



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- Remove the carbon deposit on the cylinder head with a wire brush /scraper.
- Clean the cylinder head with cleaning solvent used.
- Visually check the cylinder head for its damages and cracks.

Before removing the cylinder head check the clearance and other parameter as per the service manual.

While decarbonising, ensure the cylinder head surface is not scratched.

EXERCISE 2.9: Practice on removing rocker arm assembly and manifolds

Objectives

At the end of this exercise you shall be able to

- remove the rocker arm assembly from the cylinder head
- remove the manifolds from the cylinder head.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Box Spanner set - 1 No.
- Wire brush, scrapper - 1 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.

Materials/Components

- Tray - 1 No.
- Cotton waste - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.
- Gasket - as reqd.

Procedure

TASK 1: **Removing rocker arm assembly**

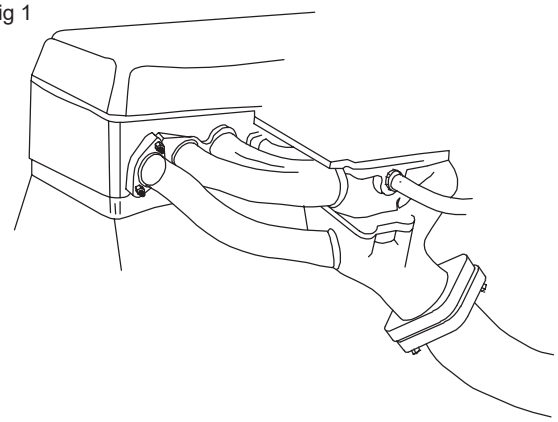
- Remove the head cover (value door)
- Remove the mounting nuts of the rocker shaft supports.
- Takeout the rocker shaft along with supports in the horizontal position.
- Ensure that the shaft does not tilt to avoid bending and breakage of the shaft.
- Place the rocker arm assembly on the work bench in tray
- Clean the rocker arm assembly with specified cleaning solvent. (avoid to prevent damage the valves and rocker arms during removing and cleaning the rocker arm assembly)

— — — — —

TASK 2: **Removing the inlet and exhaust manifold from the cylinder head (Fig 1)**

- Remove the exhaust manifold flange nuts and bolts.
- Disconnect the exhaust pipe line from exhaust manifold.
- Loosen the exhaust manifold mounting bolts.
- Remove the turbo charger before loosen the exhaust manifold mountings.
- Remove the manifold mountings and take out from the cylinder head and place it on the work bench.
- Remove the air cleaner or air intake hose from the inlet manifold
- Loosen mounting bolts of inlet manifold.
- Remove the inlet manifold mounting bolts and take out from the cylinder head and place it on the work bench.

Fig 1



- Ensure the manifold are safety placed on the work bench.
- Visually inspect the manifolds for any damages on the manifold.
- If any damages found make repair and clean it thoroughly.

EXERCISE 2.10: Practice on removing the valves from the cylinder head

Objectives

At the end of this exercise you shall be able to

- remove the valves and its parts from cylinder head and clean the parts.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Valve spring lifter - 1 No.
- Wire brush, scrapper - 1 No each.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.
- V block - Set.
- Spring tester - 1 No.
- Dial gauge with stand - 1 No.

Materials/Components

- Tray - 1 No
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Lube oil - as reqd.

Procedure

V

Remove valves

- Place the cylinder head on a work bench over the two wooden block stands.
- Mark the valves
- Press the valve spring (6) with the help of the special tool (7).
- Take out the cotters (8) (Fig 1)/ locks/collars using the special tool (7).
- Release the valve spring and take out the special tool (7).
- Remove the spring, (6) and the valve (11) and retainer (10). (Fig 2)

Fig 1

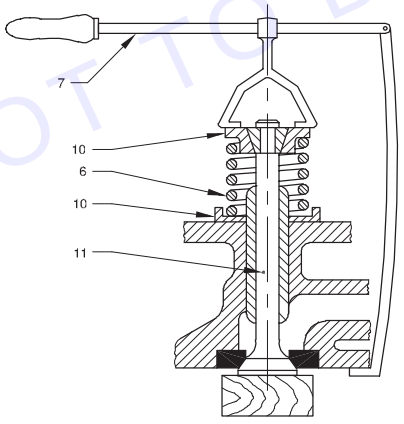
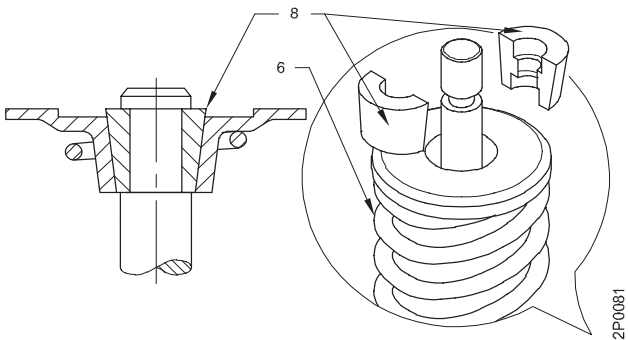


Fig 2



- Keep the valves in order.
- Clean the valves, springs and spring retainers, cotters and head surfaces using kerosene.
- Remove the carbon deposits, using a wire brush, from the valve seats and combustion chamber's surroundings.
- Inspect the valve stem for bend, using a 'V' block and dial gauge.
- Check the valve face visually, for pitting and damage.
- Check the cotter collar for damage.
- Check the valve spring for tension, on a spring tester.
- Check the valve spring, for breakage/damage.

EXERCISE 2.11: Inspection of valve assembly components

Objectives

At the end of this exercise you shall be able to

- check the flatness of cylinder head surface by the straight edge and feeler gauge
- check the flatness of manifold by the straight edge and feeler gauge.
- check valve seat and valve guide.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Straight edge - 1 No.
- Feeler gauge - 1 No.
- Wire brush, scrapper - 1 No.

Equipments/Machines

- Diesel engine - 1 No.

Materials/Components

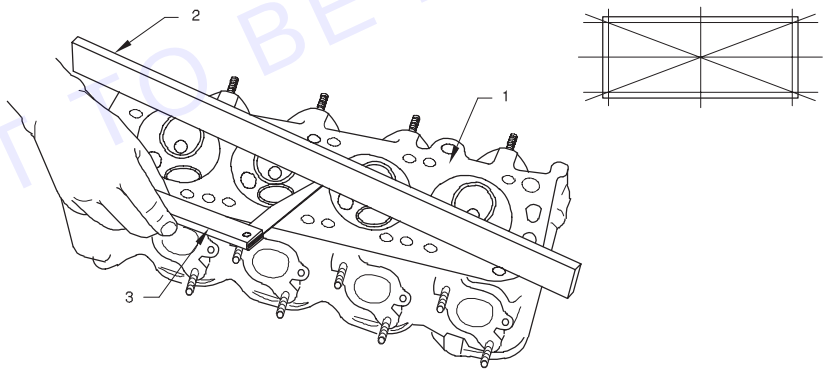
- Tray - 1 No.
- Cotton waste - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.
- Emery sheet - as reqd.

Procedure

TASK 1: **Checking flatness of cylinder head surface by straight edge and feeler gauge**

- Clean the surface to be checked.
- Place the cylinder head (Fig 1) (1) on a plain surface, so that surface, to be checked, faces upward.
- Keep the straight edge (2) (Fig 1) on surface and press the straight edge at the centre with your left hand.

Fig 1



- Insert the feeler gauges (3) leaves between the straight edge (2) and the surface.

Note down the thickness of the thickest leaf/leaves which can be inserted between the straight edge (2) and the surface. This thickness gives the maximum face out in that direction.

- Repeat above steps in four directions and note down the maximum face out in all the four directions.
- Recommend for resurfacing/replacement of cylinder head (1) if maximum face out in any one or more directions is more than the limit specified by the manufacturer.
- Clean the feeler gauge thoroughly by using a cloth.
- Clean the gap of the work to be measured.

- Find out the dimension from the drawing and select the minimum number of leaves which make the dimensions, say 2.55 mm, and pack the feelers together to form the desired dimension. (Fig 2)

Ensure that the ends of the feelers are straight, and not spread outwards.

- Pinch the feelers together and offer them to the gap.
- After the gauge dimension is done, change the feelers used, until the feelers entering the gap offer a slight resistance to movement. (Fig 3)

Fig 2

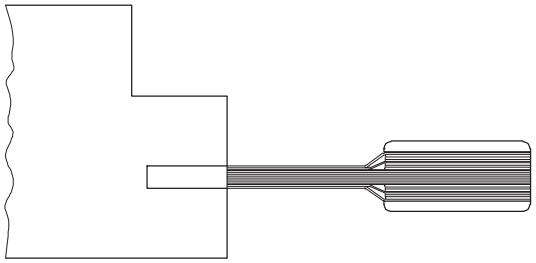
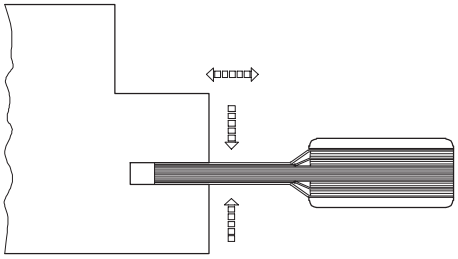


Fig 3



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- Note down the measured dimension.

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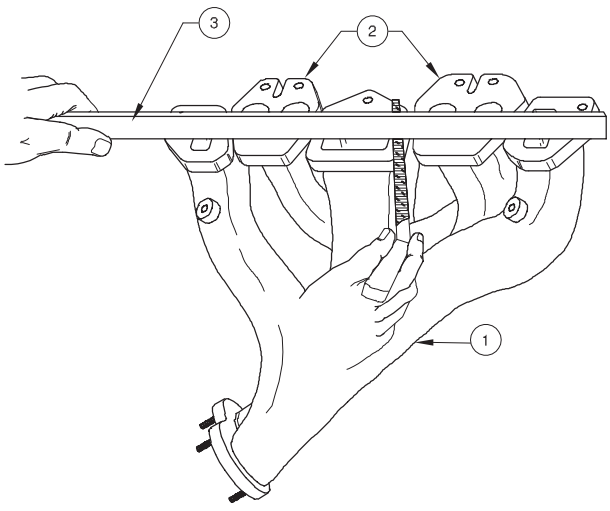
TASK 2: **Check flatness of manifold surface by straight edge and feeler gauge**

- Clean the mounting surface of the manifolds (1) free from carbon deposit (1) (Inlet & exhaust)
- Place the manifold surface parts upward to be checked
- Visually check the surface for damages/cracks
- Keep the straight edge (3) on the surface part of the manifold (1) and insert the feeler gauge is leaves between straight edge and surface (Fig 1)
- Repeat the above steps in four directions and note down the maximum face out in all the four directions
- Recommend for resurfacing/replacement of the manifold if wear is more than the limit specified by manufacturer or damaged.

Fig 1



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EXERCISE 2.12: Checking valve seat and valve guide

Objectives

At the end of this exercise you shall be able to

- check valve seat inserts
- check valve guide.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Depth gauge - 1 No.

Materials/Components

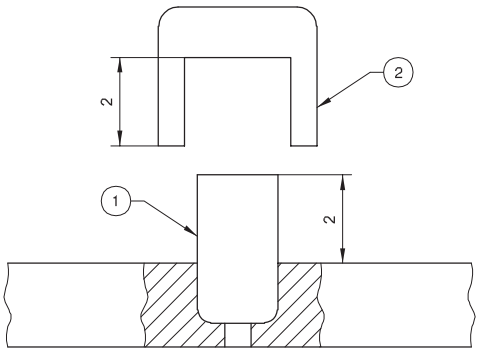
- Emery paper - as reqd.
- Kerosene - as reqd.

Procedure

Check valve seat inserts and valve guides

- Take out the valve seat insert, using the special tool.
- Drive the new valve seat insert carefully to its position, using a special punch.
- Assemble the valve to the valve seat and check its height with reference to the cylinder head surface.
- De-glaze the seat with an emery paper.
- Apply lapping compound on the valve face seat.
- Gently turn the valve on the seat with the help of the special tool using light force.
- Repeat this until a clear seating of the valve and valve seat is obtained.
- Remove the lapping compound using kerosene and visually. Check the surface of valve seat of valve face.
- If found any damages in valve seat and valve guide, replace it.
- Measure the valve stem diameter.
- Measure the internal diameter of the valve guide.
- If the clearance between the valve guide and valve stem is found more than the manufacturer's specified limit, change the valve guide as per the following procedure.
- Drive out the old valve guide from the cylinder head using a suitable drift.
- Place the new valve guide (1) on the cylinder head. (Fig 1)
- Place the drift (3) on the valve guide and press the valve guide.
- Measure the height (2) of the valve guide from the spring seating surface (use depth gauge).

Fig 1



VALVE GUIDE DRIFT

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EXERCISE 2.13: Assembling the cylinder head

Objectives

At the end of this exercise you shall be able to

- check the spring tension on a spring tester
- check tappets, pushrods, tappets screws and valve stem
- refit the cylinder head and manifolds.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Valve spring compressor - 1 No.
- Feeler gauge - 1 No.

Equipments/Machines

- Spring tester - 1 No.
- Torque wrench - 1 No.
- Oil can - 1 No.

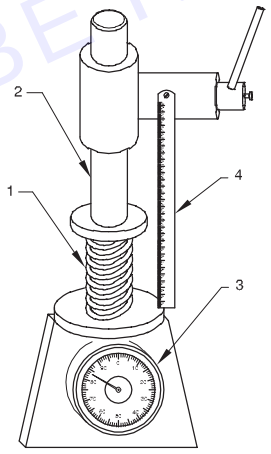
Materials/Components

- Cotton cloth - 1 No.
- Engine oil - as reqd.
- Head gasket - as reqd.
- Valve springs - as reqd.
- Head stud nuts - as reqd.

Procedure

- Clean the spring to be tested.
- Clean the spring tester.
- Place the spring (1) vertically on the spring tester. (Fig 1) Ensure that the moveable spindle (2) does not touch the spring (1).

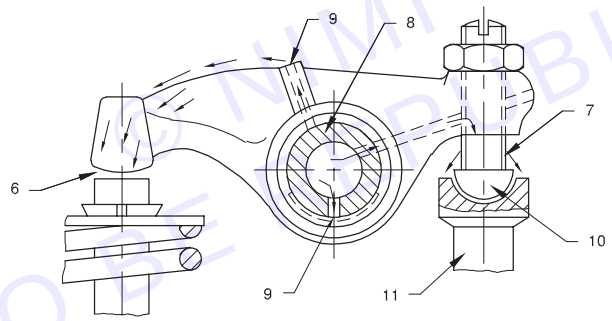
Fig 1



- Note down the height of the spring (1) on the graduated scale (4). This is the free length of the spring.
- Press the spring (1) by moving the column (2) downward. The gauge (3) will show the load on the spring. Press column (2) till the testing load (specified by the manufacturer) is obtained.
- Note down the height of the spring (1) at the testing load.
- Replace the spring, if the free length of the spring and the height at the testing load (or either of these two) is less than the minimum limit specified by the manufacturer.
- Check visually the rocker lever for cracks and pitting on the tip (Fig 2)

- Check the condition of the threads of the adjusting screw for wear, if necessary replace.
- Check the rocker arm bush and drill holes.
- Check the rocker arm ball pins for wear and damage
- Check the push-rod for bend and the socket end for wear
- Check the valve stem for bend, using a 'V' block and dial gauge
- Check the collar and stem end for damage.
- Oil the valve stem.
- Insert the valve in the valve guide.
- Support the valve head, so that it is held firmly on its seat.
- Fit the valve spring washer on the cylinder head.
- Insert the valve spring.
- Place the valve spring retainer over the spring.
- Compress the valve spring with the special tool
- Insert cotters with the smaller dia. at the bottom and release pressure on the valve springs (1) gradually (Fig 2).
- Slightly tap the valve stem (1) with a mallet (5) to ensure that the cotters (2) have locked the valves and spring retainers (4) take care that the two halves of the cotters are centrally located. (Fig 2)

Fig 2



ROCKER ARM BUSH

- Fit the circlip/lock screw at both ends of the rods shaft
- Loosen the ball pins / nuts to ensure that the push-rods do not bend while tightening the rocker shaft support brackets nuts/bolts on the cylinder head.
- Fit the rocker arm shaft assembly in the correct position on the cylinder head.
- Tighten the rocker arm shaft support bracket nuts or bolt to the specified torque (Use torque wrench)

EXERCISE 2.14: Check valve leakage and overhauling rocker arm assembly

Objectives

At the end of this exercise you shall be able to

- check the valve seat leakage with special tool
- check the rocker shaft and levers for wear and cracks
- reassemble the rocker shaft and levers in proper method.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Valve leakage test tool - 1 No.

Equipments/Machines

- Work bench - 1 No.
- Wooden block - 2 Nos.
- Diesel engine - 1 No.

Materials/Components

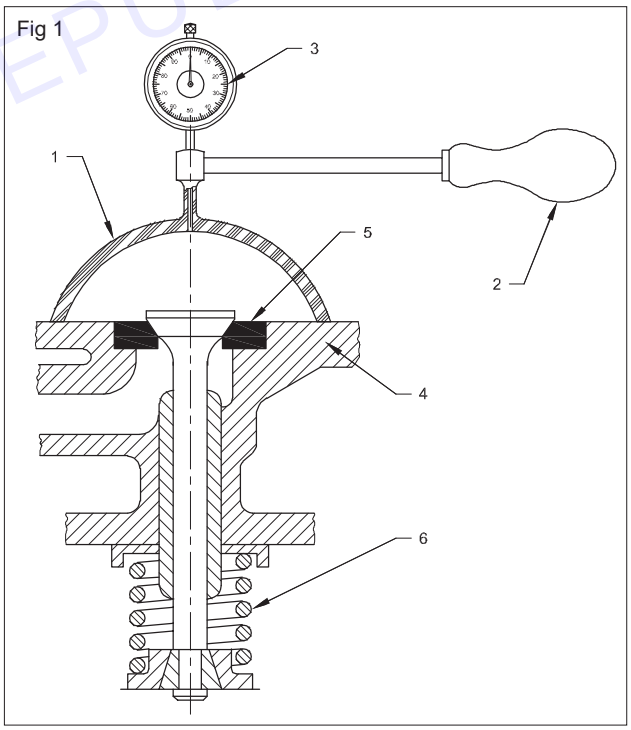
- Tray - 1 No.
- Cotton cloth - as reqd.
- Soap oil - as reqd.
- Valve grinding stick - as reqd.
- Valve lapping paste - as reqd.

Procedure

TASK 1: **Checking valve leakage (Fig 1)**

- Check the valve leakage using the special tool (Fig 1)
- Attach a suction cup (1) with a suction bulb (2) and vacuum gauge (3) on the cylinder head (4)
- Covering the cylinder head valve seat (5) and create a vacuum with the help of the suction bulb (1) (rubber bulb)
- Wait for 3 minutes and note any drop of vacuum on the gauge
- If there is any drop in vacuum, the valve seat (5) is leaky and requires lapping.
- After lapping the valve seat, assemble the valve and check for leakage as above mentioned procedure.

Fig 1



TASK 2: **Overhauling rocker arm assembly (Fig 1 & 2)**

Fig 1

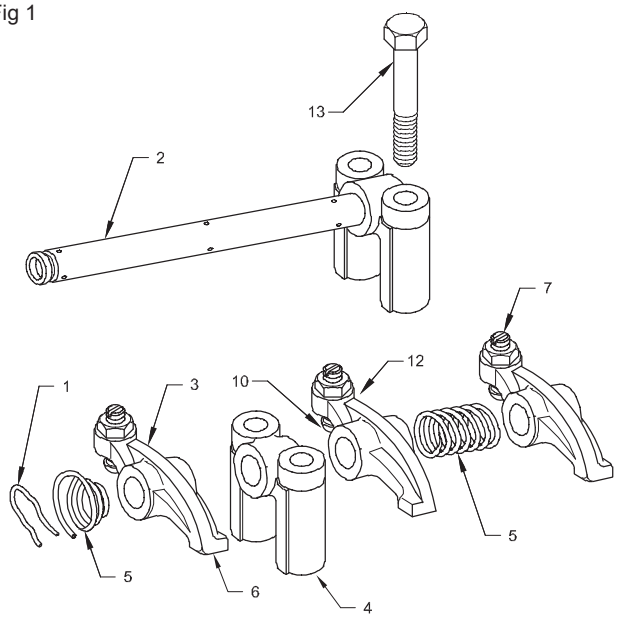
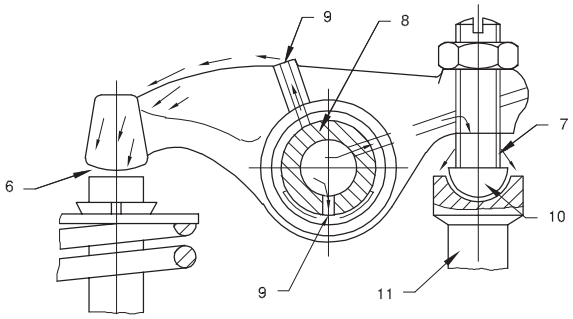


Fig 2



ROCKER ARM BUSH

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- Remove the lock-screw/circlips (1) at both ends of the rocker shaft.(2)
- Remove the rocker levers (3) rocker lever bracket (4), springs (5) and spacers from the rocker shaft. (Fig 1)
- Remove the rocker bracket which supplies oil to the rocker shaft from the cylinder head. The position of the bracket varies from one make to another make (Consult your instructor).
- Clean the dismantled parts of rocker arm assembly.
- Check the tension of the rocker spring(5). Replace it, if necessary.
- Check visually the rocker lever for cracks, pitting on tips (6). Check the condition of the threads by screwing the adjusting screw (7) in threads.
- Check the rocker shaft (2) visually for cracks and damage.
- Check the rocker arm bushing (8) for wear and tear and alignment of lubricating holes.(9) (Fig 2)
- Check the rocker arm ball pins (10) for wear and damage.
- Clean the base of the rocker shaft supports, and the seats on the cylinder head.
- Fix the ball pins on the rocker arm.
- Insert the inlet (3) and exhaust rocker lever (12), spring (5) and the distance piece between the two rocker shaft supports(4) in the rocker arm shaft (2) and fix the circlip at the both ends of the rocker shaft
- Loosen the ball pin's (10) nuts, to ensure that the push-rods do not bend, while tightening the rocker shaft support bracket's (4) nuts/ bolts (V3) on the cylinder head.

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EXERCISE 2.15: Refit the cylinder head, manifolds and adjusting valve tappet clearance

Objectives

At the end of this exercise you shall be able to

- adjust the valve tappet clearance in a 4-cylinder engine
- assemble the cylinder head assembly
- start the engine after adjustments.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Feeler gauge - 1 No.
- Screw driver - 1 No.
- Ring spanner - 1 No.

Equipments/Machines

- 4-cylinder engine - 1 No.
- Torque wrench - 1 No.

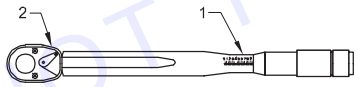
Materials/Components

- Bolts/Nuts - as reqd.
- Lock-nut - as reqd.

Procedure

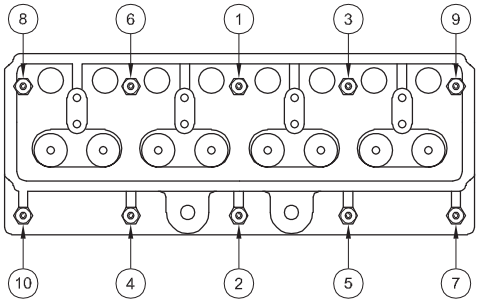
- Fit the inlet and exhaust manifold with cylinder head place the cylinder head on the engine block with head gasket. Tighten all the cylinder head bolts/nuts in correct sequence to the specified torque (use a torque wrench - refer to service manual). Fig 1
- 4-cylinder engine's cylinder head is shown in Fig 2 and torque wrench is shown in (Fig 1).
- Assemble and fit the rocker arm assembly. Turn the crank shaft in the clockwise direction and coincide the flywheels TDC 1/6 or 1/4 mark with the flywheel housings pointer. Ensure that the 1st cylinder is in compression stroke.
- Hold firmly the tappet adjusting screw with a good screwdriver. (Fig 3)

Fig 1



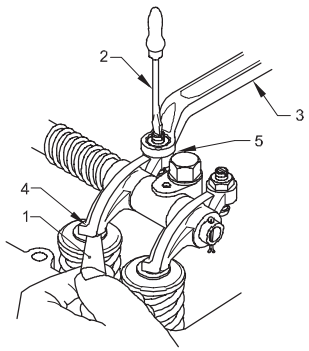
TORQUE WRENCH

Fig 2



TIGHTENING CYLINDER HEAD

Fig 3



OVERHEAD VALVE

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- Loosen the lock-nut with a ring spanner.
- Insert a feeler gauge (1) of the specified thickness between the valve stem and the rocker tip (4).
- Tighten the adjusting screw (5) by a screwdriver (2) and at the same time move the feeler gauge to and fro.
- Stop tightening of the adjusting screw when the feeler gauge can be slid with a slight effort, but it should not be jammed.
- Rotate the push-rod. It should also rotate with a slight load but it should not be jammed.
- Hold the adjusting screw in position with the screwdriver firmly and tighten the lock-nut by a ring spanner.
- Ensure that the adjusting screw does not turn while tightening the locking nut.
- Check again the adjustment by sliding the feeler gauge leaf in the gap and turning the push rod.
- Repeat the above steps to adjust the tappet clearance for other valves bringing the respective pistons on TDC of compression stroke according to firing order.
- Follow the sequence of adjusting the remaining valves by referring to the tabulation below:

When the inlet valve in No.4 cylinder is fully open, No.1 cylinder inlet valve is fully closed - this feature is useful to remember when checking valve clearances.

- Adjust No.1 valve when No.8 is lifted.
- Adjust No.2 valve when No.7 is lifted.
- Adjust No.3 valve when No.6 is lifted.
- Adjust No.4 valve when No.5 is lifted.
- Adjust No.5 valve when No.4 is lifted.
- Adjust No.6 valve when No.3 is lifted.
- Adjust No.7 valve when No.2 is lifted.
- Adjust No.8 valve when No.1 is lifted.
- For adjusting valve tappet clearance of an overhead valve with an overhead camshaft engine, repeat the above steps correctly with the following precautions (Fig 3).

Precaution: Ensure that the rocker arm is off the camshaft cams. This is to be followed for each valve adjustment.

- Start the engine and leave it in idle speed
- Check the tappet noise, if found noise adjust and rectify the noise.

EXERCISE 2.16: Practice on removing oil sump and oil pump

Objectives

At the end of this exercise you shall be able to

- remove the oil sump from the engine
- remove the oil pump from the engine.

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Box spanner set - 1 Set.
- Feeler gauge - 1 No
- Straight edge - 1 No

Equipments/Machine s

- Multi cylinder diesel engine - 1 No

Materials/Components

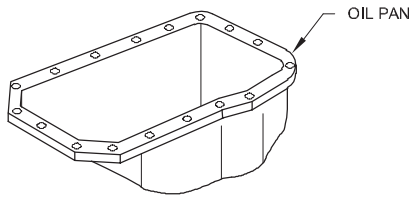
- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Procedure

TASK 1 : **Removing oil sump (Fig 1)**

- Loosen the engine oil sump drain plug
- Place the tray under the sump
- Remove the drain plug and ensure the oil is completely drained from the oil sump
- Crank the engine to drain remaining oil from the engine
- Fix the oil sump drain plug
- Loosen the oil sump mounting bolt
- Remove the all mounting bolts of oil sump
- Remove the oil sump and place it on the work bench.
- Remove the gasket from the sump
- Clean the surface of the gasket fitting
- Clean the sump with kerosene
- Clean the dust particles deposited in drain plug
- Inspect the oil sump for any damages and cracks , if found any crack, repair it.

Fig 1



TASK 2 : **Removing oil pump from the engine (Fig 1 & 2)**

- Locate the oil pump mountings
- Select the suitable tools to remove the oil pump mountings
- Loosen the oil pump mountings (Fig 1)
- Remove the oil pump along with strainer.
- Place the oil pump on tray for cleaning and inspection.
- Dismantle the oil pump parts and clean it (Fig 2)
- Inspect the dismantled parts, if any damages found, replace the defective parts.
- Assemble the all parts in sequence
- Check the pressure of the oil pump with your instructor's guidance.

Fig 1

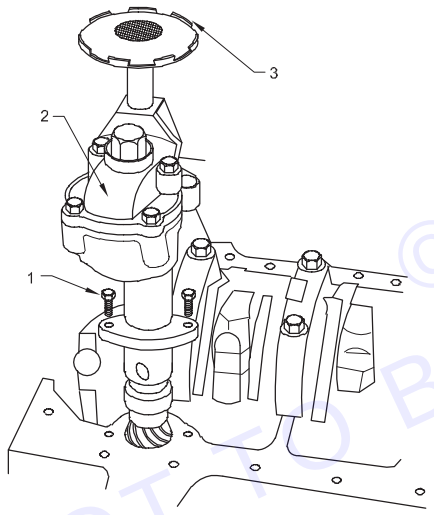
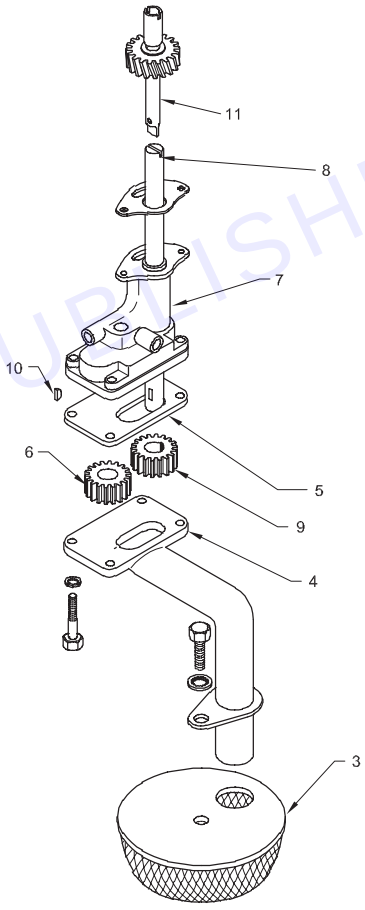


Fig 2



EXERCISE 2.17: Practice on removing piston with connecting rod assembly

Objectives

At the end of this exercise you shall be able to

- remove the big end bearing from the connecting rod
- remove the piston with connecting rod.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Torque wrench, Ring expander - 1 No each.
- Mallet, Drift punch - 1 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.

Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.
- Wooden block - as reqd.

Procedure

Remove the piston connecting rod assembly

- Remove the oil sump.
- Disconnect the oil pipe from the oil pump and remove the oil strainer.
- Remove the oil pump.
- Tilt the engine block.
- Clean and check for ridge formation of all cylinders.
- Turn the crank shaft (4) till the piston (1) comes at B.D.C.
- Remove the bolts/nuts (9) of the connecting rod (2).
- Tap the connecting rod's (2) cap with a mallet and remove the cap (6) along with the bearing shell (10) from the connecting rod.
- Turn the crank shaft (4) till the piston (1) comes at T.D.C. Tap the connecting rod (2) with a wooden block (3).
- Note down the connecting rod cap matching number stamped on it to avoid mismatching while reassembling.
- Place the upper and lower bearing shell in their respective positions in the connecting rod and cap (6). Fit the cap on the connecting rod. (Fig 1)
- Repeat the relevant steps to remove all the pistons. (Fig 2)
- Clean the connecting rod and pistons

Fig 1

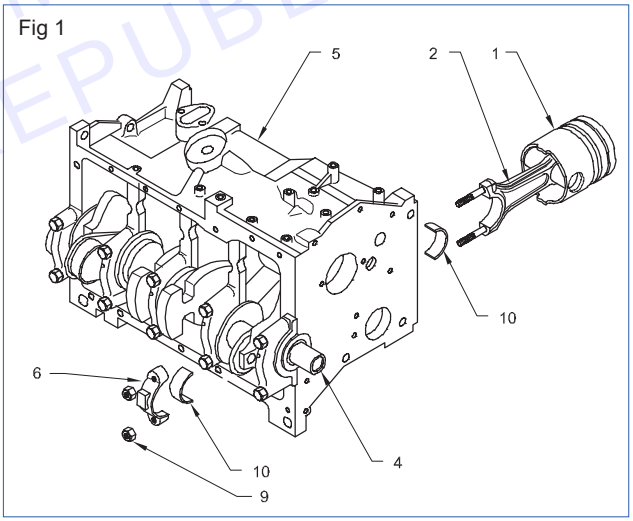
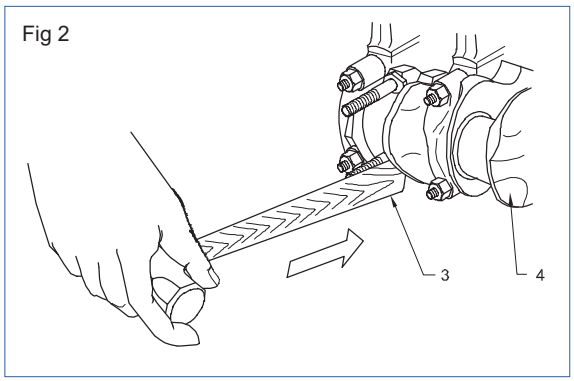


Fig 2



EXERCISE 2.18: Practice on removing and measuring the piston

Objectives

At the end of this exercise you shall be able to

- remove the piston rings and piston pin from the piston
- remove the piston from the connecting rod
- check the piston ring clearance
- check the wear of piston skirt and crown.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Feeler gauge - 1 No.
- Outside micrometer - 1 No.

Materials/Components

- Cotton waste - as reqd.
- Kerosene - as reqd.
- Piston rings - as reqd.

Procedure

- Remove the piston ring (5) with help of piston ring (8) expander as shown in (Fig 1).
- Remove the circlip (9) of the piston pin (10), using a circlip plier.
- Remove the piston pin (10) with the help of a drift (11) and hammer(12). Repeat the steps to all the pistons. (Fig 2)

Fig 1

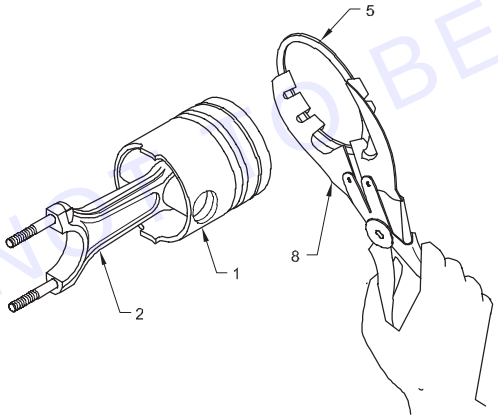
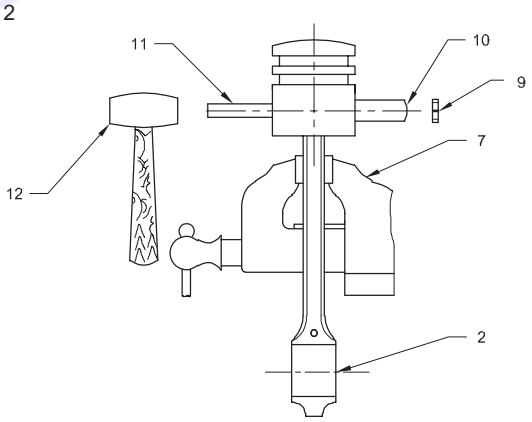


Fig 2



- Remove connecting rod from piston.
- Clean the piston, piston pin, piston rings grooves, oil ring holes.
- Remove the carbon deposits from the piston ring grooves.
- Clean the piston rings and the connecting rod by using kerosene.
- Check the piston skirt and crown for scuffing, crack, scoring etc.
- Check the piston pin circlip grooves in the piston for damage.
- Check piston ring side clearance (A) (Fig 3) in the piston's (2) groove with a feeler gauge (3).
- Check the wear of piston (Fig 4) diameter at different points.

- Check the wear of piston ring grooves and land.
- Measure the piston diameter at different points. (Fig 4)

Fig 3

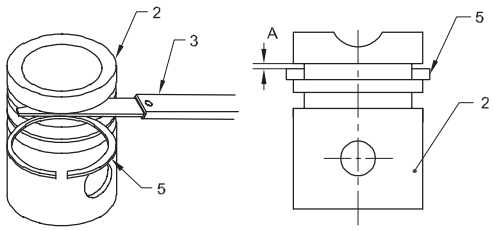
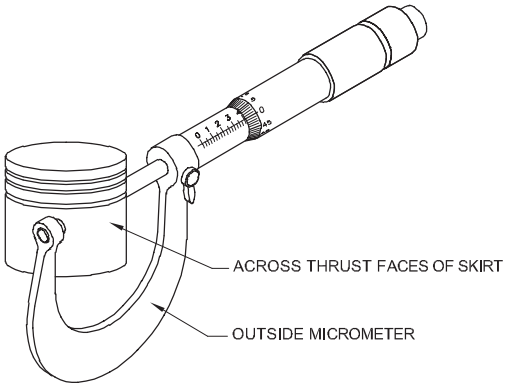


Fig 4



MEASURE THE PISTON

MDC22P0095

EXERCISE 2.19: Measure the clearance of piston, ring and big end bearings

Objectives

At the end of this exercise you shall be able to

- check the piston ring close gap
- check the clearance between the piston and cylinder wall
- check the clearance between crank pin and big end bearing.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Feeler gauge - 1 No
- Torque wrench - 1 No.
- Plastic gauge - 1 No.

Materials/Components

- Cotton cloth - 1 No.
- Soap oil - as reqd.
- Piston ring - as reqd.
- Big end bearing - as reqd.

Equipments/Machines

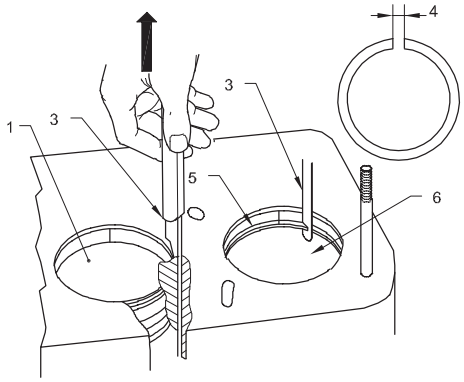
- Multi cylinder diesel engine - 1 No.
- Work bench - 1 No.

Procedure

TASK 1: **Measure the piston ring close gap (end gap) (Fig 1)**

- Clean the cylinder bore with baniyan cloth
- Clean the selected piston ring for measurement.
- Insert the piston ring inside of the cylinder bore
- Ensure the piston ring placed in specified level in side of cylinder bore (push the ring in the cylinder by piston head without rings)
- Measure the piston ring, close gap by feeler gauge
- Note the feeler gauge leaf reading and compare with service manual specification.

Fig 1



TASK 2: **Measure the clearance between the liner and piston**

- Clean the oil and dust of the piston with kerosene
- Clean the piston with compressed air and baniyan cloth.
- Clean the cylinder bore with baniyan cloth
- Insert the piston (without ring) inside of the cylinder bore/ liner
- Measure the clearance between the liner and the piston below the gudgeon pin by the feeler gauge
- Note the reading of feeler gauge leaves and compare with service manual specification.

— — — — —

TASK 3: **Measure the clearance between the crank pin and connecting rod big end bearing**

- Clean the big end bearing and crank pin
- Install the shell bearing in connecting rod and lower cap of big end
- Place the piece of gauging plastic to full width of crank pin as contacted by bearing. (avoid oil hole).
- Install the connecting rod bottom cap and tighten the nuts gradually, as follows;
  - a Tighten all cap nuts in hand tight.
  - b Retighten them as per specified torque.
  - c Repeat the relevant steps to all the connecting rod end caps
  - d Once again check the tightening torque.
- Remove the big end cap and using scale and gauging plastic width at the widest point (Clearance). If clearance exceed its limit use a new standard size bearing and remeasure the clearance between the crank pin and connecting rod big end bearing.
- If the clearance cannot be brought to within its limit even by using a new standard size bearing regrind the crankpin to under size and use 0.25 mm undersize bearing
- Same method to be followed to other crank pin and connecting rod bearings.

Note: Never place plastic gauge above oil holes.

— — — — —

EXERCISE 2.20: Check connecting rod for bend and twist

Objectives

At the end of this exercise you shall be able to

- check the connecting rod bend and twist
- assemble the piston and connecting rod.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Torque wrench, Ring expander - 1 No each.
- Mallet, Drift punch - 1 No each.
- Feeler gauge, Circlip plier (internal) - 1 No each.
- Connecting rod aligner - 1 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.

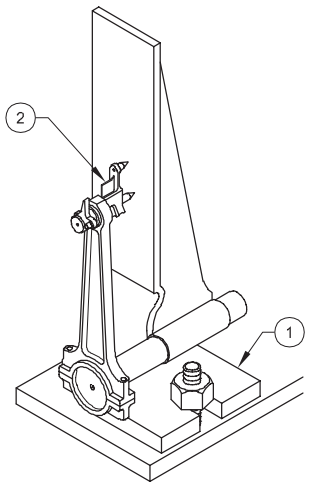
Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Procedure

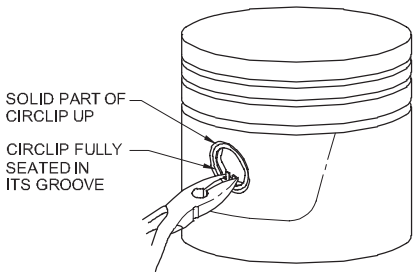
- Place the connecting rod assembly on the work bench and remove the piston from the connecting rod
- Clean the dismantled piston and connecting rod.
- Check the connecting rod's small end bush bearing for wear and scoring.
- Check the connecting rod's alignment for bend and twist.
- Check the gudgeon pin surface for any damage.
- Place the connecting rod on the alignment fixture (1). (Fig 1)
- Insert the gudgeon pin in the small end bore.
- With a square edge (2) check the square seating of the gudgeon pin. If the connecting rod is bent or twisted, the gudgeon pin will not sit squarely in the bore. Replace the connecting rod if found bent or twisted.
- Fit one circlip in the groove of the piston. (Fig 2)

Fig 1



CONNECTING ROD ALIGNMENT FIXTURE

Fig 2



INSTALL CIRCLIP

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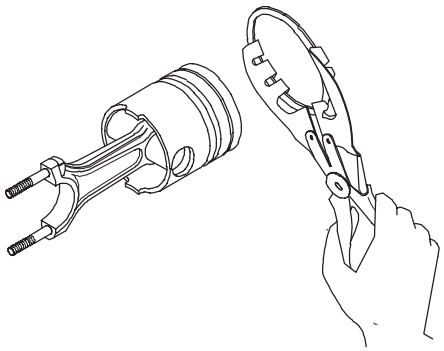
- Align the connecting rod's small end bore and the gudgeon pin bore of the piston.
- Tap the gudgeon pin into the piston pin hole with the help of a mallet. While tapping, keep the small end hole aligned to avoid damage to the connecting rod bush. Fit another circlip on the groove. Repeat the above steps for all the pistons and connecting rods.
- Hold the piston ring in the ring expander and fit it in the piston groove. Ensure that the word 'Top' stamped on the ring faces upward. Fit all the rings to the pistons. (Fig 3)
- Place the upper and lower bearing shells in all the connecting rods and caps and keep them in proper order for reassembling purpose.

Fig 3



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EXERCISE 2.21: Overhauling of crankshaft

Objectives

At the end of this exercise you shall be able to

- use of service manual
- check the clearance of crankshaft.

Requirements

Tools/Instruments

• Trainee's tools kit	- 1 No.
• Engine manual book	- 1 No.
• Soft harmer - plastic	- 1 No.
• Pry bar	- 1 No.
• Feeler gauge	- 1 No.
• Plastic gauge	- 1 No.
• Torque wrench	- 1 No.
• Dial gauge	- 1 No.
• Inside micro meter	- 1 No.

Equipments/Machines

• Work bench	- 1 No.
• Multi cylinder engine	- 1 No.

Materials/Components

• Tray	- 1 No.
• Banian cloth	- as reqd.
• Soap oil	- as reqd.
• Lube oil	- as reqd.
• Shell bearing	- as reqd.

Procedure

- Remove the bearing cap bolt (10). (Fig 1)
- Remove the bearing caps (8).

Note: The crankshaft bearing caps are marked with stamped numbers. Remove the bearing cap from the vibration damper side.

- Remove the crankshaft bearing caps (9) and lower thrust bearings (7).
- Remove the lower bearing shell (6) from the bearing cap (9). (Fig 2)

Fig 1

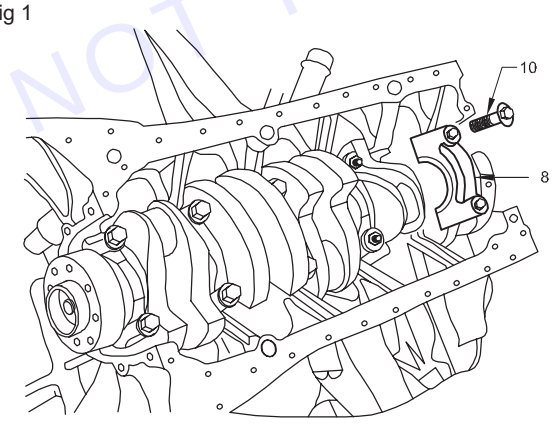
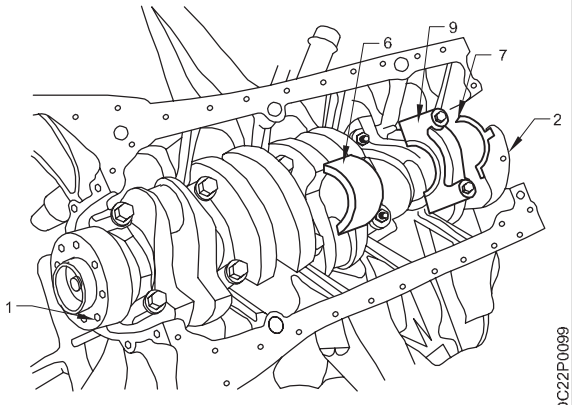


Fig 2



- Remove the crankshaft (5). (Fig 3)
- Remove the upper thrust bearings (4). (Fig 4)
- Remove the upper bearings shells (3) from crankcase.
- Thoroughly clean the oil gallery.

Fig 3

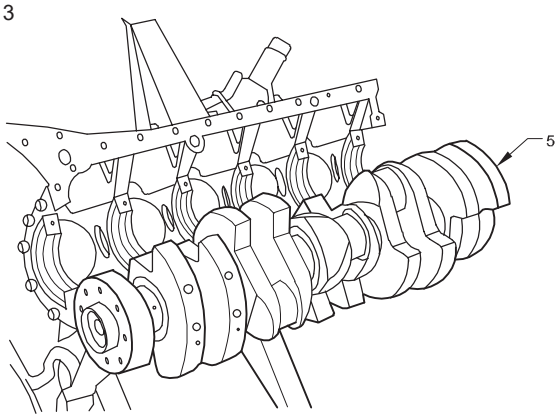
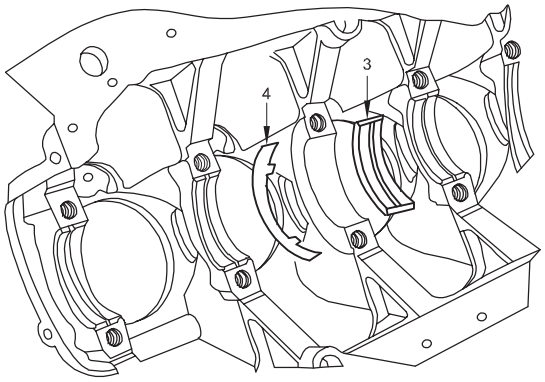


Fig 4



- Select proper new bearing shells with references to table.
- Coat the new bearing shells with oil and insert into the crankcase and into the crankshaft bearing caps.

Note: Do not mix up upper and lower crank shaft bearing shells

- Install the bearing caps according to marking and tighten the 12-sided stretch bolts. (Fig 5)

Installation Notice

Tightening Torque	55 N·m (41 lb-ft) + 90°

No. 1 is vibration damper side. (Fig 2)

- Measure crank shaft bearing diameters (E) using the dial gauge 00 and extension. (Fig 6)

Fig 5

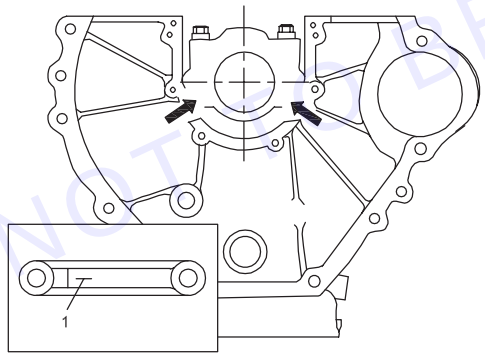
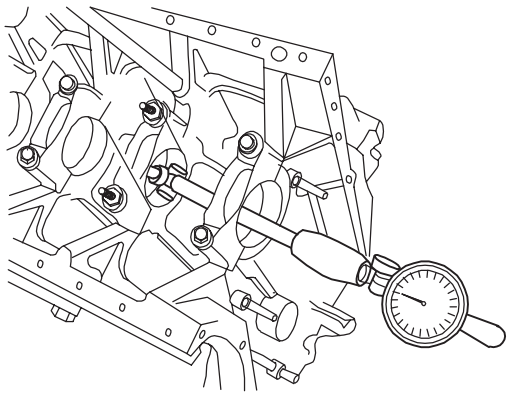


Fig 6



- Measure at 3 points (A, B and C) and if the average value of B and C is less than A's value, the average value of B and C is the mean value and if more than A's value, A's value is the mean value.(Fig 7)
- Measure crankshaft bearing journal diameter (F). (Fig 8)

Notice: When measured in A and B, the runout should not exceed 0.010 mm.

- Measure radial clearance of crankshaft bearing (G).

Clearance 'G'	0.027-0.051 mm

Note: Compare final radial clearance figure of crankshaft bearing to the service manual.

Fig 7

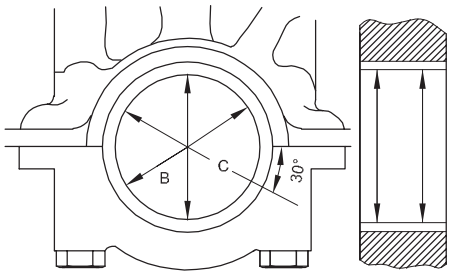
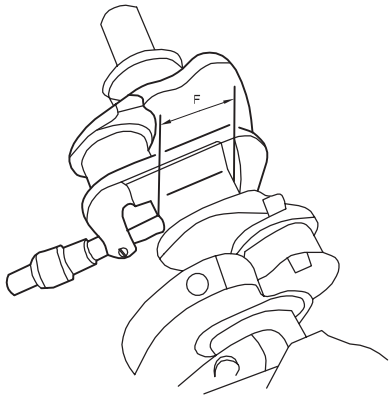


Fig 8



(Example) Measured value 'E' = 57.700 mm

Measured value 'F' = 57.659 mm

Clearance 'G' = 0.041 mm

- Remove the crankshaft bearing cap.
- Measure width of thrust bearing journal (H) and adjust with proper thrust bearings.(Fig 10)

Note: The same thickness of thrust washers should be installed on both sides of the thrust bearing.

Fig 9

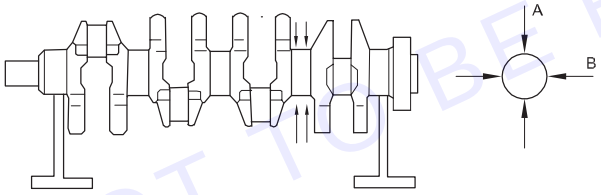
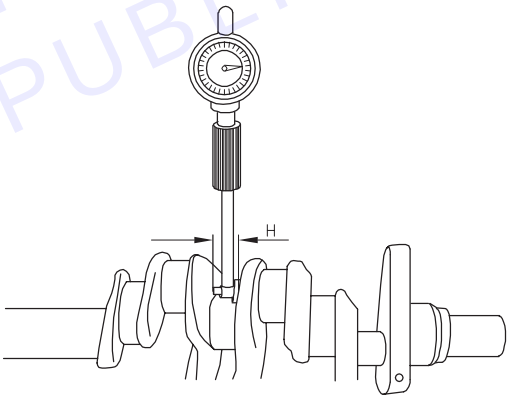


Fig 10



- Coat the upper thrust bearing (4) with oil and insert into the crankcase so that the oil grooves are facing the crank webs (arrow).(Fig 11)
- Coat the lower thrust bearing (7) with oil and insert into the crankshaft bearing cap so that the oil grooves are facing the crank webs (arrow). (Fig 12)

Note: The retaining lugs should be positioned in the grooves (arrow).

Note: If the max. length of bolts (L) exceed 63.8mm, replace them.(Fig 13)

- Coat the new crank shaft with engine oil and place it on the crankcase.
- Install the crank shaft bearing caps according to marking and tighten the bolts.

Installation Notice

Tightening Torque	55 N·m (41 lb-ft) + 90°

Install from No. 1 cap.

- Rotate the crank shaft with hand and check whether it rotates smoothly. Use soft hammer and pry bar/ screwdriver to move the crankshaft rear and forward. (Fig 14)

Fig 11

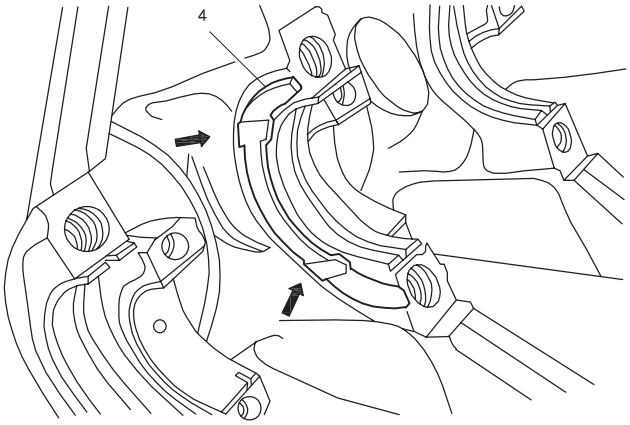


Fig 12

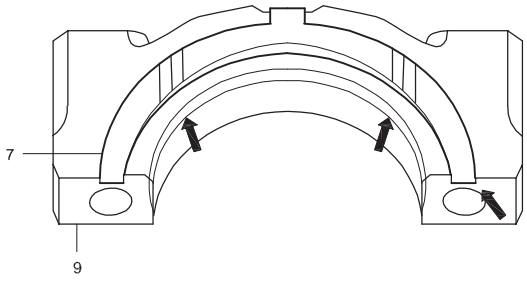


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Fig 13

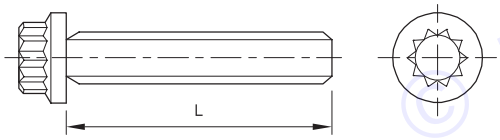
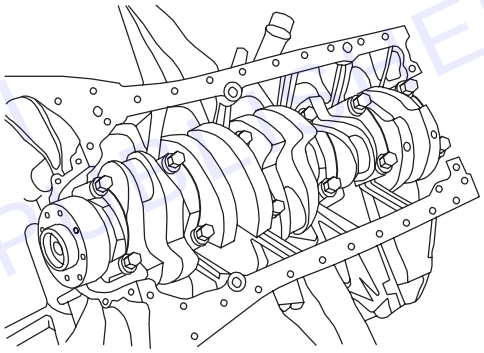


Fig 14



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- Measure crankshaft bearing axial clearance or thrust clearance with dial gauge& dial gauge holder (Fig 15)

Clearance	0.100 - 0.245 mm

Note: Compare your thrust clearance figure to the service manual

Note: The same thickness of thrust washers should be installed on both sides of the thrust bearing.

Note: If the clearance is out of standard, adjust the axial clearance of crank shaft bearing by replacing the thrust washers.

- Insert the new connecting rod bearing shells into the connecting rod and connecting rod bearing shells into the connecting rod and tighten the 12-sided stretch bolts (11).

Installation Notice

Tightening Torque	55 N·m (26 lb-ft) + 90°

- Measure inner diameter of connecting rod bearing. (Fig 16)
- Measure connecting rod bearing journal diameter (k).

Note: Refer to measurement of the crank shaft bearing journal diameter in service manual.

- Measure the radial clearance (L) of the connecting rod bearing.

Fig 15

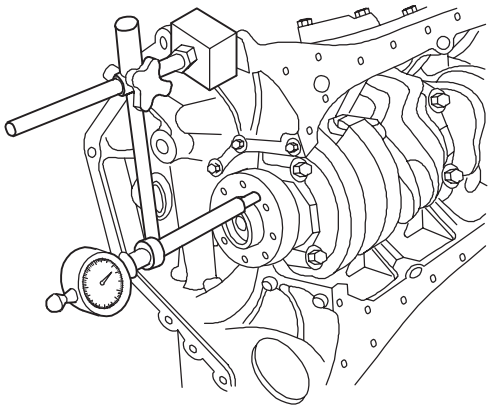
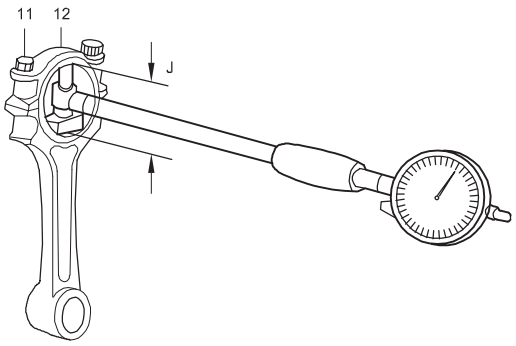


Fig 16



(Example) Measured value 'J' = 47.700 mm

Measured value 'K' = 47.653 mm

Clearance 'G' = 0.047 mm

Radial Clearance 'L'	0.026 - 0.068 mm

Note : Compare your radial clearance of the connecting rod bearing to the service manual

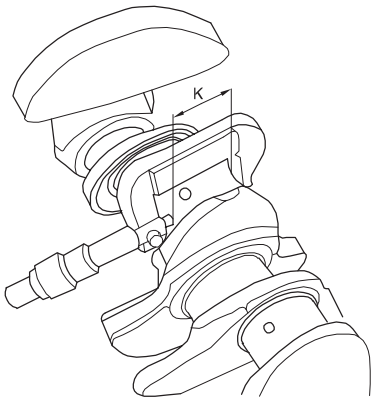
Note: If the clearance is out of standard, adjust the radial clearances of connecting rod bearing by replacing the connecting rod bearing shells.

- Remove the connecting rod bearing cap.
- Install the piston.
- Rotate the crank shaft by hand and check whether it rotates smoothly.

Note: Find how to access a dial gauge or micrometer set or plastic gauge in various different crush dimensions. (Fig 17)

Plastic gauge is a measuring tool used for measuring clearances

Fig 17



EXERCISE 2.22: Inspect the flywheel and spigot bearing

Objectives

At the end of this exercise you shall be able to

- inspect the flywheel and mounting flange
- inspect the spigot bearing.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Torque wrench - 1 No.
- Box spanner kit - 2 No.
- Bearing puller - 1 No.

Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.

Procedure

Inspecting flywheel and mounting flange

- Clean the surface of flywheel.
- Visually check the flywheel (Fig 1) friction surface by using a straight edge (1) and feeler gauge (4).
- If flywheel warpage is more than the specified limit by the manufacturer, then recommend for machining.
- Ensure that flywheel thickness after machining has not become less than the specified thickness.
- Clean the crank shaft flange and flywheel mating surface.
- Visually check the flywheel mounting flange (Fig 2) for damage and cracks.

Fig 1

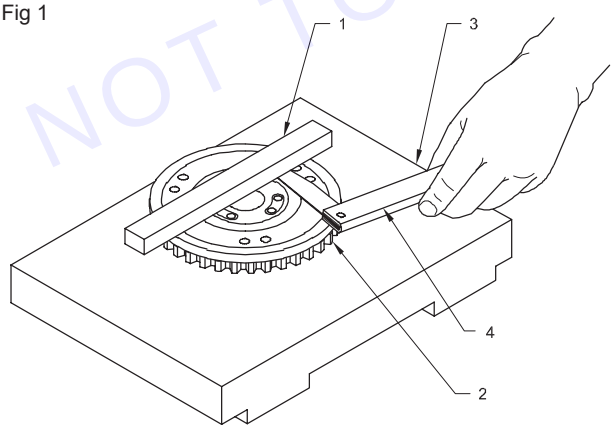
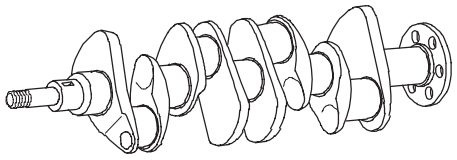


Fig 2



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- Fix the flange bolts on the crankshaft
- Remove the spigot bearing from rear end of the crankshaft/flywheel
- Clean and inspect the bearing clearance and bearing noise [If wornout, replace with new bearing].
- Fit the spigot bearing in the socket of crank shaft rear end/Flywheel.
- Align the bearing with the help of dummy shaft.

- Align the flywheel holes and flange bolts/dowel pins (5) (look for timing mark alignment with 1st cylinder (Fig 3)
- Install the flywheel (1) on the crank shaft flange.
- Lock the flywheel from rotation (by using the special tool) (2).
- Tighten the flywheel mounting bolts/nuts (4) diagonally and evenly to the specified torque.
- Use positive locking device avoid failure.
- Check the face run out of the flywheel. (Fig 4)
- If the face run out is more than the specified limit, recommend for machining. Ensure that, after machining, the flywheel thickness has not become less than the specified thickness.

Fig 3

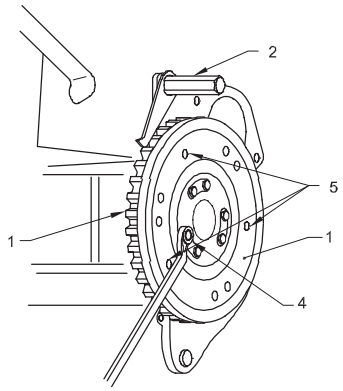
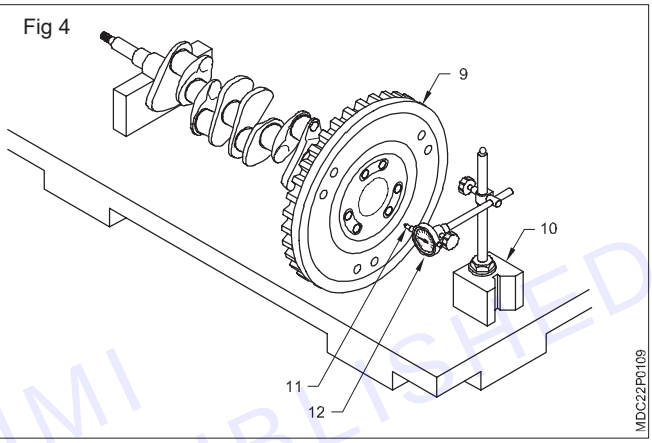


Fig 4



EXERCISE 2.23: Practice on cleaning and checking the cylinder blocks

Objectives

At the end of this exercise you shall be able to

- clean the cylinder block
- check the cylinder block.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Scraper - 1 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.
- Air compressor, pressure washer - 1 No.

Materials/Components

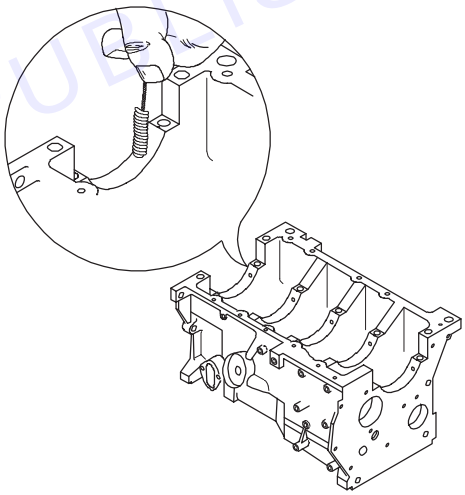
- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Procedure

Cleaning the cylinder block

- Put the cylinder block on wooden blocks (Fig 1)
- Clean cylinder block with suitable solvent or steam
- Clean the oil passages of cylinder block with help of wire brush
- Remove all sludge of dirt and carbon deposits in crankcase, cylinder walls and valve chambers
- Remove carbon deposits in cylinder block
- Use scrapper to remove hard carbon deposits and take care not to damage the highly finished surfaces
- Clean the cylinder block by using compressed air blast
- Visually check the cylinder block for cracks and damages
- Replace the cylinder block if any damage is found.

Fig 1



EXERCISE 2.24: Measure the cylinder bore taper, ovality and flatness

Objectives

At the end of this exercise you shall be able to

- check cracks and flatness of cylinder block
- check taper and ovality of cylinder bore and clean oil passages.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Straight edge, Feeler gauge - 1 No.
- Bore dial gauge - 1 No.

Equipments/Machines

- Engine cylinder block - 1 No.
- Air compressor, Water washer - 1 No.

Materials/Components

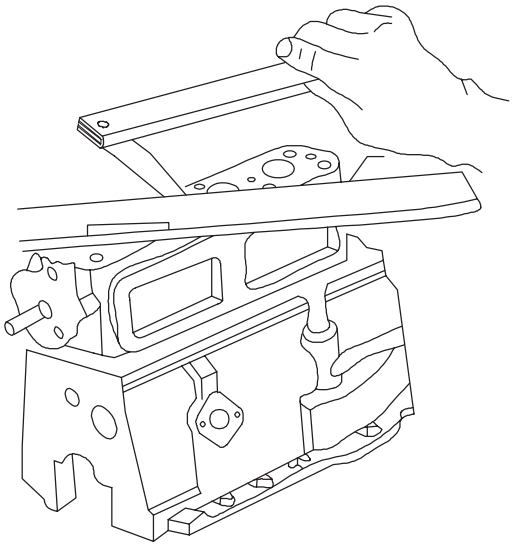
- Tray - 1 No.
- Banian cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Procedure

TASK 1: **Check flatness of cylinder block with straight edge**

- Place the cylinder block on two wooden blocks.
- Clean the top plain surface of the cylinder block.
- Wipe the plain surface with clean banian cloth.
- Keep the straight edge on the surface of the cylinder block and press the straight edge at the centre with your left hand.
- Insert the feeler gauge leaves between the straight edge and the surface of the cylinder block (Fig 1).

Fig 1



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- Note down the thickness of the thickest leaf, which can be inserted between the straight edge and the surface of the cylinder block. This thickness gives the maximum face out in the direction.
- Repeat the above steps in different direction and places on the surface of cylinder block and note down the maximum face out in all directions.
- Recommend for replacing or resurfacing of cylinder block if maximum face out is more than the specified limit by the manufacturers.

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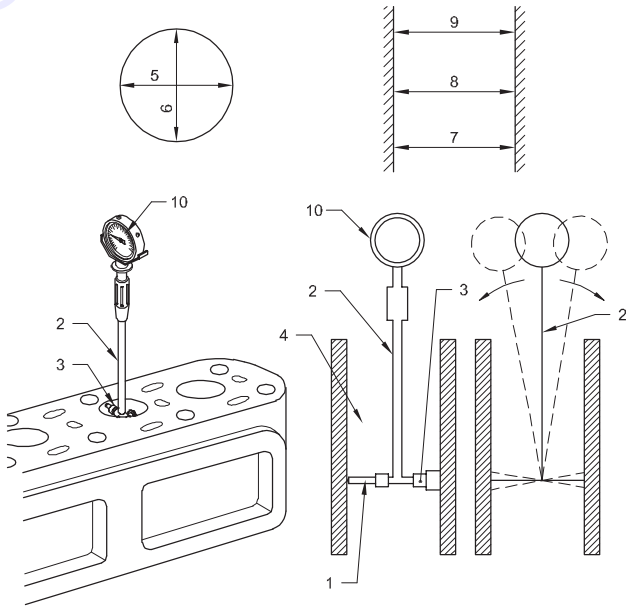
TASK 2: **Check taper, ovality of cylinder bore and clean oil passages**

- Clean cylinder bore with a piece of cloth.
- Measure inside diameter of the bore with an inside micro meter.
- Select the correct size of extension rod (1) which is more than measuring range.
- Assemble the extension rod on the stem of the dial test indicator (2).
- Press the spring loaded plunger end (3) as it enters inside the bore.
- Keep the bore gauge parallel to the cylinder wall by slightly rotating the gauge (2).
- Set the needle at '0' (zero) in dial indicator (10).
- Take measurement at (6) with the bore gauge and note down the reading.
- Take another reading (5) at right angles to the first reading.
- Repeat above at three places (7,8 and 9).
- The difference in measurement between (5) and (6) at all places is ovality. The difference in measurement between (7) and (8), (8) and (9), and (9) and (7) is taper.
- Note down maximum ovality and taper. If any one of them is more than the specified limit, recommend for reboring/ replacement of liner. (Fig 1)
- Clean the oil main gallery with help of wire brush
- Clean the oil pipe line by air pressure

Fig 1



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EXERCISE 2.25: Assembling the crank shaft, piston and connecting rod assembly

Objectives

At the end of this exercise you shall be able to

- fix the bearings in the cylinder block
- fix the crank shaft in the cylinder block
- fix the connecting rod bearing cap
- check crank shaft end play.

Requirements

Tools/Instruments

- Magnetic base with dial gauge - 1 No.
- Trainee tools kit - 1 No.
- Heavy duty screw driver/pry bar - 1 No.
- Torque wrench - 1 No.
- Box spanner - 1 Set.
- Piston ring compressor - 1 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.
- Work bench - 1 No.
- Wooden block - 2 Nos.
- Oil can - 1 No.

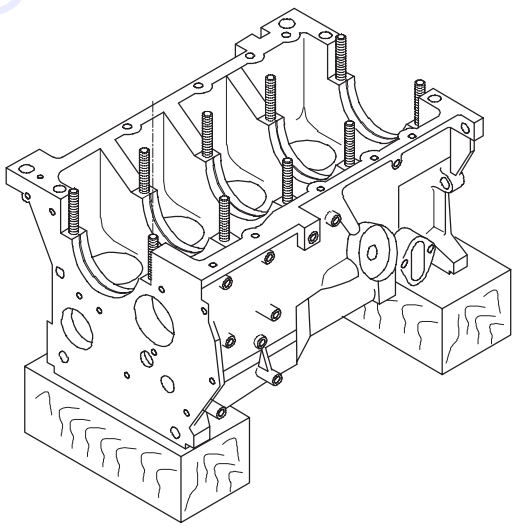
Materials/Components

- Main journal bearing - 1 No.
- Big and bearing - as reqd.
- Piston pin - as reqd.
- Nut bolts - as reqd.
- Cotton waste - as reqd.
- Baniyan cloth - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Procedure

- Place the engine block on the wooden block (Fig 1)

Fig 1

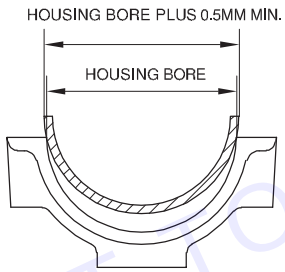


MDC22P0113

- Clean the parent bore of the main bearing in the cylinder block.
- Clean the oil holes of the parent bore.

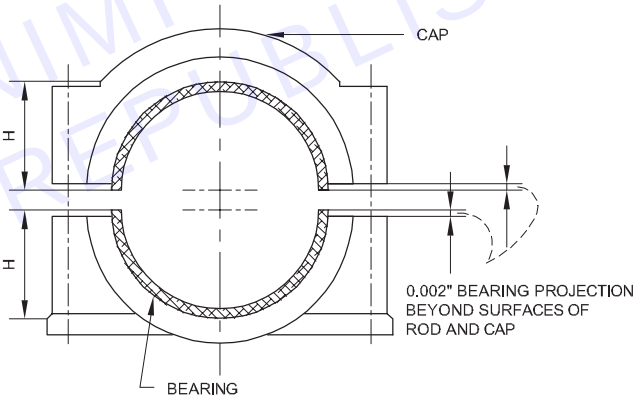
- Place the main bearing shell into its respective parent bore. Ensure that the oil holes of the bearing shell and that of the parent bore are perfectly aligned.
- Install the crank shaft rear bearing seal (oil seal). Insert the rubber packing (rubber rod) in the holes between the bearing cap and the cylinder block.
- The projection of the rubber packing should not be more than 6 mm. If it is more than 6 mm, cut off the excess length.
- Install the thrust washers into the respective bearings.
- Lubricate all the bearing surfaces with clean engine oil.
- Place the crank shaft in its position in the cylinder block.
- Place the shell bearings into their respective bearing caps.
- Check the bearing shells for spread. The inserts should 'snap' into position in the housing and cap. (Fig 2)
- Lubricate and install the main bearing caps. Ensure that the bearing caps are fitted into their original positions.
- Hand-tighten the main bearing cap bolts.
- Tighten the middle bearing cap to the specified torque and check the crank shaft for free rotation.
- Loosen the main bearing caps and bolts on one side.
- Check the gap between the main bearing cap and the cylinder block surface with a feeler gauge. This gap indicates the bearing crush. (Fig 3)

Fig 2



CHECK BEARING SPREAD

Fig 3

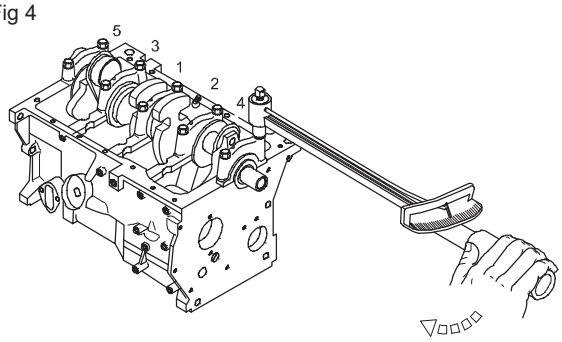


FIT OF BEARING IN HOUSING ALLOWS A SLIGHT PROJECTION OR CRUSH

MDC22P0114

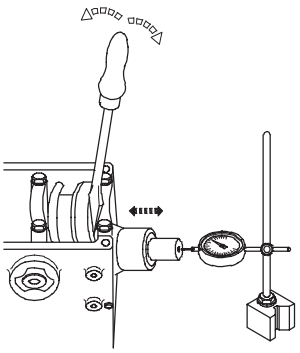
- Tighten the bolts of the main bearing caps on either side of the centre bearing, one by one to the specified torque. (Fig 4)
- Check the crank shaft for its free rotation after tightening each bearing cap's bolts.
- Check the crank shaft end play. (Fig 5)
- To increase the end play use a thinner thrust washer and to reduce the end play use a thicker thrust washer.
- Clean the cylinder block surface.
- Keep the cylinder block in a tilted position and support it on wooden blocks.
- Stagger the piston rings as specified by the manufacturer.
- Lubricate the cylinder walls, piston and rings, big end bearing shells and crankpins with engine oil.
- Place the piston in the cylinder till the bottom ring touches the cylinder block top. Ensure that the piston is placed in the cylinder in the same direction as specified by the manufacturer.
- Bring the respective crankpin to T.D.C.

Fig 4



TIGHTEN MAIN BEARING BOLTS IN SEQUENCE

Fig 5



MEASURE CRANKSHAFT END FLOAT OR CLEARANCE

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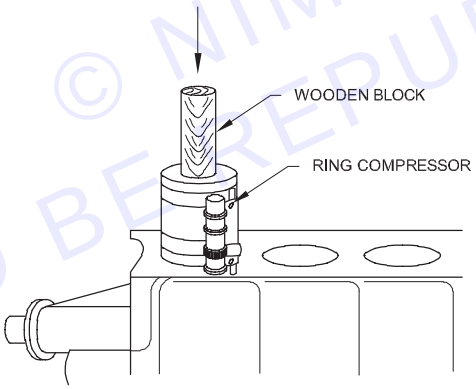
- Compress the piston rings by a ring compressor. (Fig 6) Push the piston with a wooden block till the connecting rod big end bearing sits on the crankpin.
- Push the piston, and simultaneously rotate the crank shaft till it comes to B.D.C. Ensure that the connecting rod does not dislodge from the crank shaft while rotating the crank shaft. (Fig 6)
- Fit the connecting rod bearing cap, along with the lower bearing shell.
- Tighten the bearing cap bolts/nuts to the recommended torque.
- Rotate the crank shaft and check for free rotation.
- Repeat the above steps for fitting all the remaining pistons and connecting rod assemblies.

Fig 6



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EXERCISE 2.26: Practice on checking and setting variable valve timing

Objectives

At the end of this exercise you shall be able to

- check cam shaft drive parts
- check variable valve timing components
- check operation of variable valve timing mechanism.

Requirements

Tools/Equipments/Materials

- Trainees tool kit
- Timing gear puller
- Torque wrench
- Socket set
- Digital multimeter
- Engine with VVT mechanism
- Vehicle with VVT mechanism
- Scan tool
- Timing belt/chain
- Engine oil
- Spare VVT solenoid valve
- Timing gears/sockets

Procedure

- Remove the alternator drive belt from the crank shaft pulley.
- Lock the flywheel.
- Remove the crank shaft pulley.
- Remove the timing belt cover.

TASK 1: **Check the cam shaft drive parts**

1 Check the condition of timing belt or chain. If excessive slackness on chain/belt having cracks, missing teeth and worn out condition is found, replace them.

2 Visually check the condition of gears and drive sprocket. If any war found on teeth or hub, replace the parts.

3 Check the chain or belt tensioner. Replace if necessary.

— — — — —

TASK 2: **Check variable valve timing components**

1 Inspect the variable valve timing components (VVT assembly on cam shaft hub) for any leakage, cracks and damage on mountings of VVT controller assembly.

2 If any defects found, replace VVT controller assembly.

Note: after completion of task 1 & 2, reassemble the removed parts of engine.

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TASK 3: **Check the operation of variable valve timing mechanism**

1 Start the engine/vehicle and check the MIL lamp.

2 If you found the following problems

- Rough idling/failure to start

- Under powered engine
- Erratic gear changes on automatic transmission
- It may be related to VVT mechanism

3 Connect the OBD II scan tool to the engine data link connector

4 Read the diagnostic trouble code and repair the defective component

Some VVT generic OBD II codes are given in tabulation

S. No.	VVT generic OBD II code	Possible causes and areas to be checked
1	P00l0 'A' cam shaft position actuator circuit bank -I	Cam shaft sensor 2
2	P0011 'A' cam shaft position timing over advanced bank-I	Valve timing Oil control valve
3	P0012 'A' cam shaft position timing over retarded bank-I	Oil control valve Filter screen
4	P0013 'B' cam shaft actuator circuit bank -I	Filter screen Wrong viscosity oil Cam shaft timing gears
5	P0014 'B' cam shaft position timing over advanced bank -I	Dirty or low engine oil VVT controller assembly
6	P00lS 'B' cam shaft position timing over retarded bank -I	Defective PCM or electrical wiring
7	P0020 'A' cam shaft	Defective PCM or electrical wiring
8	P0021 'A' cam shaft position timing over advanced or system fault bank II	Defective PCM or electrical wiring
9	P0022 'A' cam shaft position timing over retarded bank -II	Defective PCM or electrical wiring
10	P0023 'B' cam shaft position actuator circuit bank -II	Defective PCM or electrical wiring
11	P0024 'B' cam shaft position timing over advanced or system fault bank II	Defective PCM or electrical wiring
12	P0025 'B' cam shaft position timing over retarded bank -II	Defective PCM or electrical wiring

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TASK 4: **Checking of VVT electrical circuit**

1 Take out given engine/vehicle VVT electrical circuit diagram.

2 Check the continuity of electrical circuit.

3 Check the supply voltage of the circuit as specified the manufacturer service manual.

4 If the electrical circuit is foung ok, replace new PCM.

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TASK 5: **Ckeck oil control solenoid valve and oil**

1 Check the engine oil viscosity and ensure the oil grade as per manufacturers recommendation

2 If oil is dirty or low oil level, replace the engine oil and top up it

3 Locate the solenoid valve that controls the flow of oil to the variable valve timing mechanism

4 Find out which solenoid wire is receiving ground

5 Start the engine and run at around 2500 rpm

6 Ground the solenoid signal wire and observe engine operation. There should be noticeable change in engine speed and sound as per valve timing changes. If the engine speed or sound did not change the solenoid is defective

7 Replace the solenoid valve if it is defective

8 Remove the oil control valve and filter, clean it. If necessary replace it.

— — — — —

TASK 6: **Checking of valve timing**

1 Remove the timing gear cover

2 Rotate the cam shaft and bring the engine is 1 cylinder pistion at TDC position of compression stroke

3 Check the timing marks on the engine crank shaft and cam shaft is properly aligned, if it is not properly aligned remove the belt and realign it.

4 Refix the belt.

— — — — —

TASK 7: **Checking of cam shaft sensor**

1 Disconnect connector of CMP sensor.

2 Turn ignition switch to 'ON' position.

3 Check the voltage of CMP sensor connection (vehicle side) between terminals 1 and 2 which shows battery voltage. If faulty check power supply circuit and ground connection.

4 Check the CMP sensor signal output voltage as specified by the manufacturer.

5 If voltage is found defective, remove CMP sensor.

6 Check the CMP sensor 'O' ring id free from damage.

7 Check the end face of sensor and signal rotor tooth are free from any metal particles and damage.

8 Check the CMP sensor resistance varies as specu=ified below by passing magnetic substance (screw driver metal end tip). CMP sensor resistance varies between less than 220ohm 'ON' and infinity (OFF condition).

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TASK 8: **Erasing of VVT DTC**

1 Connect the scan tool to DTC at vehicle after rectifying the fault related to the DTC code shown earlier

2 Go to the DTC trouble code and select the trouble code

3 Press erase key on the scan tool

4 Keep the ignition key 'ON' position and engine 'OFF' condition

5 Confirm the erasing pressing 'YES' key on the scan tool

6 Now DTC is cleared. Confirm it by starting the engine once again.

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MODULE 3: Intake and Exhaust Systems

EXERCISE 3.1: Servicing air filter/cleaner

Objectives

At the end of this exercise you shall be able to

- clean the filter element
- check the oil level in the air cleaner
- fit the air cleaner on the engine.

Requirements

Tools/Instruments

- Trainee tools kit - 1 No.
- Cleaning tray - 1 No.
- Wire brushes - 1 No.

Equipments/Machines

- 4 cylinder petrol/diesel engine - 1 No.
- Air compressor - 1 No.

Materials

- Air filter element
- Diesel/Petrol
- Waste cloth
- Soap solution
- Air cleaner gasket
- Baniyan cloth - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

Job sequence

Servicing air cleaner (Dry type)

1 Unscrew the bolt or wing-nut of the air cleaner top cover with the help of a spanner or pliers.

2 Remove the top cover along with the filter element and gasket.

3 Loosen the nuts/screw of the clip fixing the air cleaner to the carburettor.

4 Remove the lower part of the air cleaner.

5 Repeat using a piece of cardboard, block the opening of the air intake on the inlet manifold/carburettor to avoid entry of foreign material.

6 Clean the air cleaner housing and cover with cloth.

7 Inspect the filter element. If it is of paper type, replace the same.

8 If the element is of metal mesh, blow off the dust from inside the element with compressed air.

9 If the metal mesh element is heavily dirtied, wash it with kerosene, a household type detergent. 10.After washing, rinse the detergent out of the element and dry it completely with compressed air.

11 Check visually the cleaned element for puncture or damage. Discard if it is found defective.

12 Check the gasket. If it is damaged or hard, replace it.

Installation

1 Place the new or old element in the lower housing.

2 Place the gasket ring on the element.

3 Place the top cover on the element.

4 Tighten the wing-nut or bolt and nut with the help of pliers/ spanners.

5 Test the air cleaner by starting the engine for smooth running.

Servicing air cleaner (Oil-bath type)

1 Unscrew the bolt or wing-nut on the top cover by hand or pliers.

2 Remove the top cover along with the element and gaskets.

3 Loosen the nuts on the clamp fixing the lower part of the air cleaner to the carburettor.

4 Remove the lower part from the carburettor.

5 Drain the oil from the lower part and clean the sludge.

6 Wash the element thoroughly in kerosene/diesel and rinse it.

7 Blow low pressure compressed air over the wire mesh from the opposite side and dry the element.

8 Clean the lower part (bowl) of the air cleaner with diesel/ kerosene and wipe with clean cloth and check for any damage.

9 Check the filter element wire mesh for damage and clogging. If damaged or still clogged, replace with a new one.

10 Check the gasket ring and clean it; if damaged or hard replace the gasket ring.

11 Check the threads of the top cover mounting bolts/wing- nut.

12 Mount the bowl (bottom portion) on the carburettor air intake using the damp.

13 Refill the air cleaner bowl/lower part with recommended grade of oil up to the level mark.

14 Place the gasket and install the filter element in the bowl/ lower part.

15 Place the gasket ring and the top cover in position and tighten the wing-nut.

EXERCISE 3.2: Service throttle body assembly

Objectives

At the end of this exercise you shall be able to

- remove throttle body from the vehicle
- clean throttle body assembly
- refit throttle body on the vehicle.

Requirements

Tools/Instruments

- Petrol engine in running condition
- General tools as required
- solvent

Procedure

- Remove the air cleaner or intake duct.
- Inspect the throttle body for any carbon deposits.
- Remove the sensors connected with the throttle body.
- Remove the throttle body from the vehicle.
- Spray solvent into throttle body.
- Allow it to soak for few minutes.
- Clean the throttle body with a brush till the deposits will remove.
- Flush the throttle body.
- Allow the throttle body to dry.
- Refit the throttle body.
- Connect all connections and install air cleaner or intake duct.
- Start the engine and check for any leaks.

EXERCISE 3.3: Overhauling the turbo charger

Objectives

At the end of this exercise you shall be able to

- remove turbo charger from vehicle
- dismantle turbo charger
- clean, replace or repair defective parts
- assemble and check turbo charger
- refit turbo charger on vehicle and start the engine.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No
- Circlip plier - 1 No
- Box spanner - 1 set
- Dial gauge - 1 No
- Torque wrench - 1 No
- Plastic mallet - 1 No

Equipments/Machines

- Work bench - 1 No.
- Turbo charger - 1 No.

Materials/Components

- Kerosene - as reqd.
- Cotton cloth - as reqd.
- Anti corrosive solution - as reqd.
- Cleaning brush - 1 No.
- Turbo charger accessories - as reqd.

Procedure

Removal

- Park the vehicle on level surface and choke the wheels.
- Make sure the engine is cool-down. Open the hood and remove the battery cables.
- Remove the compressor side hose clamp of hose pipe.
- Disconnect the oil connections/pipes from turbo charger and vacuum connections of actuator.
- Remove the mounting bolts of turbine side.
- Remove the turbo charger from vehicle and place it on working table (Fig 1).

Fig 1

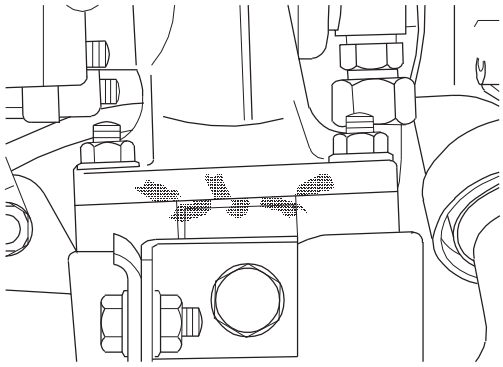
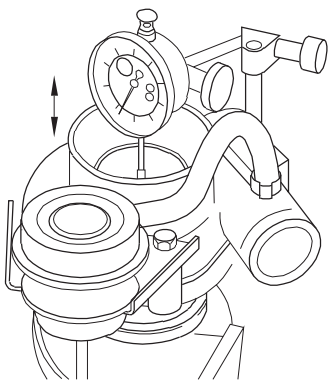


Fig 2



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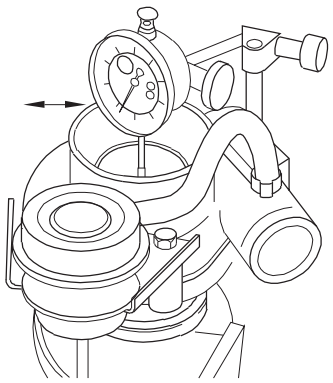
- Check visually for cracked, bent or damaged compressor wheel blades.
- Check bearing clearances-secure the turbine hosing and check the thrust clearance using a dial gauge. Ensure clearance is within MIN/MAX values. If axial clearance does not meet specification than overhaul to strip and rebuild the turbocharger. (Fig 2)

- Check the redial movement at compressor impeller nose using a dial gauge (Fig 3).

Ensure movement is within MIN/MAX TIR (Total Indicator Reading) values.

If radial movement does not meet specification than overhaul to strip rebuild the turbo charger.

Fig 3



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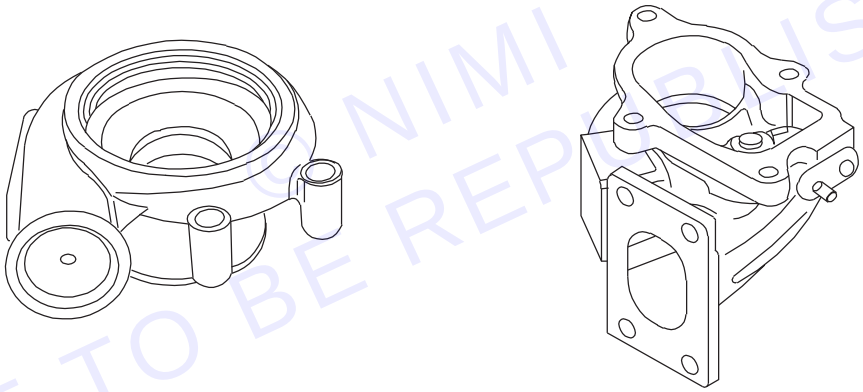
Dismantling/Cleaning

- Clean turbo charger external surface and inspect for cracks and damages (Fig 4).

Fig 4



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- Remove actuator and placed in tray.
- Remove 'V' band clamp and remove turbine body.
- Remove circlip and remove the compressor body.
- Remove the drive and driven impellor by loosening the impellor nuts (Fig 5 & Fig 6).

Fig 5

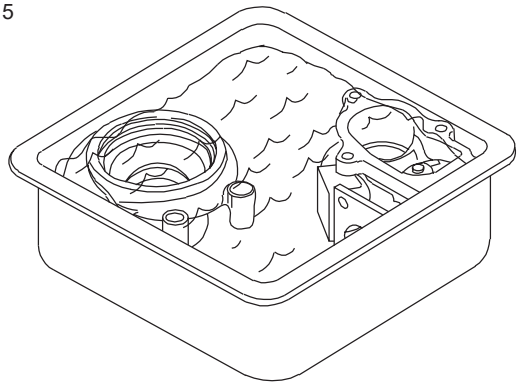
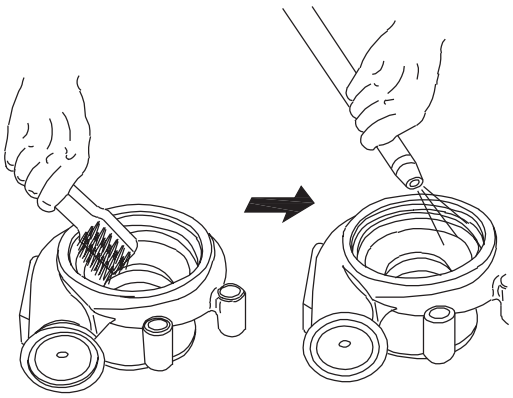


Fig 6



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- Remove both the impellors and place into tray (Fig 7).
- Remove impellor shaft with bearing.
- Remove “O” rings from both side of turbo charger body.
- Remove thrust plate and “O” ring from turbo charger body.
- Clean the above parts with kerosene except rubber parts (Fig 7 to 9).

Fig 7

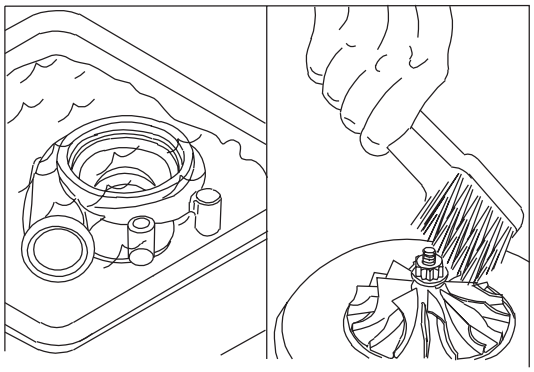

Fig 8

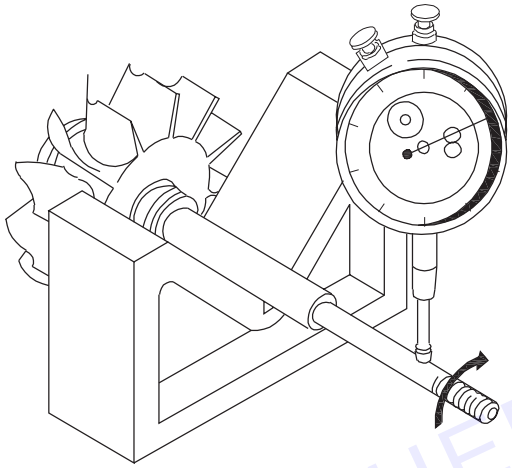

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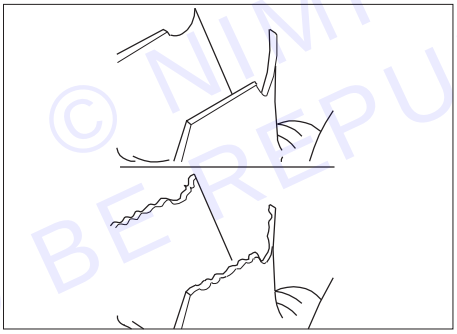
Fig 9



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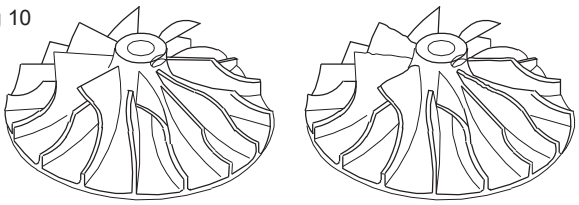
Inspection and repair

- Inspect bearing and shaft free play. (Fig 8)
- Check rubber “O” rings for crack or tear.
- Check both impellors, shaft, thrust plate.(Fig 10)
- Replace faulty parts, if necessary.

Fig 10



Assembling and testing

- Assemble rubber “O” ring and thrust washer in turbo charger body (Fig 11).
- Fit external circlip of thrust washer and insert impeller shaft along with bearing (Fig 12).

Fig 11

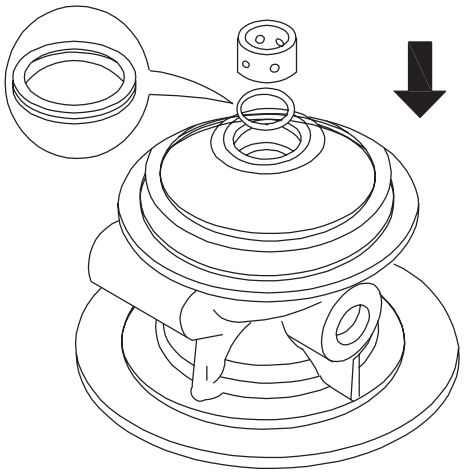
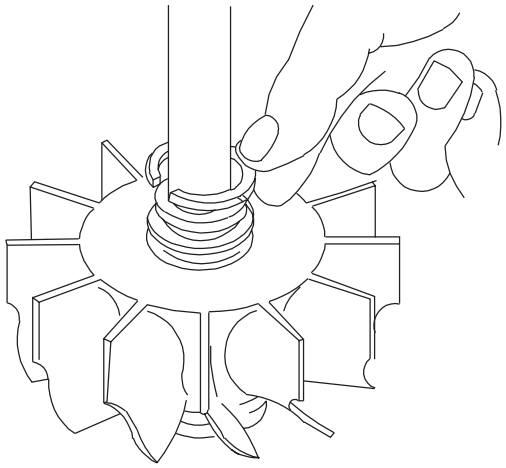


Fig 12



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- Fit both the impellers with impeller ruts (Fig 13).
- Check impeller shaft free-play and end play and check impeller free movement (Fig 14).

Fig 13

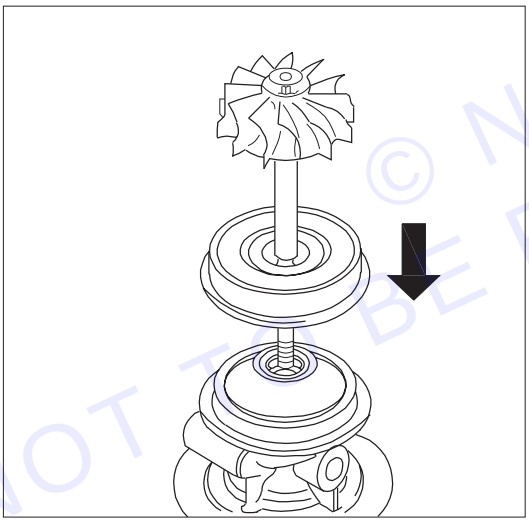
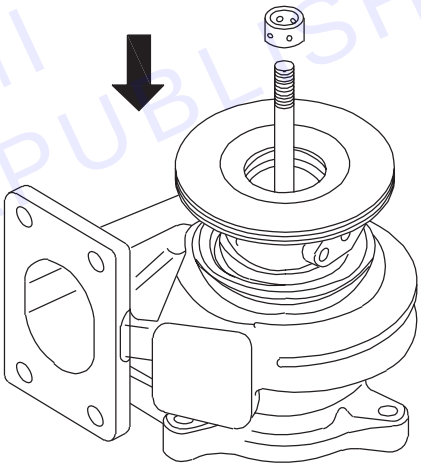


Fig 14



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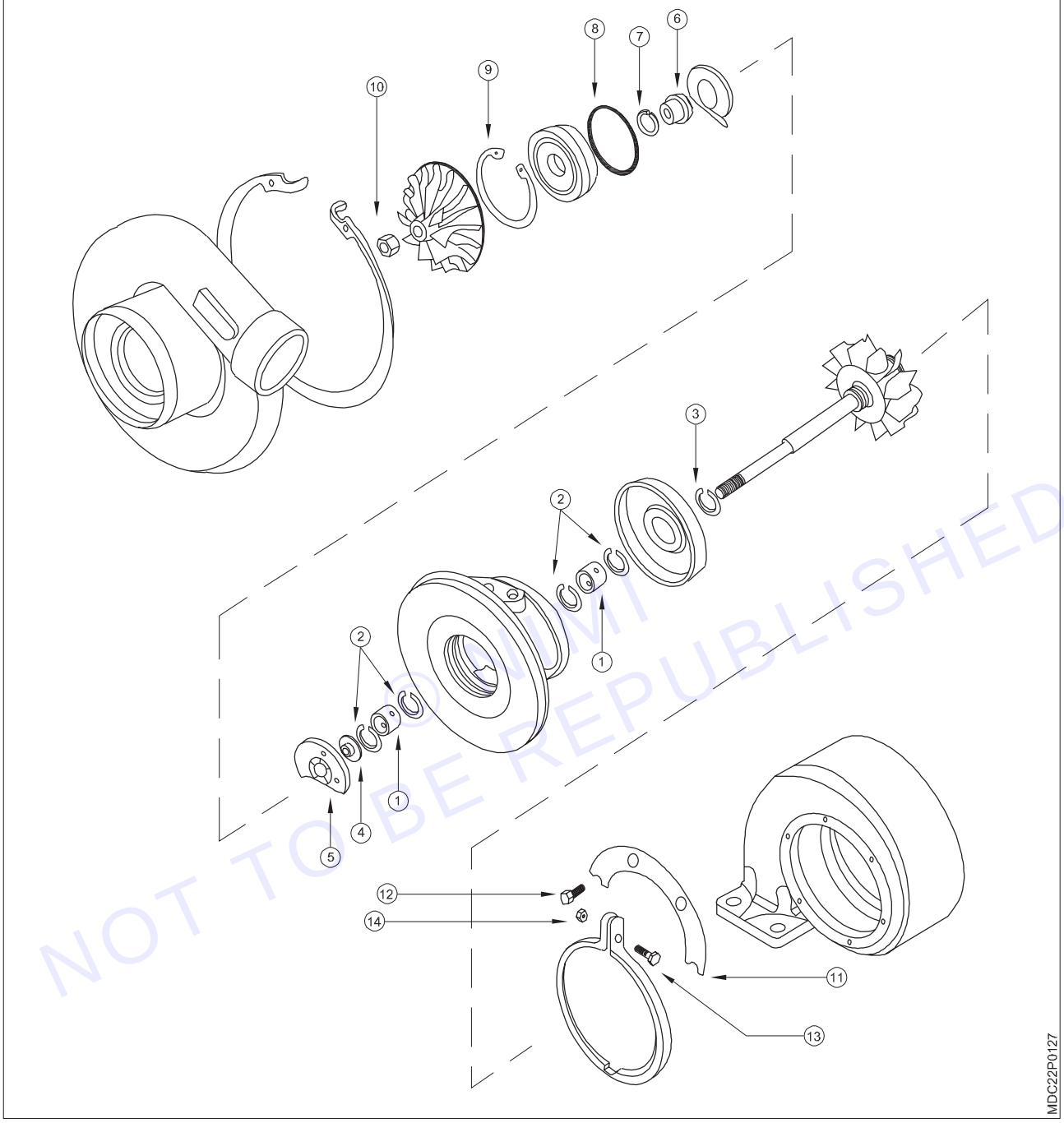
- Fit compressor and turbine flange with circlip and “V” band clamp respectively.
- Refit actuator on turbo charger.

Refitting (Fig 15)

- Fit the turbo charger on mounting and tighten the mounting bolts of manifold.
- Reconnect the oil pipe on turbo charger. Connect hose pipe on compressor side.
- Start the engine and check for proper functioning of the engine.

Fig 15



EXERCISE 3.4:Checking the exhaust system in engine off mode

Objectives

At the end of this exercise you shall be able to

- examine the exhaust system of an engine in off position.

Requirements

Tools/Instruments

- Trainee tools kit - 1 No.
- Box spanner set - 1 No.

Equipments/Machines

- Light motor vehicle - 1 No.

Materials/Components

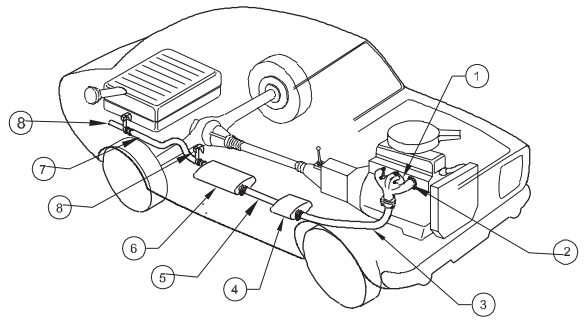
- Cotton waste - as reqd.
- Tray - as reqd.
- Soap oil - as reqd.
- Strap - as reqd.
- Gas welding plant - 1 No.
- Welding wire - as reqd.

Procedure

Examine the exhaust system of an engine in off mode (Fig 1)

- Visually check the exhaust manifold(1) mounting(2) tightness and gasket leakage symptoms.
- Examine the heat strap and exhaust damper damages.
- Examine the downpipe connection (3) gasket and mounting with exhaust manifold flange.
- Examine both side mountings of catalytic converter (4).
- Visually check the outside damages of resonator pipe (5).
- Visually check the muffler mountings (6) and connections.
- Visually check the loose connection of tail pipe (7).
- Visually check the exhaust pipe having strap (8) with vehicle body.
- Visually check the deteriorated parts in exhaust system.
- Visually check the exhaust pipe for dent and damages.

Fig 1



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EXERCISE 3.5: Servicing the exhaust system

Objectives

At the end of this exercise you shall be able to

- remove and clean the manifold, silencer, tail pipe and refit
- remove and clean the catalytic converter, muffer and refit it.

Requirements

Tools/Instruments

- Trainees tools kit - 1 No.
- Scraper - 1 No.
- Straight edge - 1 No.
- Feeler gauge - 1 No.
- Scraper - 1 No.

Equipments/Machines

- Diesel engine - 1 No.

Materials/Components

- Kerosene - as reqd.
- Soap oil - as reqd.
- Cleaning cloth - as reqd.
- Emery sheet - as reqd.
- Wire brush - as reqd.
- Manifold gaskets - as reqd.

Procedure

- Loosen the nuts (2) and disconnect the exhaust pipe (3) from the exhaust manifold (4). (Fig 1)
- Remove the exhaust manifold (4) from the cylinder head.
- Disconnect the exhaust pipe (3) and tailpipe (9), and catalytic converter (11) from the muffler (10) after loosening the clamp bolts and nuts. (Fig 2)
- Scrape the carbon deposits from the mounting faces of the manifold with a scraper (8).
- Inspect the manifold flanges (5) for alignment of level by using a straight edge (6).
- Scrape the carbon deposit from the exhaust manifold using a wire/ brush. (In some engines the exhaust manifold is in more than one piece. Remove them separately and clean.)
- Inspect the exhaust manifold for any damage/crack. if necessary, replace it.

Fig 1

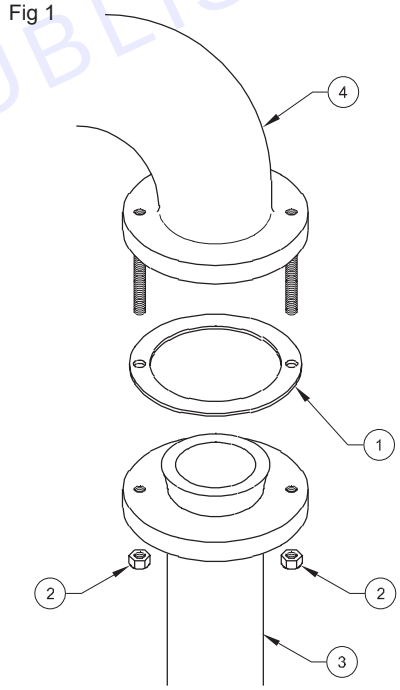
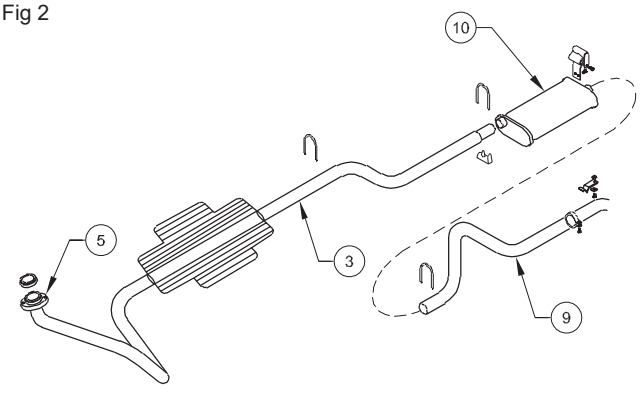
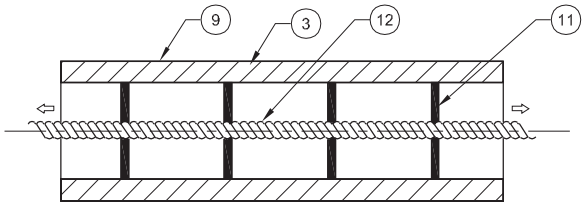


Fig 2



- Inspect the tailpipe (9) and exhaust pipe (3) for any crack/damage etc.
- Attach the scrapers (11) on the wire rope (12).
- Insert a wire rope (12) in the exhaust pipe (3) and tailpipe (9) till it comes out at the other end. Clean the exhaust pipe and tailpipe by passing a wire rope through (Fig 3).

Fig 3



- Inspect the catalytic converter for any damage or crack, if necessary replace it.
- For cleaning the muffler (10) some manufacturers recommend to cut the outer cover and weld after cleaning the baffles inside. (Consult your instructor.)
- Fix new gaskets on the exhaust manifold flange and fit the exhaust manifold (4).
- Fix a new gasket (1) between the exhaust manifold and exhaust pipe (3) and fit the exhaust pipe on the exhaust manifold.
- Fit the catalytic converter (11) with exhaust pipe
- Fit the muffler (10) with the exhaust pipe and tighten the clamp. (Fig 1)
- Fit the tailpipe (9) on the muffler and tighten the clamp.
- Align the assembly and fix it in the supporting clamps to the chassis.

EXERCISE 3.6: Checking the exhaust system in engine running mode

Objectives

At the end of this exercise you shall be able to

- examine the exhaust system of an engine.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Box spanner set - 1 No.
- Safety glasses or goggle - 1 Set.

Equipments/Machines

- Diesel engine - 1 No.
- Water sprayer - 1 No.
- Arc welding machine - 1 Set.

Materials/Components

- Kerosene - as reqd.
- Soap water - as reqd.
- Cleaning cloth - as reqd.
- Emery sheet - as reqd.
- Wire brush - as reqd.
- Metal sealing compound - as reqd.
- Pipe clamp - as reqd.
- Bolts/ nuts - as reqd.
- Gasket/ Asbestos - as reqd.

Procedure

- Start the engine.
- Identify leak in between the engine head and exhaust manifold joint (Gasket).
- Confirm the leakage by spraying soap water on it.
- Stop the engine and allow to cool
- Remove and clean the surface and studs with the help of wire brush and emery paper.
- Place a new gasket, align and tighten it with recommended torque.
- Restart the engine and check the leakage.
- Identify leaks by loose connection between muffler and tail pipe.
- Dismantle the fittings, remove carbon, rust and clean it.
- Apply metal sealing compound in between sleeve.
- Join the tail pipe and properly tighten it.
- Restart the engine and check its smooth running without noise.
- Ensure, there is no exhaust gas leaks in the exhaust system.

EXERCISE 3.7: Check catalytic converter

Objectives

At the end of this exercise you shall be able to

- test a catalytic converter.

Requirements

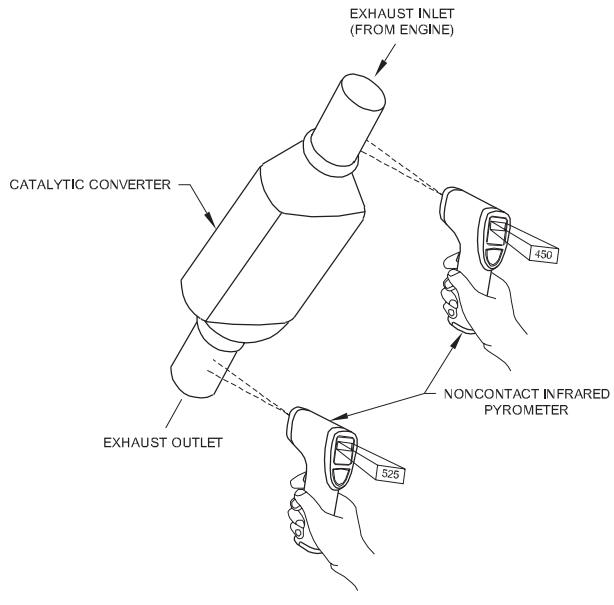
Tools/Equipments/Materials

- A running condition vehicle with catalytic converter
- Scan tool
- Infrared thermometer

Procedure

- Confirm the catalytic converter is cool.
- Strike the converter housing with a rubber hammer.
- If you found any rattle noise, then converter has internal damage such as loose catalyst, screens or baffles.
- Connect the scan tool with the vehicle.
- Check the waveform of oxygen sensor.
- This will show the whether the catalytic converter is working properly or not.
- Obtain a infrared thermometer.
- Run the engine for 5 minutes or till it reaches normal operating temperature.
- Place the thermometer at the front and rear of the converter and note down the values.
- Turn off the engine.
- There should be temperature difference in between these two and the temperature of the rear should not be greater than the front. If not, decide problem is with the catalytic converter.

Fig 1



MODULE 4: Fuel Supply System (Petrol)

EXERCISE 4.1: Servicing the fuel tank and fuel lines

Objectives

At the end of this exercise you shall be able to

- remove and clean the fuel tank
- remounting the fuel tank
- replace banjo bolts and washers.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.
- Air compressor - 1 No.

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Lubricant Oil - as reqd.
- Cleaning cloth - as reqd.

Procedure

TASK 1: **Servicing fuel tank and remounting of fuel tank**

1 Disconnect the mounting of fuel tank and drain the fuel from the tank (1) (Fig 1)

2 Disconnect suction line (2) and overflow line (5) and injector leak off pipe.

3 Remove fuel tank from the vehicle.

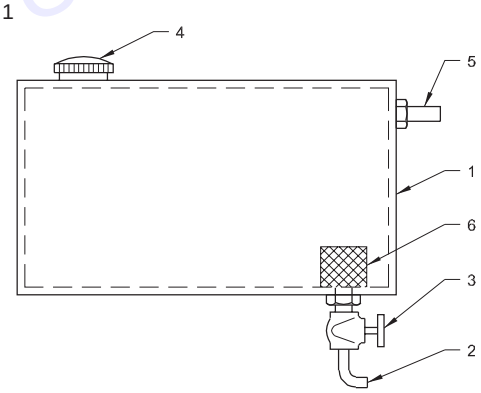
4 Clean outside and inside of the fuel tank with diesel and wash it with water pressure.

5 Remove the fuel cock (3) from tank and clean it along with strainer (6) for free passage of fuel from tank.

6 Dry tank with air pressure.

7 Ensure that the vent hole of the fuel tank cap (4) is open.

Fig 1



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TASK 2: **Remounting of fuel tank**

1 Refit the fuel cock (3) along with the strainer.

2 Place the fuel tank on vehicle and fit it.

3 Connect the pipe lines with fuel tank

4 Fill the tank with fuel.

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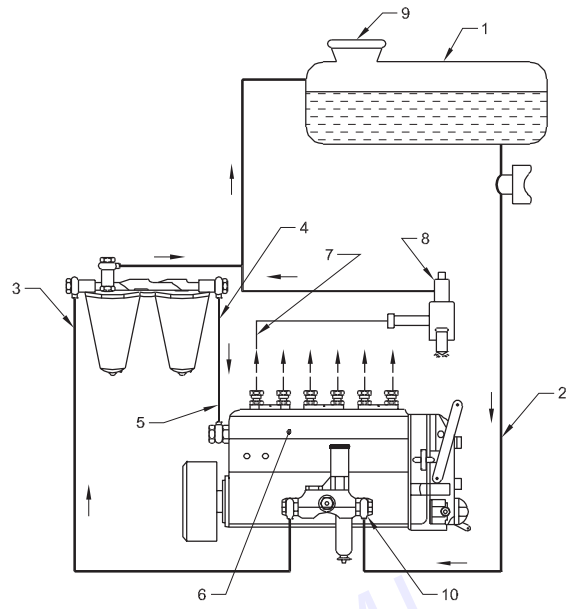
TASK 3: **Servicing fuel lines**

1 Park vehicle on the plain ground.

2 Check visually the following fuel line connections for leakages, cracks and deterioration or damage (Fig 1).

Fig 1



- Fuel tank all soldering edges (1).
- Fuel feed line (2)
- Fuel filter connection inlet (3) and outlet pipes (4).
- Connection (5) to fuel injection pump (6).
- Connection (7) to injectors (8).

3 Check the fuel tank filler cap (9) and check for the uniform seating of the gasket on the filler neck. Replace the filler cap if found damaged.

4 If fuel leakage at any connection is observed, tighten it. In case leakage does not stop. Change banjo washers and retighten.

5 Start the engine.

6 If the engine does not start, bleed the fuel with the help of hand priming pump (11) and recheck leakage (Please see Exercise 1.11.87 for procedure for bleeding).

7 Start the engine and ensure no leakage in fuel system.

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EXERCISE 4.2: Overhauling AC fuel pump

Objectives

At the end of this exercise you shall be able to

- remove the fuel pump from the vehicle
- dismantle the fuel pump
- inspect the diaphragm for any damage, and the diaphragm spring for tension
- inspect the rocker arm pivot for wear
- check the valve and valve seat for leakage
- fit the valves in the fuel pump
- align the diaphragm spindle with the rocker arm
- assemble the upper and lower body of the fuel pump
- fit the pump on the engine.

Requirements

Tools/Materials

• Trainee's tool kit	- 1 No.	• Air compressor	- 1 No.
• Measuring Tape	- 1 No.	• Cotton waste	- as reqd.
• Car	- 1 No.	• Soap oil	- as reqd.

Procedure

Air compressor

1 Removing and dismantling
2 Disconnect the inlet fuel line from the fuel tank to the fuel pump.
3 Tie the fuel line (from the tank) slightly above the tank level, to avoid spillage of fuel.
4 Remove the outlet pipe connecting the fuel pump and the carburettor float chamber.
5 Secure the outlet pipeline.
6 Remove the fuel pump mounting bolts.
7 Remove the fuel pump with the gasket.
8 Make an in-line mark on the side of the two halves, valve housing cover, pump chamber and bottom cover, to ensure the same position of the above parts when assembling back.
9 Remove the screws and washers holding the upper and lower bodies.
10 Separate the upper and lower halves.
11 Remove the valve housing cover screw, then remove the housing cover.
12 Remove the gasket.
13 Remove the strainer.
14 Remove the inlet valve assembly.
15 Remove the outlet valve assembly.
16 Remove the diaphragm assembly.
17 Remove the diaphragm return spring lock.
18 Remove the diaphragm return spring.
19 Remove the lever pin plug.
20 Remove the crank lever pin-lock.

Cleaning and inspection

1 Clean all the metal parts with kerosene.
2 Clean the diaphragm, valve housing, gasket and the valves with petrol.
3 Dry the metal parts with compressed air.
4 Dry the diaphragm, gasket and valves by low pressure compressed air.
5 Check visually all the parts for crack or damage.
6 Check visually the diaphragm for puncture and damage.
7 Check the valves for their one-way function.
8 Check the mating surfaces of the upper and lower halves of the assembly for any damage. If pitting is found, clean the surfaces with the help of zero grade emery paper on a level surface.

Assembling

1 Align the crank-lever hole and holes in the bottom half of the body.
2 Insert the crank-lever pin.
3 Lock the crank-lever pin by the retainer lock.
4 Fix the lever pin plug.
5 Assemble the diaphragm return spring and the diaphragm and lock the spring with the diaphragm lock on the lower half of the body.
6 Assemble the diaphragm spindle with the crank-lever.
7 Install the outlet valve assembly.
8 Install the inlet valve assembly.
9 Install the valve retaining plate.
10 Place the strainer.
11 Place the valve housing gasket.
12 Fix the housing cover.
13 Align the mark lines of the top and bottom halves of the pump to position these parts.
14 Fix the pump body screws. While fixing them, first tighten the first two threads by hand, then tighten the screws alternatively with a spanner/screwdriver as required.
15 Test the pump for suction and delivery.
16 Clean the pump mounting flange surface.
17 Clean the seating area of the pump on the engine block.
18 Apply shellac on the mounting flange surface.
19 Fix the new gasket on the mounting flange.
20 Position the fuel pump on the cylinder block.
21 Ensure the crank-lever of the fuel pump sits on the eccentric of the camshaft.

Fitting the pump

1 Align the mounting bolt holes on the cylinder block and fuel pump flange holes.
2 Fix the fuel pump mounting bolts. While fixing the fuel pump mounting bolts, tighten two threads by hand to avoid wrong threading.
3 Tighten the bolts alternatively with a spanner.
4 Connect the outlet pipe between the fuel pump outlet and the float chamber inlet of the carburettor.
5 Connect the inlet pipe of the fuel pump to the fuel line from the fuel tank. While connecting the pipelines tighten two threads by hand to avoid wrong threading.
6 Use two spanners, one spanner to hold the union from turning while tightening the cap nut to avoid damage.
7 Start the engine and check for fuel leakage.

EXERCISE 4.3: Overhauling carburettor

Objectives

At the end of this exercise you shall be able to

- remove the carburettor from the engine
- dismantle the carburettor
- clean the passage of the various jets of the carburettor with air
- inspect the float for any damage/puncture
- inspect the needle and the needle valve seat for scoring
- check the operation of the toggle mechanism for free movement of the needle
- check and adjust the float level
- check the bottom flange for distortion and correct it
- assemble the carburettor
- inspect the manifold flange and fit the carburettor on it.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Cleaning tray

Equipments/Machines

- Air compressor - 1 No.

Materials

- Carburetror overhauling kit
- Petrol

Procedure

Air compressor

Dismantling

- Remove the air cleaner hose and the air cleaner.
- Disconnect the accelerator pedal linkage.
- Disconnect the choke cable.
- Disconnect the fuel pipe connection to the float chamber.
- Remove the carburettor mounting nuts.
- Remove the carburettor.
- Close the inlet manifold passage with a piece of card- board.
- Remove the carburettor top cover.
- Remove the packing.
- Take out the float.
- Remove the toggle mechanism and needle valve.
- Remove the float needle valve seat from the carburettor cover.
- Remove the fuel inlet passage filter with the holder.
- Remove the starter unit.
- Remove the main jet holder with the washer.
- Remove the main jet and note down the jet number.
- Remove the pilot jet. Note down its number.
- Remove the starter jet. Note down its number.

- Remove the pump jet (outlet valve).
- Remove the pump inlet valve.
- Remove the pump spray nozzle.
- Remove the air correction jet. Note down the jet number.
- Remove the emulsion tube.
- Remove the pilot air bleed.
- Remove the venturi tube lock screw.
- Mark the venturi tube projection on the carburettor body.
- Remove the venturi tube.
- Remove the volume control screw with the spring.
- Mark the position of the pump assembly with the carbu-rettor body to fit this in the same position while re- assembling.
- Remove the pump control rod with the spring.
- Remove the pump cover screws and the pump assembly from the carburettor.
- Remove the pump cover.
- Remove the pump chamber.
- Remove the diaphragm return spring.
- Remove the pump diaphragm.
- Remove the starter lever and starter body.
- Remove the starter disc.
- Remove the starter air jet.
- Cleaning and inspection
- Clean all the parts with kerosene.
- Clean all the jets and passages with compressed air.
- Clear the dirt from the blocked jets and passages by a copper wire. (Do not use a steel wire as this will increase the diameter of the jet.)
- Check the free movement of the float needle valve. should fall freely by its own weight. Clean it, if it does not move freely.
- Check the float for puncture and damage.
- This is taken care of by manufacturers.
- Check the pump diaphragm for puncture and damage.
- Check the pump diaphragm spring for tension.
- Check the pump chamber mounting thread for wear and damage.
- Check the tension of the volume control spring.
- Check the built-in filter for damage.
- Check the toggle mechanism for damage.
- Check the toggle mechanism for free movement.
- Note down the sizes of the various jets in a note book.
- **Assembling**
- Place the disc on the choke body.
- Tighten the mounting screw of the starter body.
- Place the starter lever and hold it against the spring force.
- Tighten the starter spindle end nut.
- Place the pump diaphragm return spring in its seat on the pump chamber.

- Place the diaphragm over the return spring.
- Align the mark of the accelerating pump unit and carburettor body. Assemble the pump unit on the carburettor body with a new gasket.
- Tighten the pump cover screw.
- Connect the accelerating pump and the control rod adjusting unit.
- Fix the needle valve seat with a new fibre washer on the carburettor cover.
- While fixing the needle valve seat with a new washer note the thickness of the washer as it determines the float level.
- Fix the built-in filter with the holder on the carburettor cover.
- Fix the main jet, check the number on the jet before fixing.
- Ensure that only the jet with the correct No. is fixed.
- Fix the main jet-holder with a new fibre washer in its position.
- To avoid damaging the threads tighten the first two to three threads by hand, then tighten by spanners.
- Fix the pilot jet.
- Fix the pilot air bleed in its position.
- To avoid damaging the thread tighten one or two threads by hand, then use a spanner.
- Fix the emulsion tube into its carrier.
- Fix the air correction jet. Check the number of the jet before fixing. Ensure only the jet with the correct number is fixed.
- Fix the choke tube in its position inside the carburettor body.
- Align the marks on the choke tube and carburettor body surface.
- Fix the starter jet with a new fibre washer. Ensure the proper number of the jet before fixing.
- Fix the pump inlet valve with the filter and fibre washer in its position. Check the number of the valve, before fixing. Ensure only the valve with the correct number is fixed.
- Fix the pump outlet valve with the fibre washer.
- Fix the pump spray nozzle with the packing.
- Fix the volume control screw with the spring, tighten it fully, then unscrew one and a half threads.
- Place the float inside the float chamber. Make sure that the word 'Top' written on the float faces upward.
- Assemble the toggle mechanism to the top cover with the needle valve in place.
- Check the float level.
- Pour 75 ml petrol into the float chamber. Check the free movement of the float and the toggle mechanism and check for any leakage in the jet connection.
- Apply shellac on one side of the top cover gasket and place it on the carburettor top cover and align the screw holes.
- Place the top cover on the carburettor body and align the mounting holes.
- Tighten the three mounting screws evenly.
- Remove the cardboard closing the inlet passage of the inlet manifold.
- Place the carburettor assembly over the inlet manifold/ flange with the gasket.
- Tighten the carburettor mounting nuts evenly.
- Connect the fuel pipeline to the float chamber. To avoid damage to the thread, tighten two or three threads by hand, then use a spanner. To avoid damaging the pipe, hold the union in top cover with a spanner and tighten the nut fixing the pipe trunnion with another spanner.
- Connect the starter cable. Ensure that the starter lever is fully in home position.
- Connect the accelerator linkages. Ensure the free movement of the accelerating pedal.
- Fix the air cleaner over the carburettor.
- Start the engine and adjust the idling speed.

EXERCISE 4.4: Replacing fuel filter element (petrol)

Objectives

At the end of this exercise you shall be able to

- remove the fuel strainer from the filter cap clean the fuel strainer
- fit a new fuel filter element in the filter bowl
- fit the filter unit on the engine and connect the fuel pipes.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- 4 cylinder petrol engine
- Air compressor

Materials

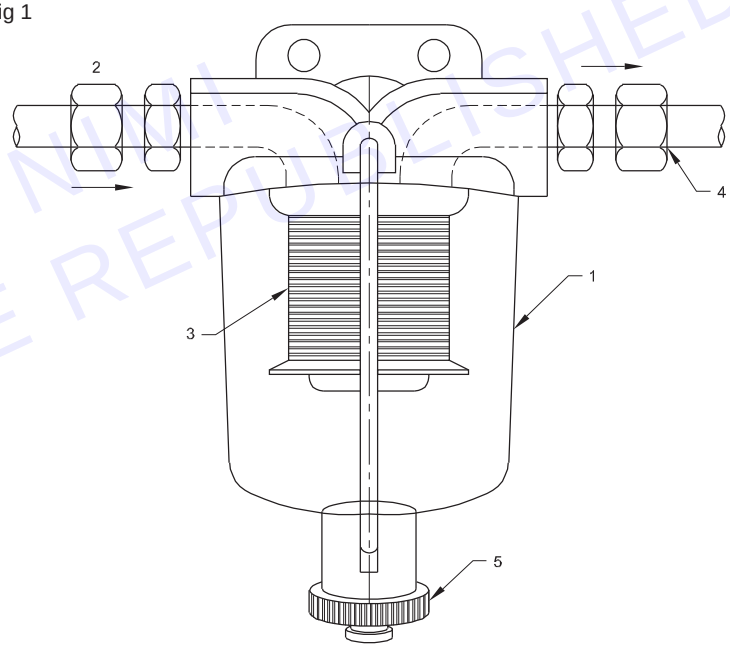
- Hose clamps
- Petrol/Kerosene
- New fuel filter element

Procedure

Removing

- Remove the fuel filter inlet hose (2) and tie it above the tank level to avoid spillage of petrol.
- Remove the fuel filter outlet hose (4) and collect the fuel in a container.
- Remove the filter mounting bolts.
- Remove the filter unit.
- Loosen the fixing thumb screw and clip.
- Remove the glass bowl (1).
- Take out the filter element (3) from the filter cap.
- Remove the filter cap and mark the position of the outlet passage.
- Cleaning and inspection
- Clean the cap with kerosene.
- Clean the bowl with kerosene and compressed air.
- Clean the inlet and outlet passages with kerosene.
- Check the cap gasket for any damage.
- Check the cap for damage.
- Check the fuel bowl neck for damage.
- Check the bowl for cracks and damage.
- **Assembling**
- Insert the new filter element into the cap.
- Assemble the glass bowl with a new gasket.
- Fix the clip and tighten the thumb screw.
- Align the mark on the filter cap with mark on the outlet passage.
- Fix the filter cap.
- Fix the filter with the bracket on the vehicle.
- Connect the inlet hose.
- Connect the outlet hose.
- Clamp the hoses securely.
- Start the engine and check for fuel leakage.

Fig 1



FUEL FILLTER

EXERCISE 4.5: Tuning carburettor

Objectives

At the end of this exercise you shall be able to

- tune the carburettor adjust the idling speed of the engine
- tuning of carburettor
- ensure the following.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Ignition timing light - 1 No.

Materials

- Petrol
- Waste cotton cloth

Equipments/Machines

- 4 cylinder petrol engine
- Air compressor

Procedure

- Choke valve of the carburettor is at fully closed position.
- The ignition timing is set correctly.
- The air cleaner is in good condition and properly in- stalled.
- The engine tappet clearance is set correctly.
- Start the engine and release the choke and run it for some time till it attains the operating engine temperature.
- Idling speed adjustment
- Adjust the idling speed to the specified r.p.m. by repositioning the volume control and throttle adjusting screw.
- With the engine running at idling speed turn the idle mixture adjusting screw clockwise/anticlockwise and set it where the highest r.p.m. is achieved with exhaust gas flow in good rhythm. This is the best position.
- If the engine misfires at the idling speed check the pilot jet and adjust the volume control and throttle screw.
- In case the engine's top speed is insufficient, check the main jet; if found defective, replace the main jet.
- If the carburettor is flooding frequently remove the float and needle valve seat, along with the needle valve from the upper cover.
- Clean the seat and needle.
- Adjust the float level to the specified measurement by inserting a suitable shim between the valve seat and upper cover by slightly bending the toggle lever.
- If a flat spot occurs during acceleration of the vehicle, the accelerating pump supplies less quantity fuel resulting in weak mixture. Hence, stop the engine immediately.
- Remove the pilot and main jets, clear them from obstructions and refit them again on the carburettor. If jets are found defective, replace them.
- Also adjust the accelerator pump stroke correctly to the specified measurement given by manufacturer of the carburettor. (Refer to Vehicle Operating Manual for correct measurement of stroke of the accelerating pump.)

MODULE 5: Fuel Supply System (Diesel)

EXERCISE 5.1: Servicing dry and wet air cleaner and charge air cooler

Objectives

At the end of this exercise you shall be able to

- service the dry type air cleaner
- service the oil bath type air cleaner.
- dismantle charge air cooler and inspect, clean test and refit into the engine.

Requirements

Tools/Materials

- Trainee's tool kit - 1 No.

Equipments/Machines

- A light motor vehicle
- Air compressor

Materials

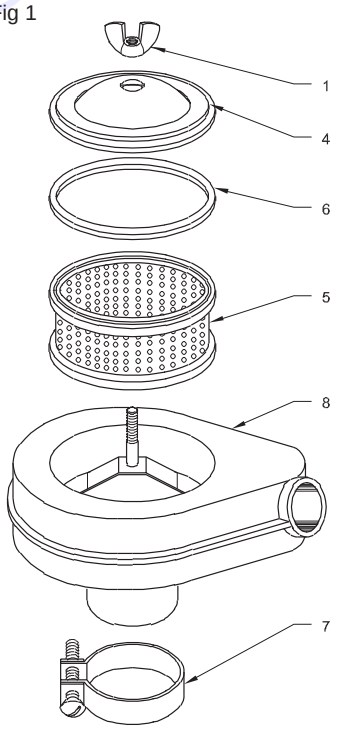
- Engine oil
- Kerosene
- New air cleaner gaskets
- Hose clamps
- New air filter element

Procedure

TASK 1: **Service air cleaner (Dry type)**

1 Open the bonnet.
2 Unscrew the bolt or wing-nut (1) of the air cleaner with the help of a spanner or plier (Fig 1).
3 Remove the top cover (4) with the filter element (5) and gasket (6).
4 Loosen the nuts/fixing clip (7) fixing the air cleaner on the inlet manifold.
5 Remove the bottom case (8) of the air cleaner.
6 Clean the air cleaner housing and cover with cloth.
7 Inspect the filter element (5). If it is clogged, replace the same.
8 Blow off the dust from the inside element by compressed air.
9 If the element is heavily dirty, wash it with a household type detergent
10 After washing rinse the detergent out of the element and dry it completely
11 Check visually the cleaned element (5) for puncture or damage. Discard if it is found punctured or damaged.
12 Check the plastic or rubber gasket ring (6) for smoothness which acts as a gasket
13 Place the new or old element (5) in the lower housing (8).
14 Put the plastic gasket ring (6) on the element (5).
15 Put the top cover (4) on the element (5).
16 Tighten the wingnut (1) with the help of a plier.
17 Test the air cleaner by starting the engine for smooth running.

Fig 1

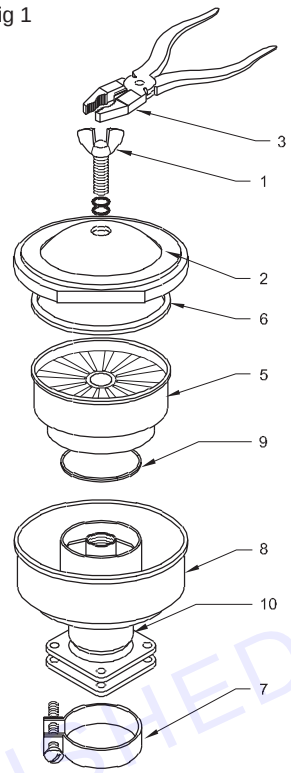


TASK 2: **Service air cleaner (Oil bath type)**

1 Open the bonnet of the vehicle.
2 Unscrew the bolt or wing-nut (1) on the top cover (2) by hand or plier (3) (Fig 1).
3 Remove the top cover (2) with the element (5) and gaskets (6 & 9).

4 Loosen the nuts/fixing clip (7) of the lower portion (10) of the air cleaner.
5 Remove the bowl (8) from the inlet manifold.
6 Drain the oil from the bowl (8) and clean the sludge.
7 Using a piece of cardboard, block the opening of the air intake on the inlet manifold to avoid entry of foreign material.
8 Pour a little diesel/ kerosene over the air cleaner element (5). Hold it in vertical position. Rotate and stir the element by hand until all the dust is absorbed by the oil. Drain the used oil. Repeat the procedure until all the dust or dirt is removed from the wire mesh.
9 Blow compressed air under reduced pressure over the wire mesh from the opposite side and dry the element.
10 Clean the bottom case (bowl) (8) of the air cleaner with diesel/kerosene and wipe with clean cloth.
11 Check the filter element and the wire mesh for damage and clogging of dust. If damaged, replace with a new one.
12 Check the gasket ring (6) and clean it; if damaged replace the gasket ring.
13 Check the threads of the top cover mounting bolts/wing-nut (1).
14 Check the air cleaner bowl (bottom case) for damage.
15 Mount the bowl (bottom portion) on the engine manifold by tightening the fixing nuts or bolts of the clip (7).
16 Refill the air cleaner bowl /housing up to the oil level mark with clean, recommended grade of oil.
17 Place the gasket (9) and install the filter element (5) in the housing bowl(8).
18 Place the gasket ring (6) and fit the cover (2) by tightening the wing-nut (1).
19 Start the engine and check the performance of the engine for smooth running.

Fig 1



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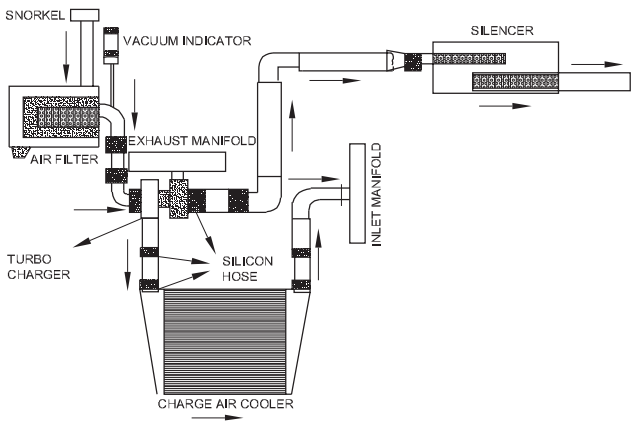
TASK 3: **Servicing charge air cooler (Fig 1)**

1 Remove charge air cooler mounted along side or a head of radiator by removing the bolts.
2 Disconnect hose pipe connection from both LHS & RHS.
3 Clean external fins by controlled water jet.
4 Clean interior passage by pressurised water and dry the same.
5 Check for leaks by blocking one end and applying air pressure in the other end and dip the CAC completely in water.
6 Look for leaking air bubbles.
7 If there is a leakage follow the manufacturer's guide line to repair it.

Fig 1



8 If leakage from welded joints and severe, this may have to be replaced.
9 Refit the cleaned & tested CAC and connect the silicon hoses.

CAC is made of aluminium & fins are welded - needs adequate care in handling.

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EXERCISE 5.2: Servicing the fuel tank and fuel lines

Objectives

At the end of this exercise you shall be able to

- remove and clean the fuel tank
- remounting the fuel tank
- replace banjo bolts and washers.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.
- Air compressor - 1 No.

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Lubricant oil - as reqd.
- Cleaning cloth - as reqd.

Job sequence

TASK 1: **Servicing fuel tank and remounting of fuel tank**

1 Disconnect the mounting of fuel tank and drain the fuel from the tank (1) (Fig 1)

2 Disconnect suction line (2) and overflow line (5) and injector leak off pipe.

3 Remove fuel tank from the vehicle.

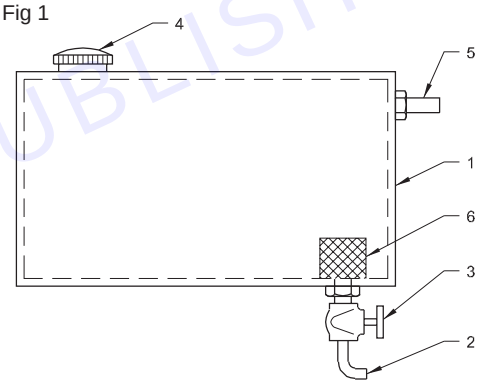
4 Clean outside and inside of the fuel tank with diesel and wash it with water pressure.

5 Remove the fuel cock (3) from tank and clean it along with strainer (6) for free passage of fuel from tank.

6 Dry tank with air pressure.

7 Ensure that the vent hole of the fuel tank cap (4) is open.

Fig 1



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TASK 2: **Remounting of fuel tank**

1 Refit the fuel cock (3) along with the strainer.

2 Place the fuel tank on vehicle and fit it.

3 Connect the pipe lines with fuel tank

4 Fill the tank with fuel.

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TASK 3: **Servicing fuel lines**

1 Park vehicle on the plain ground.

2 Check visually the following fuel line connections for leakages, cracks and deterioration or damage (Fig 1).

- Fuel tank all soldering edges (1).
- Fuel feed line (2)
- Fuel filter connection inlet (3) and outlet pipes (4).

- Connection (5) to fuel injection pump (6).
- Connection (7) to injectors (8).

3 Check the fuel tank filler cap (9) and check for the uniform seating of the gasket on the filler neck. Replace the filler cap if found damaged.

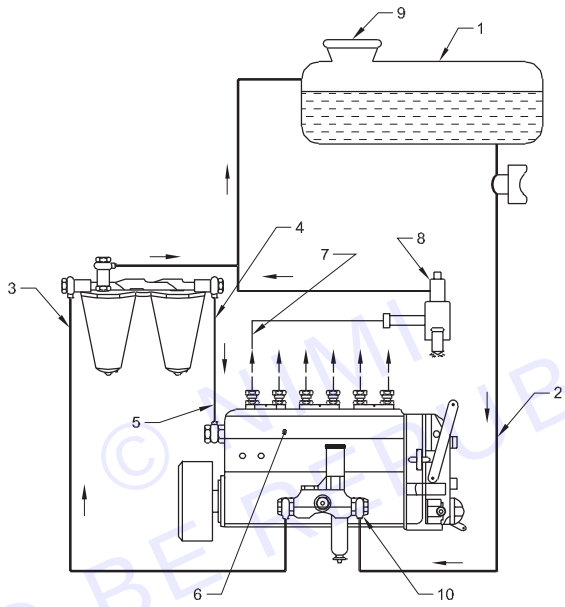
4 If fuel leakage at any connection is observed, tighten it. In case leakage does not stop. Change banjo washers and retighten.

5 Start the engine.

6 If the engine does not start, bleed the fuel with the help of hand priming pump (11) and recheck leakage (Please see Exercise 1.11.87 for procedure for bleeding).

7 Start the engine and ensure no leakage in fuel system.

Fig 1



EXERCISE 5.3: Overhauling the fuel feed pump in diesel engine

Objectives

At the end of this exercise you shall be able to

- overhaul the mechanical fuel feed pump
- overhaul the electrical fuel feel pump.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Circlip plier - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.
- Air compressor - 1 No.

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cotton cloth - as reqd.
- New gasket - as reqd.

Procedure

TASK 1**: Overhaul the mechanical fuel feed pump**

Dismantling (Fig 1)

1 Disconnect the fuel lines of the feed pump.

2 Remove the feed pump assembly from the fuel injection pump by loosening the mounting nuts uniformly.

3 Remove the filter housing (17) by loosening the clamping nut (14), screw (13) and clip (15) along with the spring (16), filter (18) and gasket (20).

4 Remove the snap ring (7) and take out the roller tappet assembly of the feed pump.

5 Remove the screw plug (2) and gasket (3) and take out the plunger and spindle (5 & 6) with the return spring (4).

6 Remove the hand priming pump (12) and gasket (21).

7 Remove the screw plug (22), gasket (21) and remove the valves (24), along with the springs (23).

8 Remove the roller pin (9) and roller (8).

9 Remove the slider (10), tappet (11) and spring (19).

10 Clean all the parts of the fuel feed pump with kerosene or diesel.

11 Check visually all the parts for wear and replace if required.

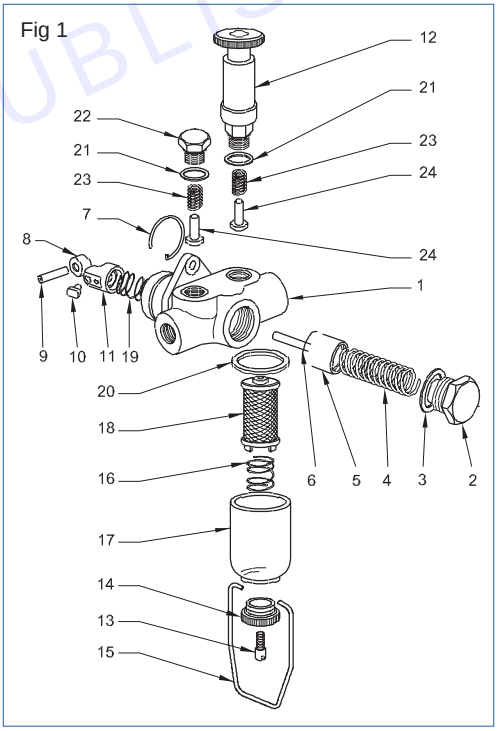
12 Check the tension of all the springs, and replace if necessary.

13 Check the valve seats.

14 Check the gaskets, and replace if necessary.

15 Check the filter clamping nut threads.

Fig 1



TASK 2: **Assembling**

1 Assemble the roller tappet assembly in the housing and secure it by the snap ring.

2 Assemble the spindle and plunger assembly and tighten the screw plug.

3 Place valves on their seats along with the springs and the gasket in position and screw in the plug.

4 Fit the hand priming pump.

5 Fit the filter assembly.

6 Rotate the F.I.P camshaft so that the heel of the cam driving end of feed pump is at the front.

7 Fit the feed pump on the F.I.P.

8 Tighten the feed pump mounting screws uniformly.

9 Connect the inlet fuel line.

10 Check for the operation of the pump by the hand priming pump and also by turning the engine. If the fuel comes out freely without air bubbles, connect the outlet line.

— — — — —

TASK 3: **Overhauling electrical feed pump**

1 Disconnect the +Ve and -Ve battery terminal.

2 Disconnect the wires connections of the electrical feed pump.

3 Unscrew the mounting bolts & nuts.

4 Remove the electrical feed pump.

5 Place it on the work bench.

6 Clean dust on the pump and dismantle it.

7 Check the fixed contact point and movable point.

8 Remove the pitting by fine emery paper.

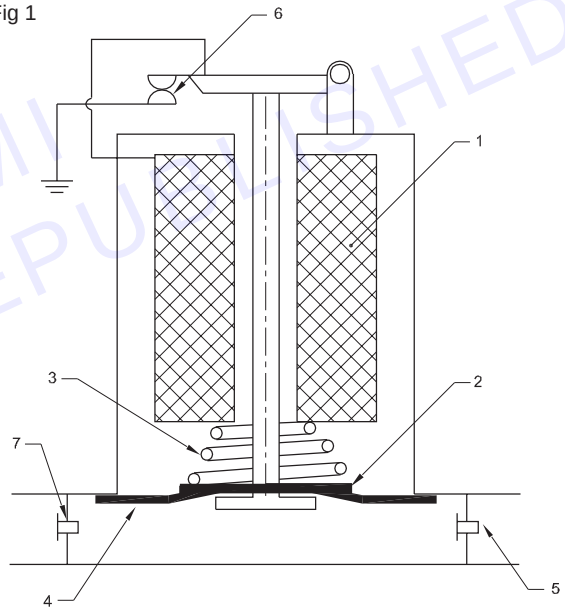
9 Check the fixed point body earth.

10 Check the insulation and continuity of armature coil.

11 Check the plunger movement.

12 Inspect the inlet and outlet valve fitted below the diaphragm.

Fig 1



13 Check the diaphragm, if damaged replace it.

14 Assemble all the part of fuel pump and fit the fuel pump in the engine.

15 Connect the wiring with insulation switch.

16 Connect the battery terminal.

17 Check its operation at high speed and idle speed.

18 Ensure no loose connection and leak in fuel pump.

— — — — —

EXERCISE 5.4: Remove and replace the fuel filter and bleed the system

Objectives

At the end of this exercise you shall be able to

- dismantle and replace filter element
- bleed the fuel system.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.
- Air compressor - 1 No.

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cotton cloth - as reqd.
- Gasket - as reqd.
- Filter element - as reqd.

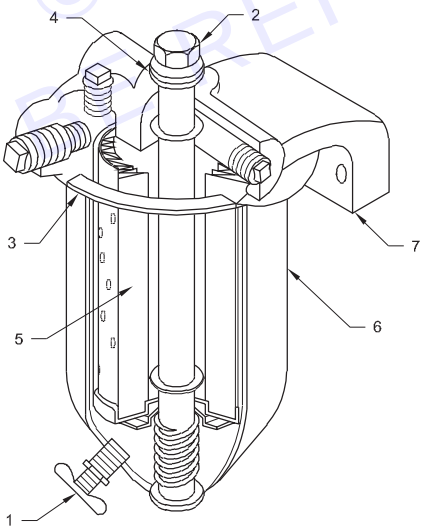
Procedure

TASK 1**: Dismantle and replace the filter**

1 Disconnect fuel lines from the filter.

2 Drain fuel, dirt and water from the filter housing by opening the drain plug (1) (Fig 1).

Fig 1



3 Loosen the centre stud bolt (2) located at the top of the assembly.

4 Remove the top cover (7)

5 Remove the used elements (5) from the filter housing (6). Discard the element.

6 Wipe the inside of the filter housing.

7 Clean fuel residue and other deposits. Use kerosene/diesel for cleaning the housing.

8 Place a new gasket (4) on the centre stud bolt.

9 Place a new gasket (3) in the filter cover assembly.

10 Place a new fuel filter element in the filter housing.

11 Fit drain plug in the filter housing

12 Fill diesel fuel in filter housing (6)

13 Assemble the housing with cover and tighten the centre bolt.

14 Connect the fuel hoses with fuel filter

— — — — —

TASK 2: **Bleeding**

1 Check all fuel line connection joints and leakages in fuel lines before start bleeding.

2 Operate the hand priming pump till fuel/pressure built up.

3 Loosen the fuel filter bleeding screw by one to two turns so that air can escape through the hole in the bleeding screw (Fig 1).

4 Tighten the bleeding screw (1) again.

5 Repeat the operation till the air in the system is fully drawn out in both filters.

7 Loosen the bleeding screw (1) at F.I.P. (5) by one or two turns so that air can escape through the hole from the bleeding screw.

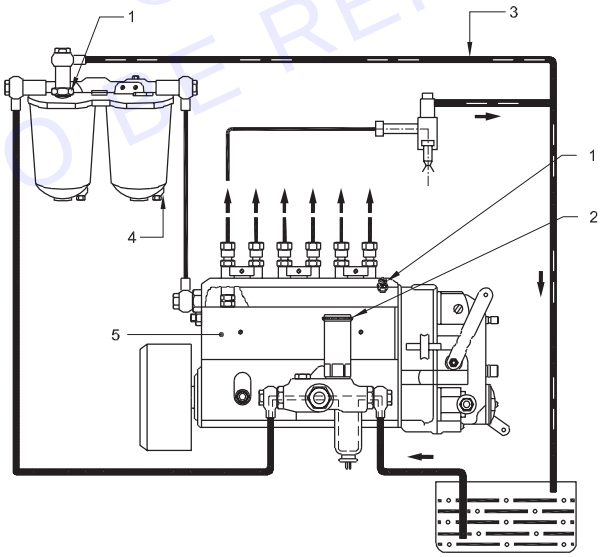
8 Tighten the bleeding screw (1) again.

9 Repeat the operation till the air in the system is fully drawn out.

10 Ensure all fuel connections and bleeding screws are securely tightened.

11 Start the engine and check to performance.

Fig 1



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EXERCISE 5.5: Removing and refitting the F.I.P

Objectives

At the end of this exercise you shall be able to

- remove the F.I.P from the engine
- check the injection timing by the spill cut off method
- set the fuel injection pump timing.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.
- Air compressor - 1 No.

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cotton cloth - as reqd.
- New gasket - as reqd.
- Swan neck pipe - as reqd.

Procedure

TASK 1**: Removing F.I.P from the engine**

1 Disconnect the accelerators linkage connection of F.I.P.

2 Disconnect the injector's high pressure line from F.I.P delivery valve holder.

3 Disconnect the F.I.P main gallery fuel connection.

4 Disconnect the fuel feed pump fuel line connections.

5 Dismount the F.I.P mounting bolts from engine.

6 Remove F.I.P from the engine.

7 Place the F.I.P in a tray on work bench.

8 Clean the F.I.P with cleaning solvent & tools.

— — — — —

TASK 2**: Setting timing of the fuel injection pump in relation to the engine**

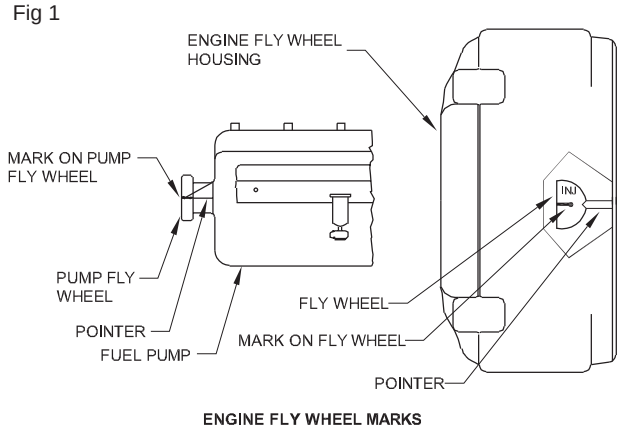
1 Before coupling the F.I.P pump to the engine for setting timing, the engine piston No.1 cylinder should be positioned at the injection point before T.D.C.

2 Align the engine timing marks (Fig 1 & 2)

3 Observe the TDC/BTDC (Injection marks) and a pointer made in the flywheel, on the 'V' belt pulley or on the vibration damper. (Fig 3)

4 Crank the engine in clockwise direction till the injection mark (3) on the flywheel/vibration damper coincides with the pointer (1) on the flywheel housing or timing gear housing.

Fig 1



ENGINE FLY WHEEL MARKS

When the above marks are aligned, the piston stands at 23° BTDC. (Ex: TATA vehicle) (Refer to the service manual for other vehicles).

5 Now the engine is ready for coupling with the FIP.

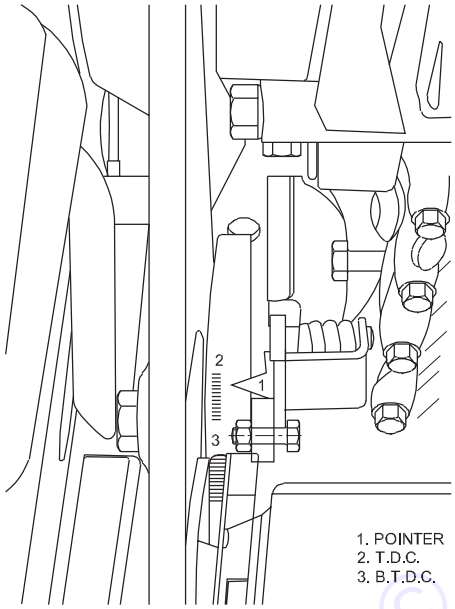
6 Prepare the F.I.P for coupling to the engine.

7 The pump plunger next to the drive end must be set to the commencement of delivery position for respective direction of rotation.

8 Observe the timing marks on FI pump shaft and housing.

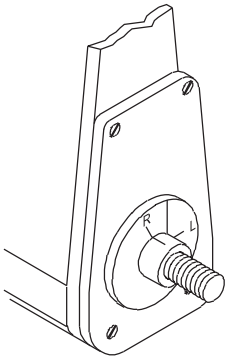
9 Rotate the pump camshaft and align the mark on the shaft taper with lines marked as R or L depending on the rotation of the pump shaft.(Fig 3)

Fig 2



ENGINE TIMING MARKS

Fig 3



THIS MARK MERELY INDICATES THE POSITION REQUIRED FOR THE INSTALLATION OF THE CAMSHAFT-DO NOT USE IT FOR ADJUSTING.

MARKS ON FUEL INJECTION PUMP

10 Fix the woodruff key on the taper end of the pump shaft and push the non-adjustable pump side half coupling on the shaft and tap it with a mallet.

11 Observe the line mark on the coupling boss aligning with R or L mark on the pump housing.

12 Fix the spring washer on the taper end of the shaft-screw in the nut and tighten it to the specified torque value. (Refer to Mico pamphlet) - use correct size spanner and tomy bar.

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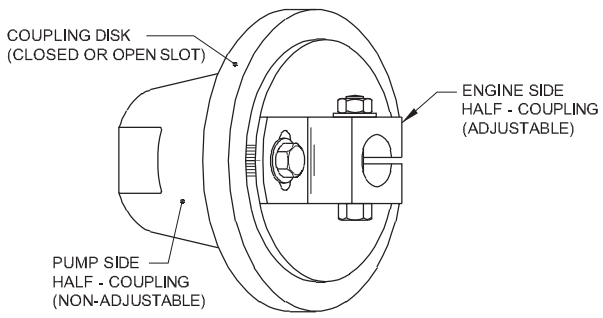
TASK 3**: Coupling the pump with the engine (Fig 1)**

Fig 1



COUPLING FOR FUEL INJECTION PUMPS WITHOUT INJECTION TIMER UNIT

MDC22P0148

1 Assemble the coupling unit on the pump with their zero marks exactly matching. (There are 3 units in all)

2 Measure the end clearance between the coupling flange and the coupling disc of the drive. (Use a feeler gauge) (Minimum clearance is 0.02” or 0.5 mm)

3 Fix the FI pump on its engine bracket - move it to the engine side - insert the drive side half coupling on the drive shaft of the air compressor or exhauster (depending on the make of the engine).

4 Insert the fastening bolts on the pump mounting holes and tighten them with nuts to the specified torque.

5 Crank the engine and check for free rotation of the pump shaft along with exhauster/air compressor shaft.

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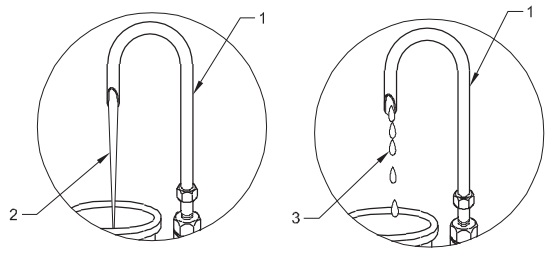
TASK 4**: Spill cut method (Fig 1)**

Fig 1



1 Disconnect the first injector pipe at the FIP's end.

2 Remove the 1st delivery valve holder and remove the valve pin and spring and fit the delivery valve holder

3 Fit the swan neck pipe (1) on the 1st delivery valve holder. (Fig 1)

4 Connect the fuel gallery of the FIP to the fuel container placed at a higher level.

5 Move the FIP towards the engine till the fuel (2) starts flowing freely through the swan neck pipe.

6 Now move the FIP away from the engine till the fuel flow is cut off completely.

7 Again move the FIP towards the engine and stop when the fuel flow regulates in such away that there is a flow of a drop (3) between 15 and 20 seconds; at that time tighten the bolts of the FIP flange without varying the flow of the drop.

8 Remove the swan-neck pipe (1) and delivery valve holder and replace the pin and spring and fit the delivery valve holder.

9 Connect the pressure pipes between the injectors and fuel injection pump. Fill the governor lubrication oil. Start the engine and adjust idle speed.

— — — — —

EXERCISE 5.6: Overhauling fuel injection Pump (Inline)

Objectives

At the end of this exercise you shall be able to

- dismantle the F.I.P
- inspect all the parts of the F.I.P
- assemble the F.I.P.

Requirements

Tools/Instruments

- Fuel injection pump - 1 No.
- Swivelling vice - 1 No.
- Special tools - as reqd.
- Plunger and barr - as reqd.

Procedure

Dismantling

- Keep the unserviceable fuel injection pump on the work bench
- Loosen the mounting screws of the feed pump. Do not loosen any mounting screw completely. Gradually remove the mounting screws and take out the feed pump slowly.
- Remove the control rack (14).110
- Remove the inspection cover (1) and mount the injection pump on a swivel vice.
- Remove the plate (22) from the governor cover (4).
- Unscrew the torque control capsule (2) from the tensioning lever (3) after removing the lock-nut with a combination wrench
- Remove the screws securing the governor cover (4). Tap me cover lightly with a rubber mallet to loosen it from the governor housing. Drain the lubricating oil by removing the drain nut.
- Disconnect the fulcrum lever by displacing the spring with a screwdriver
- Remove the starting spring (19).
- Unscrew the round nut (20).
- Remove the flyweight assembly (6).
- Remove the woodruff key from the camshaft (10).
- Lift off all the roller tappets (7) from the camshaft and remove the housing (8)
- Remove the intermediate bearings (9) and remove the camshaft (10).
- Remove the bearing end plate (21).
- Push the roller tappets (7) upward and remove the tappets Remove all the plunger elements (12) with the springs (11)
- Remove the control sleeve assembly (13-15) together with the upper spring plate. Remove the control rack (14)
- Remove the delivery valve holders (16) and the delivery valves (17) along with the spring (18).
- Take out the element barrels.
- Keep the respective barrels and plunger elements together. Do not interchange the barrels and the plunger elements.
- Place the components in the respective compartments of a clean standard workshop tray. Ensure that the plunger element and barrel are not interchanged.

Inspection

- Inspect the plunger and barrel element for wear, and replace, if abnormal wear is found.
- Clean the plunger with test oil. Withdraw the plunger about 1/4 of its length vertically upward from the element barrel. It must slide back slowly by its own weight into the element barrel.
- Inspect the delivery valves for wear on the relief piston, wear on the delivery valve pin and body seat, wear on the seating surface. Replace the delivery valve if it has any of the above defects. These should not be reconditioned
- Inspect the roller tappets for wear and damage. If excessive wear is found, replace. Inspect the camshaft for wear damage.
- Inspect the taper roller bearings for pitting/worn out races.
- Inspect the control rack for smooth slide in the pump housing. If it sticks, polish it with fine 00 emery-paper.
- Replace the control rack if the teeth are found to be worn out. Replace the worn out guide bushes.
- Inspect the plunger spring for corrosion, cracks and edge replace it, if necessary.

Assembling

- Mount the pump housing on the swivelling vice Fit the gallery plug.
- Rinse the elements in clean test oil and insert so that thee groove of the barrel engages the locating pins.
- Insert the delivery valve and washer. Fit the delivery spong and delivery valve holder. Tighten the every valve holder at the recommended torque with as not to spoil the thread after cleaning the threads.

Barrel seal tightening test

- Remove the FLP from the swivel vice.
- Connect the compressed air connection to the fuel inlet, se the outlets. Dip the pump in the test oil tank and at 0.5 to 1.0 (kgf/cm^2). If an air bubble appearly once in a while from the barrel seating, then the auto is considered tight.
- Fit FI.P. on the swivel vice. Remove the plunger assembly.
- Fix the control rack and screw in the control rack locating
- Insert the control sleeve in the quadrant in such a way mat the clamping jaws of the quadrant with the control Jack in the centre position point accurately forward
- Fit the upper spring plate plunger spring. Insert the plunger element in the lower spring plate. The plunger must tum smoothly with the control rack movement
- Insert the roller tappet and align the tappet pins into the grooves in the pump housing. Push the roller tappets and insert the tappet holders.
- Press the oil seals and the outer bearing races into the and plate. Insert the camshaft coating journals and cams with light oil.
- Force the intermediate bearing into the pump housing by taping the camshaft with a rubber mallet.
- Remove the tappet holders by rotating the camshaft. Check the plunger element has a clearance of atleast 0.2 mm at the TDC position of the cam and then lock the tappet screws.
- Fit the bearing end plate and tighten the screws. Fit the governor housing with gasket.
- Insert the woodruff key into the camshaft and fix the fly weight assembly. Sequence of governor assembly
- Fix the guide sleeve and actuating T between the flywheels and connect sleeve to the guide lever.
- Connect the guide lever and fulcrum lever on their respective fulcrum pins and locate the bottom of the fulcrum lever into the slot or governor cover.
- Connect the control rod rack to the fulcrum lever through the shackle. (Link fork)
- Hook the starter spring ends to their respective fulcrum points.
- Attach the tension lever on the same pivot point of the guide lever.

- Hook the governor spring eyes on and to the tension lever and the other end to the rocker of the swivelling lever.
- Fix the control lever (stop lever) to one end of the shaft of the swivelling lever.
- If it is a special stop device, fit it on the same side of control rack.
- Screw in the torque control device (adaption capsule) into the tension lever observe the lever end of the tension lever bearing against full load stop screw.
- Fix the supplementary idling spring on the governor cover.
- Fix the plug and supplementary idling speed spring screw them inside the governor cover and also screw the stop screw or idling stop screw in its place.
- Check the control rack movement by pushing the control rack to stop, and release. The control rack must automatically return to the full load position
- Fit the end cover.
- Rotate the camshaft till the cam that operates the feed pump is at the inner dead centre. Insert the gasket and fix the feed pump with hexagonal nuts using lock washers.
- Fill the pump and governor with the recommended oil up to level
- Phasing and calibration of fuel injection pump Select the correct calibration chart
- Use only recommended calibration oil
- Carry out all tests in the indicated direction of rotation as seen from the drive end. Check injection order (cam sequence) by rotating pump in the specified direction.
- Ensure that for all pump elements, the plunger clearance at TDC (tappet clearance) is at least 0.2 mm. Check whether control rack moves freely.

Mounting the pump on test bench

- Mount pump on test bench using suitable mounting and clamping devices. Connect inlet flexible pipe.
- Run pump at low rpm and bleed.
- Connect high pressure pipes and run the pump at 200 rpm until pump and test injectors are working perfectly. Fix control rack measuring device and set it to 'O' when control rack is in STOP position.

Adjustment of commencement of delivery

- The 'commencement of delivery' takes place when element plunger just covers the in-take port on its upward stroke from BOC position.
- It this point, there is no flow of oil from pump gallery to the element as a result of which the oil flow from swan neck pipe fitted to the test injector cuts off.
- The prestroke is the plunger travel from BOC position to the port closure (commencement of delivery).

To set the prestroke

- Move control rack to about 12 mm position and open vent screws of test injectors. Set the change-over valve of test bench to commencement of delivery position.
- In this position, oil supply is at about 45kgf cm. pressure, sufficient to keep delivery valves in open position.
- Rotate pump in proper directing with lever until the element plunger next to the drive end (No. 1 cylinder) is at BDC position.
- Fix prestroke measuring device so that the feeler rests on roller tappet of No. 1 cylinder.
- Set the dial indicator to 'O' Rotate pump in proper direction until the test oil just stops flowing through test injector swan neck pipe.
- Read the dial indicator.
- The value should be as specified for prestroke in the respective calibration chart.

- If not, adjust tappet screw. Set the pointer on the graduated drive to a position convenient for checking and adjusting other elements of the pump. Rotate pump camshaft further until No. 1 cylinder reaches TDC position. Set the dial indicator to 'O' again. Check the plunger clearance at TDC (tappet clearance) on the dial indicator by lifting the roller tappet with a screw driver. The clearance should be minimum 0.2 mm.
- Remove prestroke measuring device.
- 'Commencement of delivery of other elements should be adjusted according to the cam displacement angles starting from No. 1 cylinder. Rotate camshaft through 90 for 4 cylinder and 60 for 6 cylinder
- The plunger clearance at TDC (tappet clearance) should be checked individually immediately after setting the commencement of delivery. If it is less than 0.2mm,the particular tappet should be re-adjusted within permissible tolerances, if necessary, the setting of the No. 1 cylinder should-be re-done.

Adjusting the delivery quantity

- Set the change over valve of the test bench to delivery quantity test position and set the fuel gallery pressure to 1.0 kgf/cm^2.
- Set the control rack measuring device to the specified value and run the pump at the specified Adjust the control sleeve of the elements so as to obtain equal' specified delivery values.
- A final correction of the setting, in particular the spread in delivery, can be carried out while setting the full load quantity.

Spread in delivery

- The delivery from all the cylinders should be equal for basic setting. It should be ensured that the spread remains as small as possible for the other measurements as this is the yard stick to assess the serviceability of
- Elements and delivery valves. The maximum spread specified (0.3 or 0.4 CC for 100 strokes) is primarily applicable for elements and delivery valves which have been in service for some time.

EXERCISE 5.7: Overhauling and testing the fuel injector

Objectives

At the end of this exercise you shall be able to

- dismantle the injectors
- inspect and assemble injector
- testing injectors.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Injector cleaning kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.
- Injector testing machine - 1 No.
- Air compressor - 1 No.

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cleaning cloth - as reqd.
- injector - as reqd.

Procedure

TASK 1**: Dismantling (Fig 1)**

1 Remove overflow line of injectors.

2 Remove high pressure lines. Ensure that the pipes do not bend.

3 Remove injector clamp.

4 Remove the injectors from cylinder head

5 Plug the inlet (injector seating) and leak-off openings.

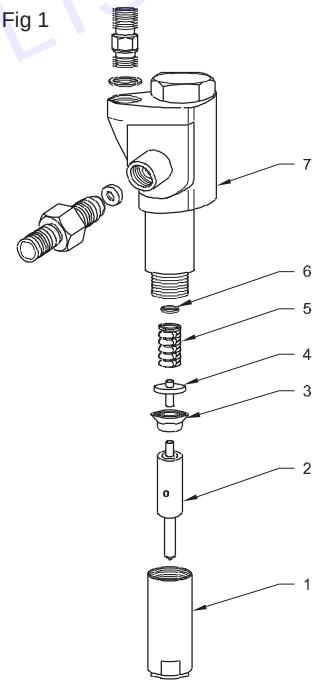
6 Clean the nozzle tip and wipe off the dirt from the injectors.

7 Hold the injector in inverted position.

8 Unscrew nozzle cap nut (1) and remove the cap nut (Fig 1).

9 Remove nozzle (2), intermediate washer (3), pressure bolt (4), spring (5) and shims (6).

Fig 1



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TASK 2: **Cleaning and inspection (Fig 1)**

1 Keep the components in the respective compartments of a standard work tray.

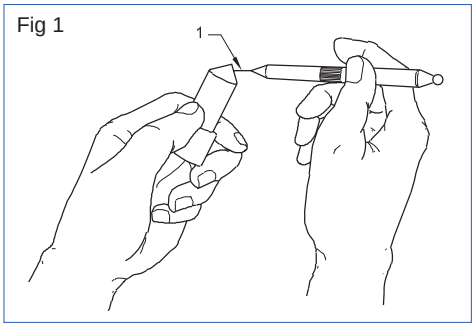
2 Rinse nozzle in clean diesel and withdraw nozzle needle from the nozzle body.

3 Inspect the nozzle needle for damage, roughness and wear.

4 Inspect the nozzle body (7) for damage.

5 Clean the nozzle either by blowing air or with a nozzle cleaning wire. Cleaning wire's (1) diameter should be smaller than spray hole's diameter. Ensure that while cleaning wire does not break inside the hole (Fig 1).

Fig 1



6 Rinse nozzle needle and nozzle with clean testing oil.

7 Hold the nozzle vertically, pull out nozzle needle to 1/3 of its engaged length and release the nozzle needle. Nozzle needle should slide down to its seat on its own weight when it is released.

8 If it does not slide, lap the needle and nozzle body with paste.

9 Clean carbon deposits from inner and outer surfaces of cap nut.

10 Inspect cap nut for any crack/damage.

11 Inspect spring for crack or any damage, replace if necessary.

12 Check spring tension on spring tester. Replace spring if necessary.

13 Dip the body and nozzle in clean oil.

14 Ensure that nozzle and nozzle needle are not interchanged.

15 Hold nozzle body in inverted position on a vice. Place shim, spring, pressure bolt, intermediate washer and nozzle with needle in nozzle body.

16 Tighten the nozzle cap nut by hand and centralise the nozzle. Then tighten nozzle cap nut at recommended torque.

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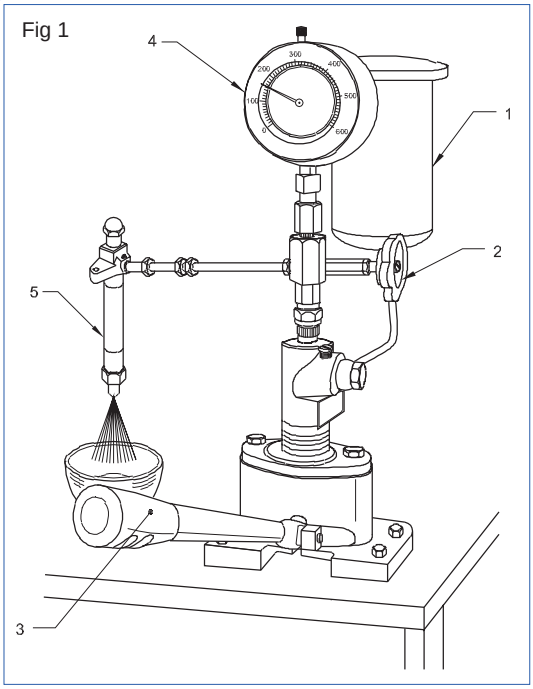
TASK 3: **Testing of injectors**

1 Fit injector (5) on injector tester (Fig 1).

Fig 1



2 Fill test oil in container (1).

3 Close shut-off valve knob (2).

4 Operate hand lever (3) as fast as possible and observe that test oil is sprayed through all spray holes of nozzle.

Caution: Do not put your hand underneath the injector being tested.

5 Open the shut off valve knob.

6 Operate hand lever and observe the maximum pressure from gauge (4) at which test oil sprays out of nozzle.

7 If this pressure does not match with manufacturer's recommendation, then adjust it with a shim/adjusting screw. Adding a shim/tightening the screw will increase pressure.

8 Observe that the test oil is sprayed from all the holes of nozzle. If not, then clean the nozzle hole.

9 Observe that the test oil does not dribble after spraying. If it does, then grind the nozzle needle.

10 Remove injector (5) from injector tester.

11 Fit injector on engine with new seating washer.

12 Connect high pressure pipe.

13 Connect over flow pipe.

— — — — —

EXERCISE 5.8: General maintenance of fuel injection pumps

Objectives

At the end of this exercise you shall be able to

- carry out maintenance of F.I.P.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.

Materials/Components

- Cleaning tray - as reqd.
- Cotton cloth - as reqd.
- Soap oil - as reqd.
- Bleeding screw - as reqd.
- Nut and bolts - as reqd.

Procedure

1 Check the F.I.P mounting bolt and tighten if necessary.

2 Check the F.I.P governor's lubrication oil if necessary top up.

3 Check the fuel line leakages if found leakage and rectify it.

4 Check the control rod movement if sticky and correct the rack rod - movement.

5 Check the fuel feed pump operation and pressure of fuel injection.

6 Check the high pressure line mounting and leakages.

7 Check the engine idle speed adjustment screw. If necessary, adjust it.

8 Check the F.I.P function during engine starting. If necessary, bleed the fuel line.

9 If struggling to start the engine after bleeding the fuel system, recommend to overhaul the F.I.P & injectors.

10 Lubricate the accelerator linkage and ensure the proper operation.

MODULE 6 : Engine Lubricating System

EXERCISE 6.1: Changing the engine oil

Objectives

At the end of this exercise you shall be able to

- drain the engine oil
- fill the engine oil to a specified level
- check the engine oil pressure at different r.p.m.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.

Materials/Components

- Tray - 1 No.
- Cotton waste/Banian cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil as prescribed by the manufacturer, Filter elements - as reqd.

Procedure

1 Start the engine and warm up till the operating temperature is achieved.

2 Stop the engine.

3 Unscrew the engine oil dipstick.

4 Check the level and condition of the oil (using a dip stick).

5 If engine oil colour changed into brown or black, sludge or contaminated change engine oil and filter.

6 Unscrew the pan drain plug and drain oil completely.

7 Change the oil filter in the bowl (Fig 1). Ensure that the washer and spring are fitted in correct position.

8 Check the drain plug gasket washer and replace it, if found damaged.

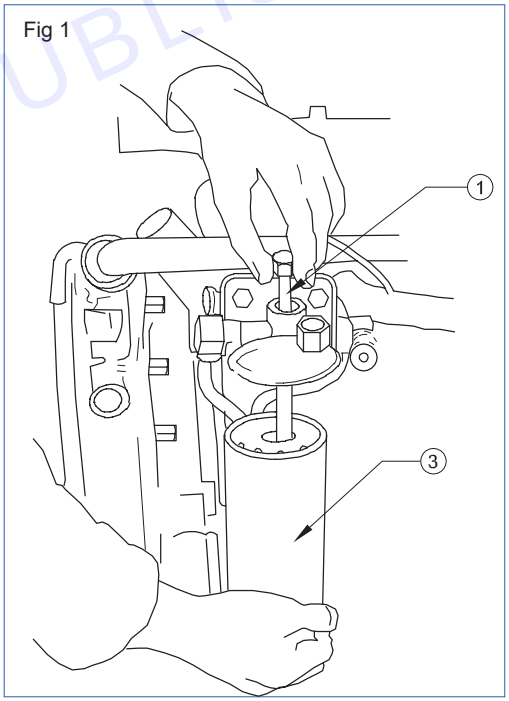
9 Refill the engine oil with the correct grade of oil, as recommended by the manufacturer.

10 While refilling, check the oil level by the dip stick till the oil level reaches the upto level mark.

11 Refit the oil filling cap.

12 Start the engine and warm up.

Fig 1



13 Check the oil leak through the drain plug and filter; if a leak is found, rectify the leakage.

14 Stop the engine and check the oil level with the dip stick. If required Top - up oil till the oil level reaches the maximum mark on the dip stick.

15 Start the engine and observe the oil pressure at the idling speed of 600 to 700 r.p.m., 1000 r.p.m., 1500 r.p.m. and 2500 r.p.m. Observe the engine speed with the help of a tachometer and note down all the readings and compare them with the manufacturer's specifications.

EXERCISE 6.2: Overhauling the oil pump, oil cooler, air cleaners and oil pressure relief valve

Objectives

At the end of this exercise you shall be able to

- dismantle the oil pump
- check the clearances and endplay
- assemble the oil pump
- service oil cooler
- adjust oil pressure relief valve.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Box spanner set - 1 Set
- Feeler gauge, Puller - 1 No.
- Straight edge - 1 No.

Equipments/Machines

- Multicylinder diesel engine - 1 No.

Materials/Components

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.
- Oil filter - as reqd.
- Air cleaner filter - as reqd.

Procedure

1 Remove the oil sump.
2 Remove the oil pump mounting bolts/nuts (1) (Fig 1).
3 Take out the oil pump (2) along with the strainer (3).
4 Remove the strainer assembly (3) from the pump.
5 Remove the oil pump end cover (4) (Fig 2).
6 Remove the pump cover packing (5).
7 Remove the idler gear (6) from the oil pump housing(7).
8 Remove the driving gear (9) with the shaft (8).
9 Press out the driving gear from the drive shaft.
10 Remove the woodruff key (10) from the driving shaft.
11 Remove the driving gear by using the puller.

Fig 1

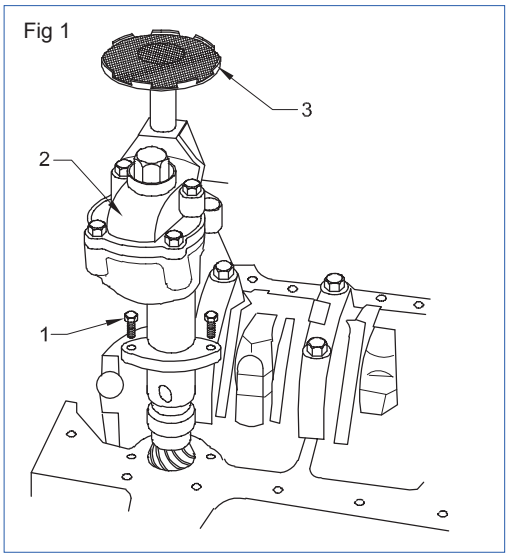
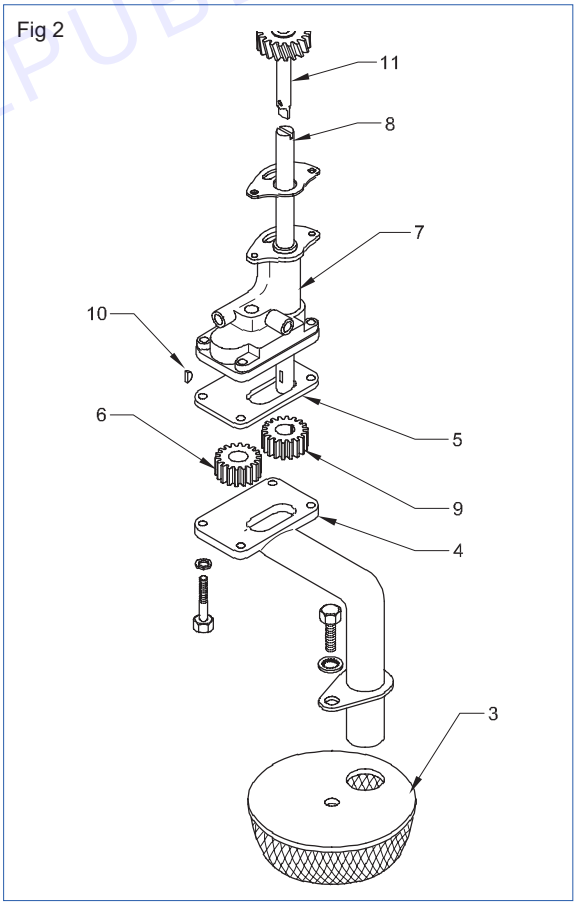


Fig 2



TASK 2: **Cleaning and Inspection**

1 Clean all the parts by kerosene oil.

2 Clean the suction pipe by compressed air.

3 Inspect visually the gears and shafts for pitting and damage.

4 Check visually the contact surface of the oil pump housing and cover for scoring marks.

5 Check the radial clearance between the oil pump housing (7) and gear teeth with a feeler gauge (10) (Fig 1).

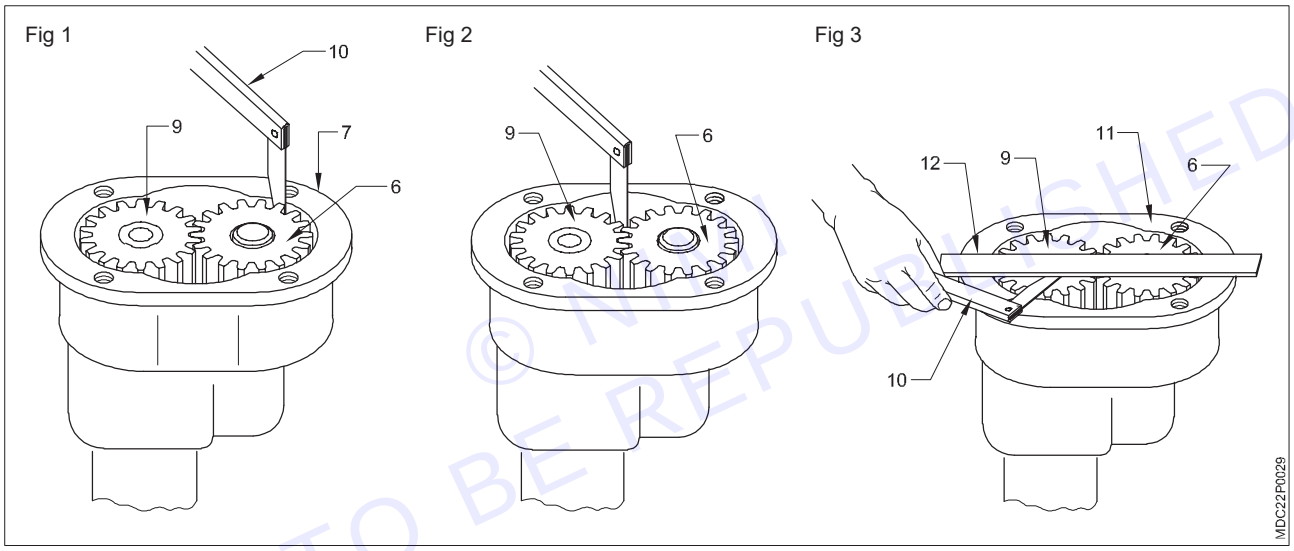
6 Check the backlash between the oil pump gears (9&6) with a feeler gauge (Fig 2).

7 Check the depth of the gears (6 & 9) from the oil pump housing surface (11) by using a straight edge (12) and feeler gauge (10) (Fig 3).

8 Check the condition of the strainer for damage and blockage and clean the blockage of strainer.

9 Check the suction pipe for cracks, damage and blockage and clean the blockage through air pressure.

10 If any damage/cracks in oil flow pipe and unions repair or replace it.



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TASK 3: **Assembling**

1 Fix the driving gear (9) on the driving shaft (8) with a new woodruff key by using a press.

2 Place the driving gear (9) with the shaft (8) in the pump housing (7).

3 Place the driven gear (6) on spindle in the pump housing.

4 Place the pump housing packing and align the holes.

5 Place the pump cover, align the holes and tighten the pump cover bolts.

6 Check for the free rotation of gears.

7 Fit the suction strainer (3).

8 Insert the oil pump into the crankcase.

9 Tighten the mounting bolts to the specified torque.

10 Install the oil sump with a new gasket.

11 Fill recommended oil in the sump up to the correct level.

12 Start the engine.

13 Note down the oil pressure at the various r.p.m. and compare them with the manufacturer's specification.

— — — — —

TASK 4: **Servicing of oil cooler**

1 Remove the oil cooler (1) from the engine block (2) (Fig 1).

2 Remove by pass valve (3) and spring (4).

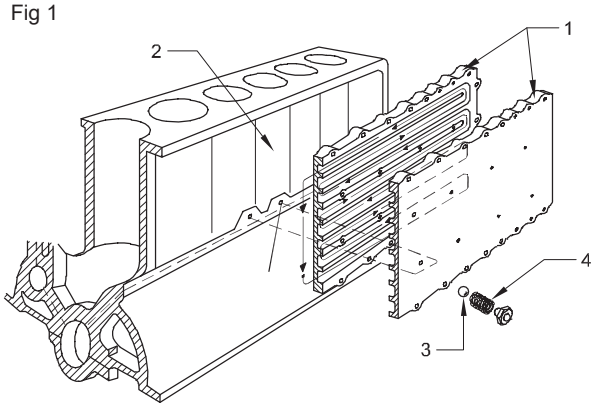
3 Clean the oil cooler with kerosene oil and compressed air.

4 Check oil cooler for crack.

5 Check the bypass valve ball (3). If necessary replace the bypass valve ball.

6 Check the bypass valve spring's (4) free length and tension. Replace the spring if necessary.

Fig 1



7 Fix gasket and washer in between oil cooler's halves, with the help of grease and fix the screws.

8 Fix gasket on the cylinder block (2).

9 Fit the oil cooler and tighten all the screws at recommended torque in correct sequence.

10 Fit the bypass valve ball, spring and tighten retaining nut with washer.

— — — — —

TASK 5: **Adjust oil pressure relief valve**

1 Remove the bypass valve (1) from the filter head.

2 Remove the oil pressure relief valve closing plug (5).

3 Remove the oil pressure relief valve (3) and pressure spring (4) (Fig 1 & 2).

Fig 1

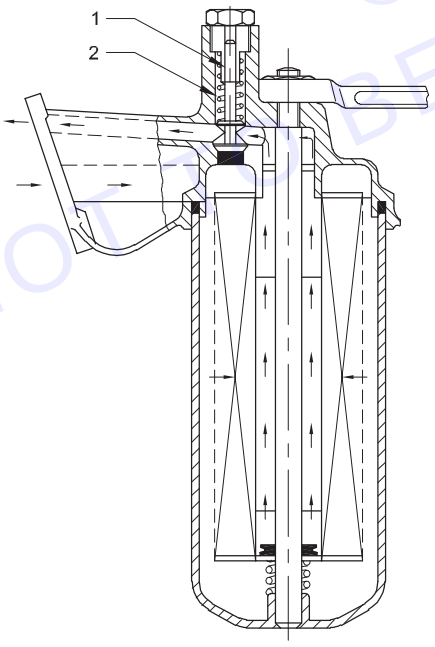
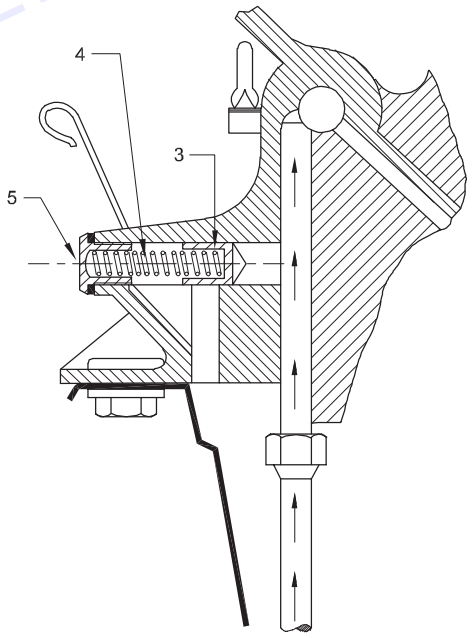


Fig 2



4 Check visually the oil pressure relief valve seating area of the crank case, for pitting.

5 Check the filter bypass valve spring for damage and tension.

6 Check the filter bypass valve seating area for pitting/ scoring.

7 Place the bypass valve in its seat on the filter head.

8 Place the spring over the bypass valve.

9 Tighten the bypass valve holder.

10 Place the oil pressure relief valve and spring in its seating in the crank case.

11 Tighten the pressure adjusting screw.

12 Tighten the closing plug.

13 Start the engine and warm up.

14 Check for leakage of oil from the filter edge, bypass valve, centre bolt and pipe connection.

15 Check the oil pressure on the oil pressure gauge.

16 Correct it if necessary by adjusting the relief valve spring tension. To increase the oil pressure, tighten the pressure adjusting screw and to decrease the oil pressure, loosen the adjusting screw.

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MODULE 7: Engine Cooling System

EXERCISE 7.1: Checking and replacing the radiator hoses

Objectives

At the end of this exercise you shall be able to

- check the radiator rubber hoses
- drain the coolant from the radiator
- replace the hoses and top up the coolant.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Tray - 1 No.

Equipments/Machines

- Running diesel engine - 1 No.

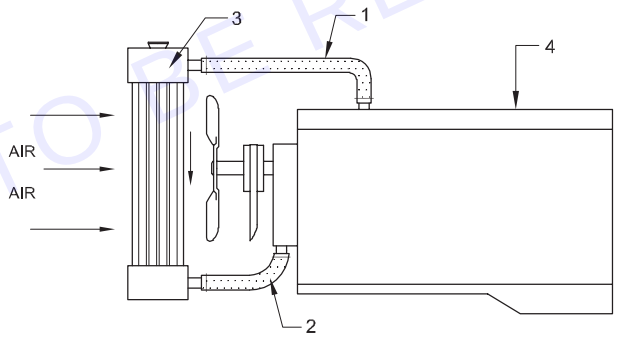
Materials

- Coolant - as reqd.
- Cotton cloth - as reqd.
- Radiator hose - as reqd.
- Hose clamp - as reqd.
- Grease - as reqd.
- Soap oil - as reqd.
- Funnel

Procedure

1 Locate the top and bottom hoses between the radiator and engine. (Fig 1)

Fig 1



2 Check swelling, cracking and leaking of the hoses.

3 Allow to cool the engine.

4 Keep a tray below the engine

5 Open the drain cock of radiator and drain water completley

6 Close the drain cock.

7 Remove all the clamps by using screw driver

8 Remove the top and bottom, of the hoses.

9 Clean the fittings spots with fine sand paper or emery cloth.

10 Check and compare the new hoses with removed hoses. (Make sure they are of correct length, diameter and shape)

11 Apply sealing compound inside of the new hoses.

12 Slide the new hoses into the position on the fittings with new clamps.

13 Tighten the clamps (6mm from the end of the hoses).

14 Refill the coolant in cooling system by using the funnel

15 Start and run the engine for few minutes.

16 Check the hose connections to make sure there is no leak.

17 Stop the engine and allow to cool

18 Open the radiator cap

19 Check the coolant level, top up if necessary.

EXERCISE 7.2: Testing the leakage in cooling system

Objectives

At the end of this exercise you shall be able to

- test the pressure of cooling system.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Cap pressure test kit - 1 No.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.

Materials

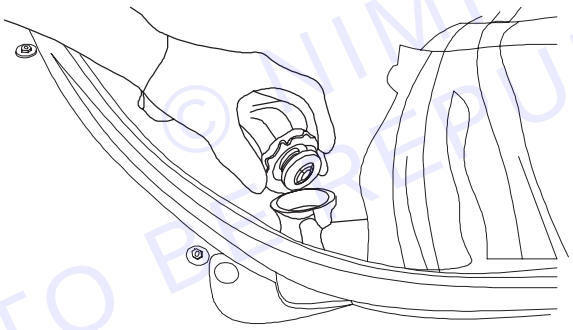
- Cotton cloth - as reqd.
- Pressure cap - as reqd.
- Coolant - as reqd.

Procedure

1 Remove the radiator cap

Before removing the radiator cap squeeze the upper radiator hose to check for pressure in the system. Determine no pressure inside, otherwise slowly remove (Fig 1)

Fig 1



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2 Make sure the radiator is full, and attach the pressure tester to the filler neck of the radiator (Fig 2).

3 Grasp the pressure tester and pump the plunger rapidly to build up pressure inside the system, like pumping air into a tyre. (Fig 3)

Fig 2

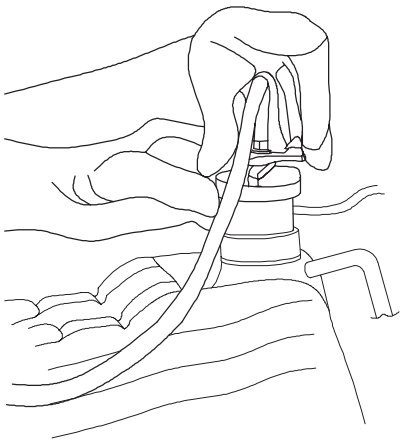
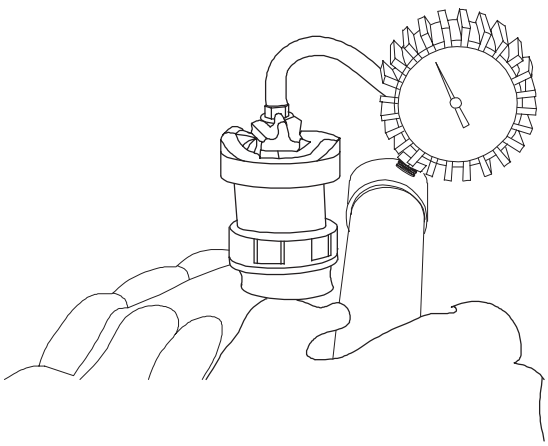


Fig 3



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4 Keep pumping the plunger until the pressure reads about 15 PSI; (avoid the excess pressure it will damage the system)

If the pressure gauge hold its value, the cooling system is likely free of leaks. If the pressure slowly drops, leak somewhere or the pressure tester may not be attached properly, recheck the tester connection. Listen out for the leaks or bubbling if escaping pressure and thoroughly go over the engine bay for any sign. If no sign leak is inside engine

5 This test is good for checking coolant leak from engine radiator or hose, blown head gasket, damage line bottom 'O' ring etc

6 Remove the pressure tester by twisting the connector lock after release pressure.

7 Clean and reinsert the tester back into its case and store in cool dry place.

EXERCISE 7.3: Overhauling of radiator and check the pressure cap

Objectives

At the end of this exercise you shall be able to

- check the radiator cap
- remove the radiator from the frame
- clean the radiator
- assemble the radiator
- adjust fan belt tension.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No
- Box spanner set - 1 Set.

Equipments/Machines

- Multi cylinder diesel engine - 1 No.
- Air compressor, Water washer - 1 No. each

Materials

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Coolant - as reqd.
- Pressure cap - 1 No
- Thermostat - 1 No
- Radiator - 1 No

Procedure

TASK 1: **Dismantling**

1 Remove the radiator cap (1).

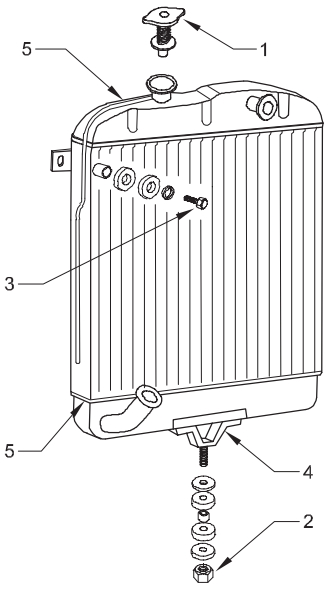
2 Place a suitable container below the radiator and unscrew the drain cock of radiator and drain the water from the radiator.

3 Open the drain plug at the cylinder block and drain the water from the cylinder block.

4 Disconnect the top and bottom water hoses.

5 Remove the nuts (2) securing the radiator to the mounting bracket (4) on the frame.

Fig 1



6 Remove the stay bolt (3) at the radiator end.

7 Remove the bracket if provided.

8 Remove the radiator. Place it vertically with proper support so that it does not fall. Ensure that the radiator cores do not touch the support (Fig 1).

9 Unscrew and remove the thermostat housing

10 Remove the thermostat valve and place it in a tray.

— — — — —

TASK 2 : **Cleaning and inspection**

1 Check the radiator pressure cap (1) and its valve mechanism for movement, pressing it by hand.

2 Check visually the radiator core for damage, clogging and leakage.

3 Check the mounting straps on the tanks of the radiator for tightness.

4 Check the soldered joints (5) of the top and bottom tanks as well as the filler neck.

5 Check visually the radiator mounting brackets for cracks, damage etc. Repair/replace the damaged parts.

6 Check visually the stay rod end for damage. Replace the damaged parts.

7 Clean the thermostat valve

8 Check the thermostat valve, if it is defective, replace it.

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TASK 3 : **Assembling**

1 Assemble the mounting bracket to the radiator, if provided.

2 Mount the radiator on the frame aligning the top and bottom hose connections.

3 Fix the radiator stay bracket.

4 Tighten the radiator mounting and stay bracket with the help of a suitable ring spanner.

5 Fix the thermostat valve and pressure cap

6 Connect the water hoses-top and bottom. Tighten hose clips.

7 Fix the drain plug in the cylinder block and close the radiator drain tap and fill the radiator with a coolant. Start and keep the engine running for approx. one minute at high speed. Check the water level in the radiator. Fill it again, if required.

8 Start the engine and check for leaks. Rectify if there is any leak. Replace water hose if they are found leaky.

Check the radiator pressure cap

- Carefully touch the radiator hose and feel its hot.

Do not attempt to remove the radiator cap if engine is hot.

- Pushing down first and then twist it counter - clock wise (Fig 1) take the cap adapter from the radiator neck (Fig 2)
- (Radiator cap hold pressure between 6 to16-PSI)

Attach the pressure tester to the filer neck of the radiator.

- Pump the pressure tester handle until the pressure builds to the specification written on the radiator cap

Note: The radiator cap should be able to hold the max pressure for up to five minutes. This take little bit of judgement on your part. Identify the gauge should reach atleast 15 PSI.

(If the pressure cap is not functioning correctly, then the gauge will start to drop)

- Clean any sediment or debris off the pressure cap.
- Retest the cap, ensure the leak was not due to blockages
- If damage is found in radiator pressure cap valve or valve spring, replace it.

Note: Too much pressure in the system can result damage

Fig 1

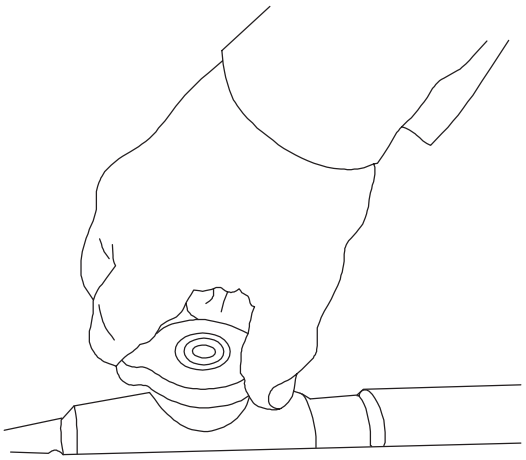
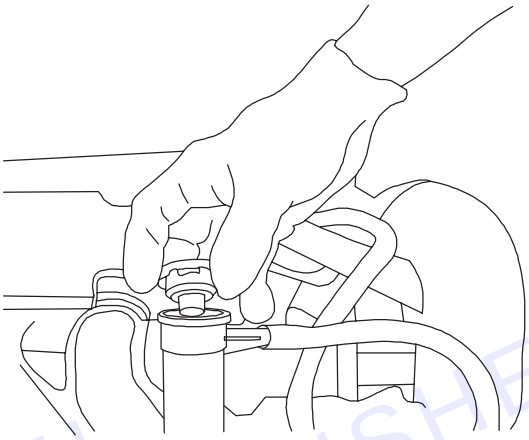


Fig 2



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EXERCISE 7.4: Testing the Thermostat valve

Objectives

At the end of this exercise you shall be able to

- remove the thermostat valve
- inspect and test the thermostat valve
- refit and test the thermostat valve.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Water jar - 1 No.
- Thermometer - 1 No.
- Heater

Equipments/Machines

- Work bench - 1 No.

Materials

- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Coolant - as reqd.
- Gasket - as reqd.
- Thermostat valve - 1 No.

Procedure

Inspection (Thermostat valve)

1 Remove the thermostat cover from the thermostat case.

2 Remove the thermostat valve.

3 Clean the thermostat valve cap, and valve seat.

4 Tie the thermostat valve's collar with a thread.

5 Immerse the thermostat valve in water. Ensure that the thermostat valve (1) is fully merged in the water but does not touch the walls or the base of the jar.

6 Heat up the water (Fig 1).

7 Note down the temperature of the water in the thermometer (2) at which the thermostat starts to open.

8 Note down the temperature at which the thermostat opens fully.

Fig 1

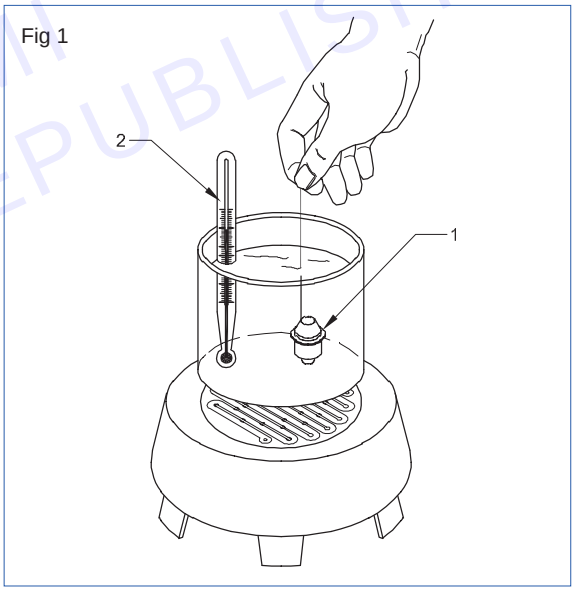
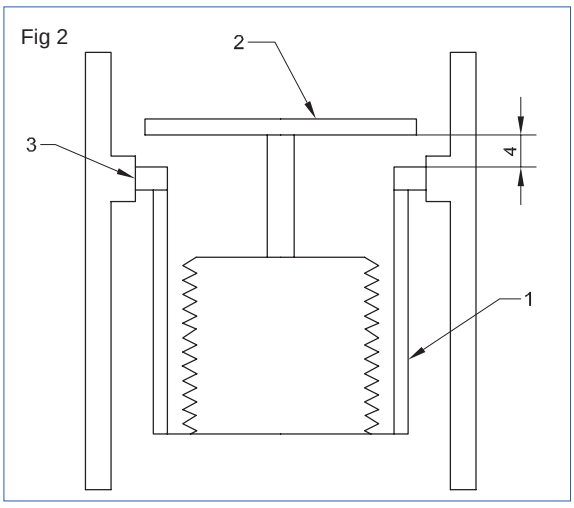


Fig 2



9 Remove the thermostat valve (1) from the water and measure the gap between the thermostat collar (2) and the shroud (3). (Fig 2)

10 Compare the thermostat's opening temperature, thermostat's opening (4) and the temperature at which the thermostat opens completely, with the specifications given by the manufacturer. If any of these three observations do not match with the manufacturers specifications, then replace the thermostat (Fig 2).

11 Fit the thermostat in the thermostat case.

12 Fit the thermostat cover in the thermostat case.

EXERCISE 7.5: Practice on reverse flushing radiator

Objectives

At the end of this exercise you shall be able to

- clean and reverse flush the radiator.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Box spanner set - 1 Set.

Equipments/Machines

- Multi cylinder diesel engine
- Air compressor, water washer - 1 No.

Materials

- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Coolant - as reqd.
- Radiator hose and clamp - as reqd.

Procedure

1 Remove the radiator upper and lower hose

2 Attach a drain hose pipe (6) at the top of the radiator.

3 Attach a new piece of hose (7) to the radiator outlet at the bottom.

4 Insert a flushing water and air gun in the mouth of the hose pipe at the radiator outlet (Fig 1).

5 Connect the water hose of the flushing gun to a water line and the air hose to an air line.

6 Start the water line and fill up the radiator.

7 When the radiator is full of water, switch on the airline and blow air in short blasts. Fill water into radiator again and blow air in short blasts again.

8 Continue the flushing operation until the water runs clear through the top hose.

9 Plug the outlet at the bottom of the radiator.

10 Fit the radiator filler cap.

11 Remove the drain cock. Connect a long air hose to the radiator at the drain cock hole.

12 Submerge the radiator in a water tank with the air hose above the water level.

13 Admit air at 1 to 1.5 kg/ cm2 pressure into the air hose and check for signs of leakages.

14 Repair the leaky spots.

15 Repeat the air pressure test for check radiator leaks, ensure there is no leakages in the radiator assembly.

EXERCISE 7.6: Overhauling the water pump

Objectives

At the end of this exercise you shall be able to

- dismantle the water pump
- inspect the parts of a water pump
- assemble the water pump.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Box spanner set - 1 Set
- Puller, Circlip pliers - 1 No each

Equipments/Machines

- Multi cylinder diesel engine

Materials

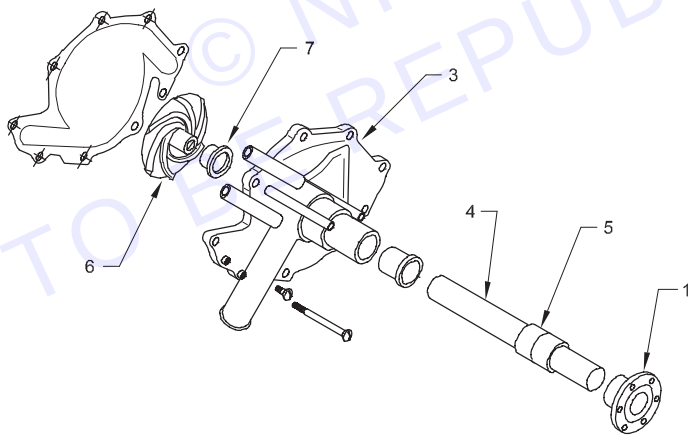
- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Coolant - as reqd.
- Grease - as reqd.

Procedure

TASK 1: **Dismantling**

1 Lock the water pump's pulley hub (1) (Fig 1).

Fig 1



2 Remove the water pump pulley hub nut(8) (Fig 2).

3 Remove the water pump pulley hub. Use a puller.

4 Remove the water pump rear cover, if provided.

5 Unscrew the oil seal holder and remove the oil seal shims and gasket.

6 Place the water pump housing (3) on support and press out the water pump shaft (4) with the bearing assembly (5) from the impeller (6).

7 Remove the inner oil seal (7) from the housing.

8 Place the water pump shaft on the tube, supporting the inner bearing's inner race, with the shaft's taper end facing upward.

9 Fix the nut on the threaded end of the shaft to protect the shaft's threads from damage.

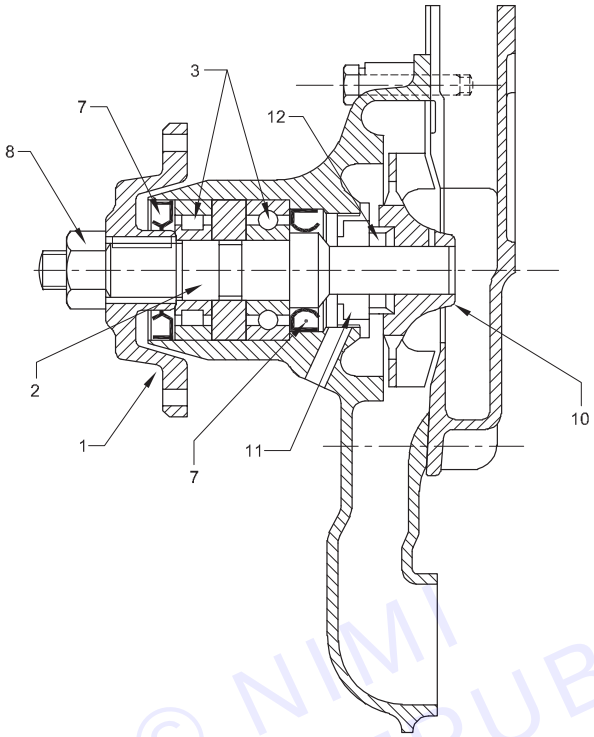
10 Press/tap the shaft till the bearing comes out of its seat, from the water pump shaft.

11 Remove the outer race of the bearing from the housing with the help of a drift and hammer.

12 Remove the insert (12) with its rubber sleeve from the impeller (10).

13 Remove the water seal (11) from the water pump housing.

Fig 2



TASK 2: **Inspection**

Inspect the following parts visually for any crack/damage.

1 Water pump shaft

2 Bearing

3 Water seal

4 Impeller

5 Water pump housing

6 Check the water pump shaft for bend

7 Hoses and engine drive belt

TASK 3: **Assembling**

1 Press the bearings on the water pump shaft.

2 Press the water pump pulley hub on the shaft.

3 Fit the oil seal in the water pump housing; use a drift.

4 Fit the water seal in the water pump housing; use a drift.

5 Press the shaft assembly in the pump housing.

6 Invert the water pump housing and press the impeller on the water pump shaft.

7 Rotate the water pump shaft and check that the impeller does not touch the water pump housing. If the impeller touches the water pump housing, replace it.

8 Fit the rear cover with a new gasket.

9 Check the water pump shaft for free rotation.

10 Fix the water pump pulley and fan

11 Ensure the tightness of fan and water pump pulley.

— — — — —

TASK 4 : **Refitting and testing**

1 Apply grease on both side of the pump gasket.

2 Fix the gasket between water pump and engine.

3 Fix the water pump mounting bolts and ensure the specified tightness of mountings.

4 Connect the fan belt and radiator hoses.

5 Fill the coolant in the radiator.

6 Start the engine and check noise from the water pump.

7 Ensure no noise and leaks from the water pump.

— — — — —

EXERCISE 8.1: Diagnosis of Battery Trouble in Vehicle

Objectives

At the end of this exercise you shall be able to

- diagnose the battery fault occurred in the vehicle
- remove the battery from vehicle

Requirements

Tools/ Instruments

- Open end spanner (10,11) - 1 No.
- Ring spanner (10,11) - 1 No.
- Combination plier - 1 No.
- Screw driver - 1 No.

Equipments/Machines

- A light motor vehicle in running condition

Materials

- Waste cloth - as reqd.
- Sterile gloves - as reqd.
- Vehicle remote battery - as reqd.

Procedure

1 Operate the vehicle remote key to unlock the vehicle door

2 Observe the beep sound and indication light response

Note: If beep sound and Indication light is not responded, the vehicle battery or remote key battery is down. Try again after replacing the remote key battery still problem persist vehicle battery is down.

3 Open the vehicle door

4 Apply the parking brake

5 Check the neutral position of gear shift lever. If not put in neutral position

6 Turn the ignition key `ON'

7 Observe the dashboard cluster power `ON'

Note: Cluster does not get power battery is dead

8 Observe the battery charging indicator light `ON'

9 Put the head lights `ON' with main beam.

10 Check the head light brightness. If head light brightness is dull, battery may be down.

11 Start the vehicle, if it is not started but slow cranking happens, battery may be down. While starting head lights gets `off and then come back again, the battery charge is less. A rapid clicking (almost like a machine gun sound) from the starter means there's not enough power to engage it as well.

12 Switch off headlights. Open the bonnet cover.

13 Check the battery cable loose connection. If it is loose, tighten it properly.

14 Turn the headlights on for 2 minutes with the vehicle off. Turn off the headlights again after 2 minutes.

15 Connect the digital multi meter positive and negative test leads to battery terminals respectively. Set DC 20 V mode in Digital multi meter, Note down the voltage whether it is showing 12.6 V or not. If it is less, crank the engine and note down the voltage. If it is less than 10 V battery charge is less or Battery weak.

16 Watch the multi meter for 15 to 20 seconds to ensure the reading goes up to 14V Check the battery charging indicator light in the cluster goes off after starting.

Note: If battery charging indicator light still on after starting, the battery is not getting charge from the charging system.

17 Turn on the headlights with the multi meter connected and car running. The voltage reading should still be higher than 12.6 in order to sustain the battery.

Note: If the vehicle can't sustain the increased load of additional things like headlights, the battery will need to be replaced.

18 Check the battery casing temperature, if it is too hot the battery is defective. It is to be replaced.

19 Switch off the headlights.

20 Turn off the Ignition key.

21 Remove the mounting clamp nuts.

22 Remove the battery negative terminal clamp connected to the battery.

23 Remove the positive terminal clamp connected to the battery.

24 Remove the battery from vehicle to check the battery charging condition.

EXERCISE 8.2: Check Battery Condition

Objectives

At the end of this exercise you shall be able to

- clean the battery terminals and body of the batteries
- top up the battery electrolyte level
- test the battery specific gravity with a hydrometer
- test the battery with a volt meter.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Hydrometer - 1 No.
- Digital multimeter - 1 No.
- Battery tester - 1 No.
- 12v lead acid battery - 1 No.
- Temperature Gauge/thermometer - 1 No.

Equipments/Machines

- Air compressor - 1 No.
- Cotton rag -as reqd.
- Distilled water -as reqd.
- water emery -as reqd.
- Vaseline -as reqd.
- sodium bicarbonate -as reqd.
- Bristle brush -1 No.
- sterile gloves -1 Pair
- safety goggles -1 No.

Procedure

TASK 1 : **Cleaning and top up of lead acid battery**

1 Clean the battery casing using cotton cloth.

2 Apply a solution of baking soda and water over the battery casing.

3 Use a stiff bristle with brush and clean the dirty particles.

Note: Be sure the solution cannot enter the battery cells. Do not clean the battery top surface keeping the vent plugs open.

4 Rinse the battery with clean water.

5 Wipe the battery casing with dry cloth and remove the wetness.

6 Un screw all the went plugs and check the level of the electrolyte.

Note: Do not use open flame to check the electrolyte level.

7 Top up the electrolyte to the marked level up to max level in all the cells with distilled water.

Note:

- **If marking levels are not provided in the battery top up the electrolyte minimum 10mm over the plates.**
- **No acid should be used to top up the electrolyte.**
- **Do not over fill the electrolyte**

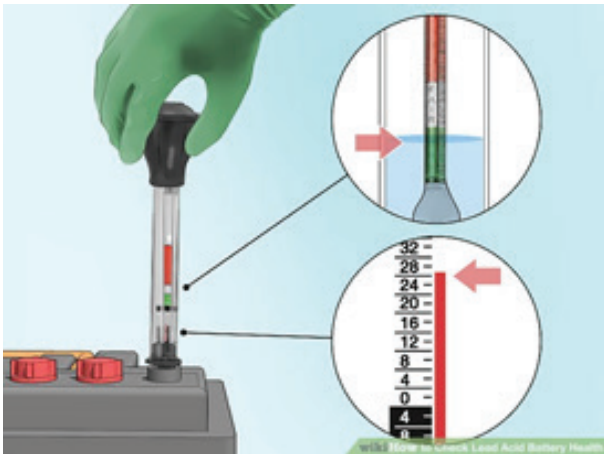
— — — — —

TASK 2: **Battery specific gravity test using hydrometer**

1 Keep the battery on a levelled wooden work bench

2 Remove all the vent plugs

3 Hold the hydrometer vertically



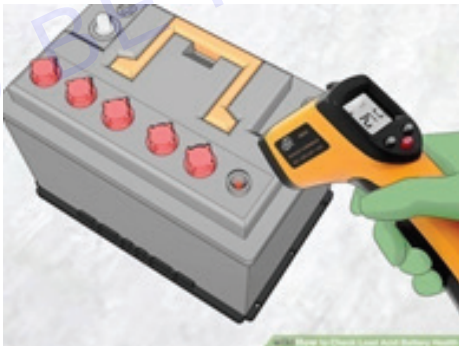
4 Place the nose of the hydrometer in the cell. Ensure that the nose is dipped in the electrolyte

5 Press the rubber bulb of the hydrometer

6 Release bulb to draw the electrolyte upwards

7 Ensure that the electrolyte does not come into the bulb.

8 Record the reading in the tables .Measure the temperature of the battery electrolyte and make temperature correction of reading by adding or subtracting 4 points(.004) for each 10◦F (-10◦c) above or below the standard of 80◦ F(26.7◦C)



Cell No. 1	Cell No. 2	Cell No. 3	Cell No. 4	Cell No. 5	Cell No. 6	Remarks

Note:

1 The cell readings should not vary more than 50 point between cells.

2 Protect your hand, eyes and cloth from the battery acid spills.

9 Recharge the battery if specific gravity drops below an average of 1.230.

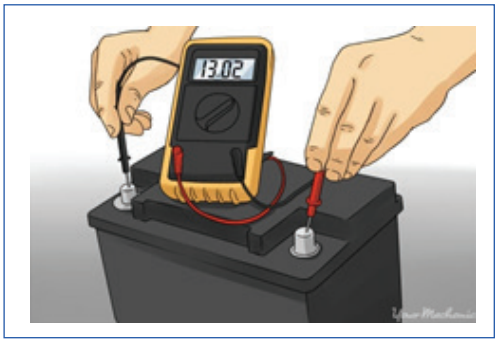
— — — — —

TASK 3: **Test the battery by open volt test using volt meter**

1 Set the Digital voltmeter in DC 12 volt mode.

2 Connect the leads of multimeter to battery positive (+ve) and negative (-ve) terminal.

3 Take the reading from the multi meter and record it.



Note: The voltage of fully charged battery should be 13.2 volts. if a battery goes below 12.2V, it means it is 50% charged. If it goes below 11.9V, it is considered"discharged". Recharge the battery if necessary .

4 Check the voltage of battery after recharging.

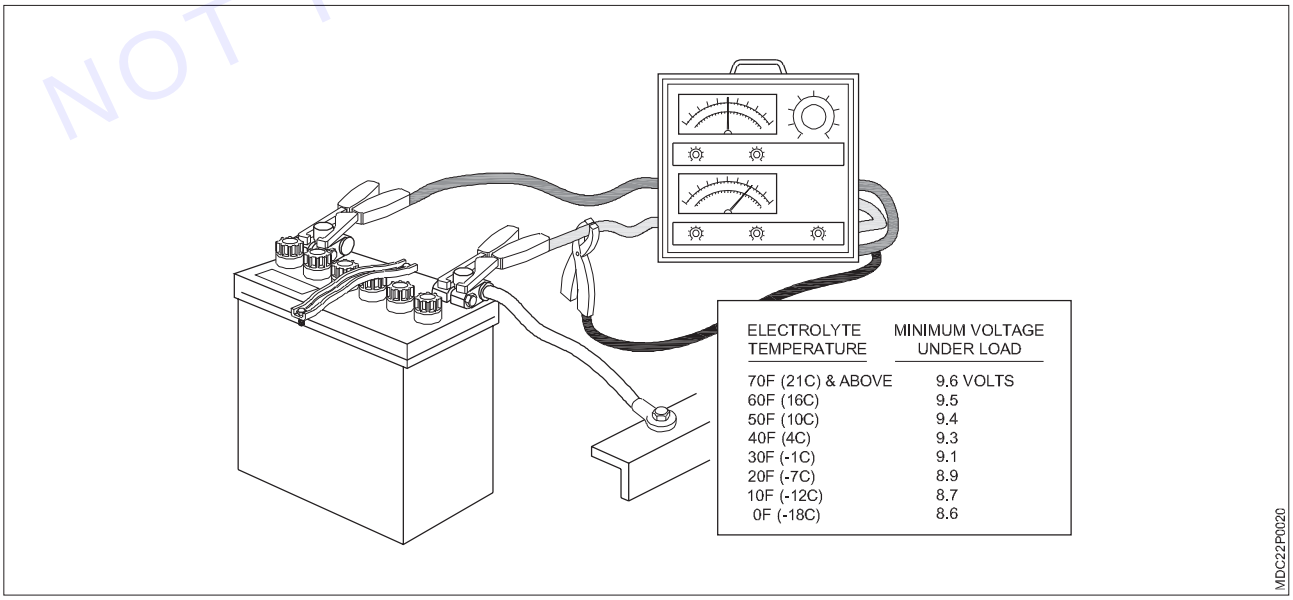
Note: While checking of battery voltage after recharging the surface charge must be removed before checking.

— — — — —

TASK 4: **Test the battery using battery tester**

1 Use an infrared temperature gauge to measure the temperature on the side of the battery and check that it is within the test parameters.

Note: The battery electrolyte should be at room temperature, between 21°C and 27°C. A cold battery shows a significantly lower capacity. Never test a sealed battery if its temperature is below 15°C. A load test is performed only on a fully charged battery.



2 Connect the red clip to the plus pole of the battery and the black to the minus pole.

3 Connect the inductive pickup surrounds all of the wires from the battery negative terminal.

4 Note down the battery ampere hour rating and CCA rating from the battery label.

5 Load the battery by Turning the load control knob until the ammeter shows three times the Ampere hour rating or one –half of its CCA rating.

6 Maintain the load for maximum 15 seconds.

7 Note the voltmeter reading. If reading shows 9.6Volts or more battery is good,9.5V or less the battery is defective and needs replacement.

8 Disconnect the load tester.

EXERCISE 8.3: Charge the battery

Objectives

At the end of this exercise you shall be able to

- connect the battery to charger
- charge battery by constant current method
- charge battery by constant volt method.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Hydrometer - 1 No.
- Voltmeter - 1 No.

Equipments/Machines

- Battery charger - 1 No.
- Light Motor Vehicle - 1 No.

Materials

- Vaseline - as reqd.
- Battery acid - as reqd.
- Battery Cable/Wire with crocodile clips - as reqd.
- Distilled water - as reqd.
- Cotton rag - as reqd.
- Water emery - as reqd

Procedure

TASK 1: **Battery charging**

1 Place the battery on the charging table

2 If the battery is not sealed, check the electrolyte level in all of the cells and adjust the level if necessary.

Do not attempt to charge a battery that appears to be frozen or if ice crystals are visible in the electrolyte. Allow the battery to become unfrozen fully before charging is attempted.

3 If the battery is sealed battery, check the built in hydrometer. Do not attempt to charge the battery if the indicator appears clear or light yellow. (Fig 1)

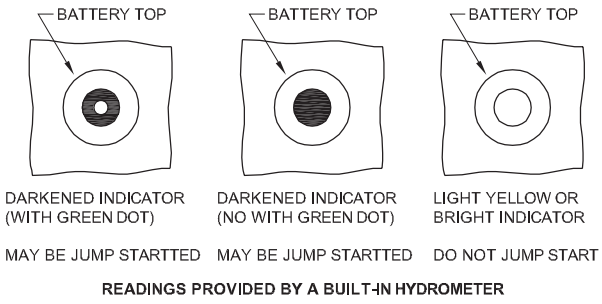
4 Clean the battery terminals and the battery top

5 Consult an appropriate manual and determine the charging rate and time for the battery.

6 Turn off the charger switch. (Fig 2 & Fig 3). Connect the charger leads to the battery. The positive (+)lead must be connected to the positive(+) terminal. The negative (-) lead must be connected to negative (-)terminal.

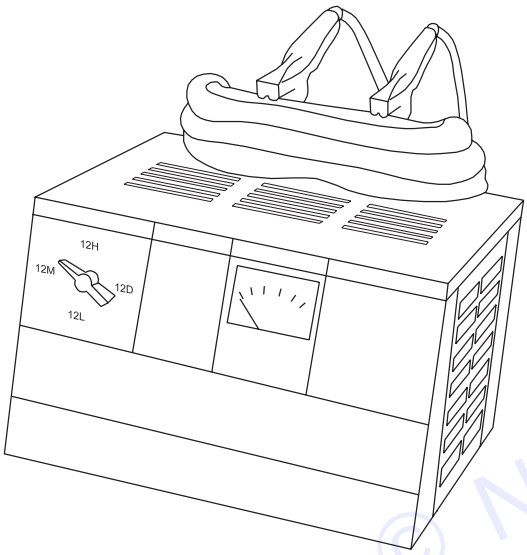
7 Turn on the charger switch

Fig 1



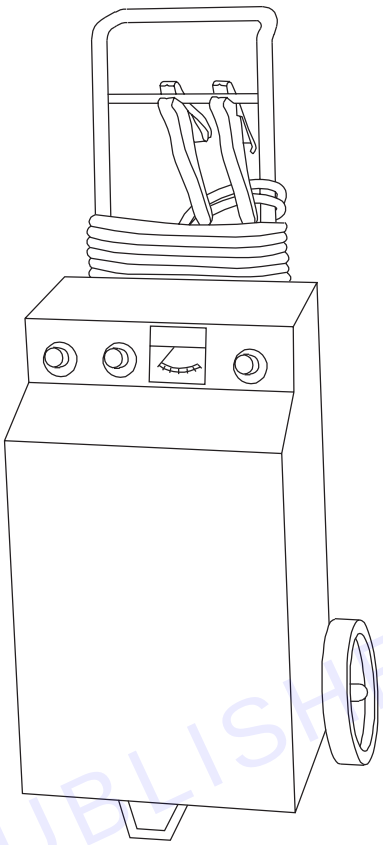
READINGS PROVIDED BY A BUILT-IN HYDROMETER

Fig 2



A TYPICAL SLOW CHARGER

Fig 3



A TYPICAL FAST CHARGER

MDC22P0021

On some chargers, the timer must be set to turn on the charger.

8 Adjust the charging rate.

9 Adjust the timer.

10 Check the charging rate and the battery temperature after the battery has been charging for about 15 minutes. Adjust the charging rate if required

11 Continue charging until the allotted time or until the battery is fully charged.

12 Turn off the charger switch. Disconnect the charger leads from the battery

Watt rating	5Amperes	10Amperes	20Amperes	30Amperes	40Amperes	50Amperes
Below2450	10Hours	5Hours	2½Hours	2Hours	-	-
2450-2950	12Hours	6Hours	3Hours	2Hours	1½Hours	-
Above2950	15Hours	7½Hours	3¼Hours	2Hours	1¾Hours	1½Hours

Note: To avoid damage, charging rate must be reduced or temporarily halted if:

Electrolyte temperature exceeds125F.

Violent gassing or spewing of electrolyte occurs.

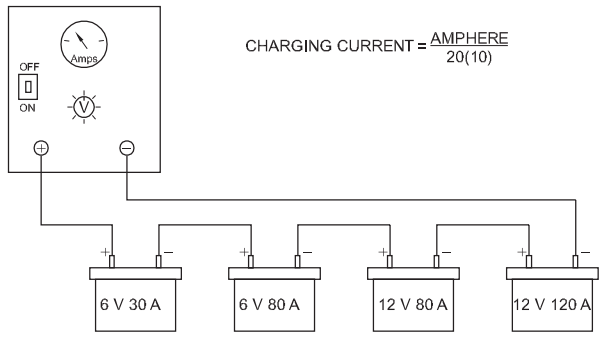
Battery is fully charged when over at which our period at a low charging rate in amperes all cells are gassing freely and no change in specific gravity occurs. For the most sat is factory charging, the lower charging rates in amperes are recommended.

Full charge specific gravity is 1.260-1.280 corrected for temperature with electrolyte level at split ring.

TASK 2: **Constant current method**

1 Connect all the batteries in series as shown in Fig 1.

Fig 1



2 Connect the charger to batteries.

3 Set the voltage rate in charger according to no. of batteries.

4 Charge the battery.

5 Switch off the battery charger

6 Test the specific gravity of each battery cell.

7 Record the reading inTable.1

Table 1

Battery	Cell No.					
S. No.	1	2	3	4	5	6
1						
2						
3						
4						

TASK 3: **Constant Voltage method (Fig 1)**

1 Connect all the batteries in parallel as shown in Fig 1

2 Connect the charger to batteries.

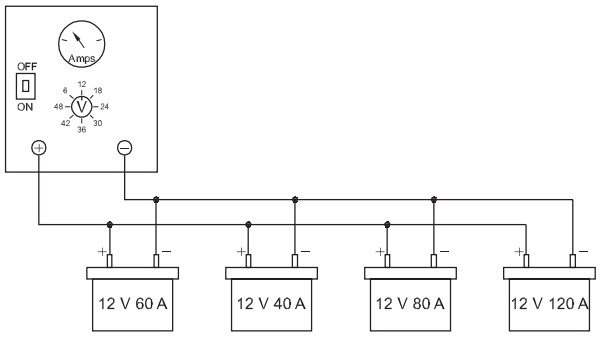
3 Set the current rate by varying the voltage to be charged.

4 Charge the battery till full charging

5 Switch off the battery charger

6 Record the reading.

Fig 1



CONSTANT VOLTAGE METHOD

MDC22P0023

EXERCISE 8.4: Service and maintenance of battery

Objectives

At the end of this exercise you shall be able to

- perform visual inspection battery
- cleaning and top up battery electrolyte level
- service the battery
- perform maintenance of battery.

Requirements

Tools/ Instruments

- Trainee's tool kit - 1 No.
- blow lamp, Digital multimeter - 1 No.
- Voltmeter - 1 No.
- Scraper - 1 No.
- Steel die for positive terminal & negative terminal, - 1 No. each
- Ladle - 1 No.
- Hand file - 1 No.
- Battery terminal clamp puller - 1 No.
- Weighing scale range of 10 kg - 1 No.

Materials

- Emery sheet fine - as reqd.
- Cotton cloth - as reqd.
- Baking soda - as reqd.
- Bristle wire brush - 1 No.
- Rubber gloves - 1 Set
- Safety goggles lead alloy - as reqd.
- Distilled water - as reqd.
- Sulphuric acid - as reqd.
- Cleaning detergent or solvent - as reqd.
- Glass jars - 3 Nos.

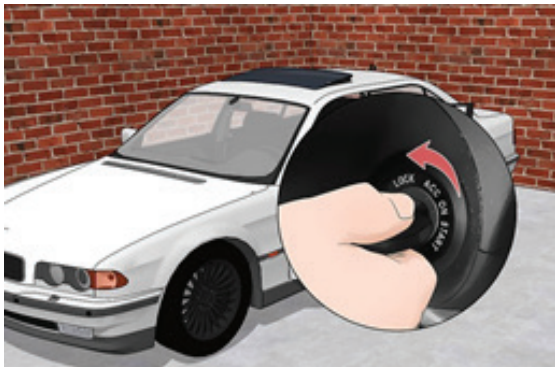
Equipments/Machines

- A Light Motor Vehicle fitted with 12V lead Acid Battery

Procedure

1 Park the vehicle on plain ground.

2 Turn the Ignition key off.



3 Apply hand brake.

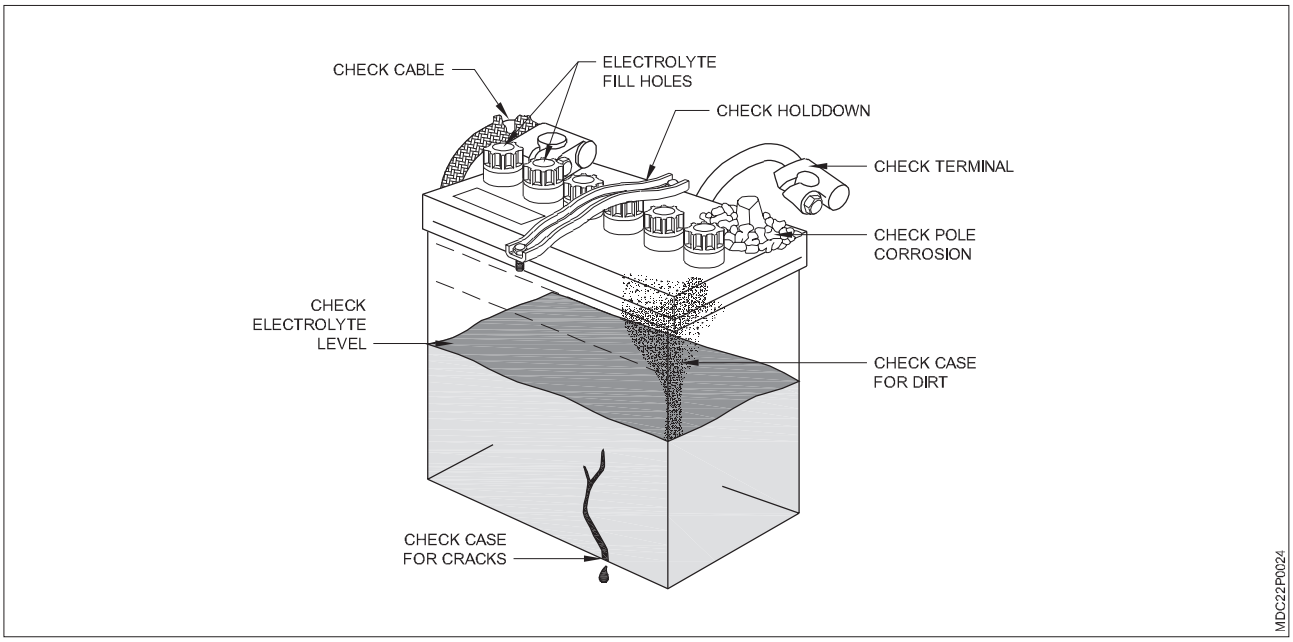
4 Open bonnet and fix the stay rod in position.

5 Inspect the battery visually.

6 Check the battery casing whether it is having any cracks, electrolyte leakage, and bulging of battery.

Note: If so replace battery

7 Check for cracked or broken cable or connection, replace if it is necessary.



8 Check for corrosion on terminals and dirt or acid on the case top.

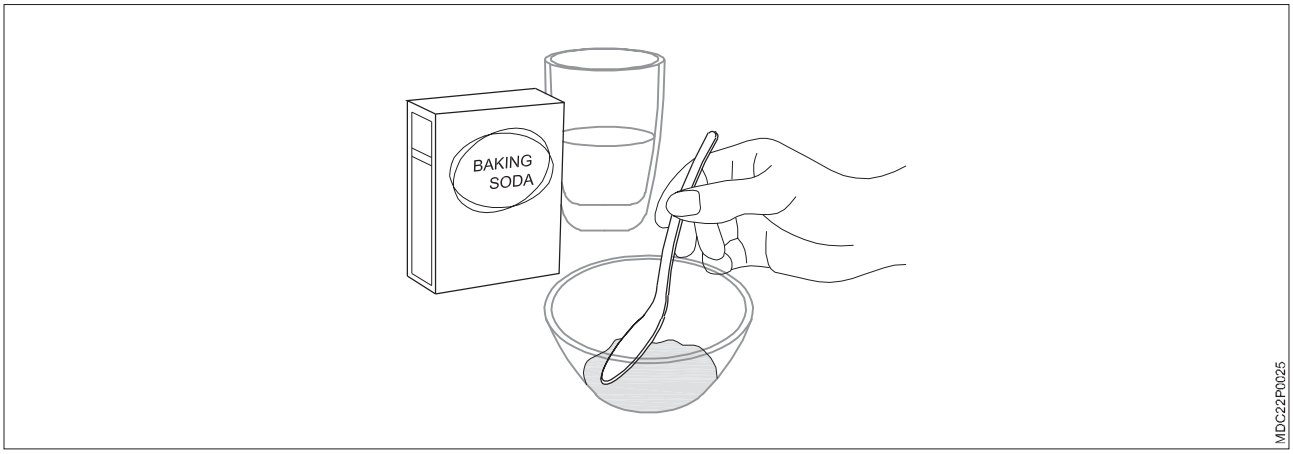
9 Clean the battery casing top using cotton cloth. Wipe off any acid spillage

Perform battery leakage test multimeter in low DC volt range. Connect the multimeter negative to negative post of battery. Touch the positive probe on battery casing top, sides of battery and move across it. If any voltage is measured, current is leaking out of the battery.

10 Replace the battery if needed.

11 Mix 1 cup (240 mL) of water with 1 teaspoon (4.6 g) of baking soda .

12 Apply a solution of baking soda and water. This acts as a base to neutralise the acid.



13 Scrub the baking soda mixture into the terminals and clean the corroded/sulphate deposits on the terminals using wire brush

Note:

Do not splash the corrosion on to vehicle`s parts, metal or rubber parts or onto your hands and face

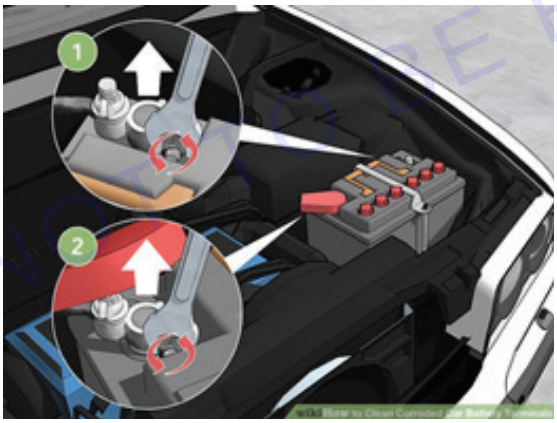
Ensure the solution cannot enter the battery cells.

14 Clean the dirt and grease with a detergent solution or solvent

15 Rinse the battery and cable connections with clean water

16 Dry the components with a clean cloth

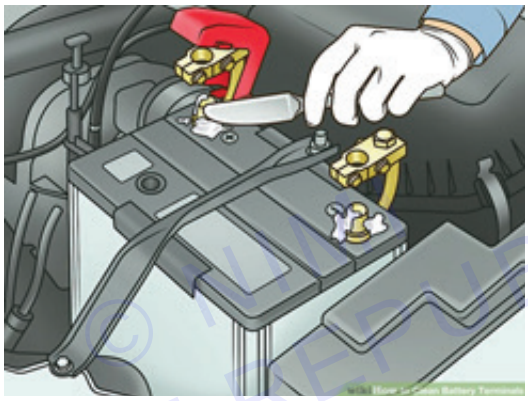
17 Remove the battery connector after loosing the bolt. If the connector does not lift easily use the battery terminal clamp puller.



18 Neutralize any remaining corrosion by dipping the connector in backing soda.

19 Clean inside the connector and battery terminal post using wine brush.

20 Clean the heavy deposits using scraper.



21 Clean with water and dry it.

22 Check the positive and negative post of battery.

Note: If it is badly corroded and its diameter is reduced lead posting is to be done.

Reconditioning of terminal post

1 File the battery terminal post and remove the burns. Make it into the round shape.

2 Clean the terminal post with emery sheet and clean with a rag.

3 Use proper size steel dies for positive and negative terminal post and place over it.

4 Take required amount of lead alloy material in a ladle.

5 Heat the ladle and melt the lead alloy into molten state.

6 Pour the molten lead alloy into the terminal post steel dies.

7 Allow some time for cooling the lead alloy.

8 Remove the steel dies form terminal posts.

23 Check the status at charging of the battery using magic eye if fitted.

Note: If green colour is shown battery is charged, white means check for recharge, Red mean Add distilled water or replace the battery.

24 Remove the vent plugs.

25 Check the electrolyte level and top up the electrolyte upto `max' level with distilled water.

Note: Never add Acid.

Never use open flame to check the electrolyte level.

If the electrolyte Level is critically low, Don`t top up. Replace with new electrolyte.

Preparation of electrolyte

1 Take a glass jar.

2 Fill the sulphuring acid with specific gravity of 1.835.

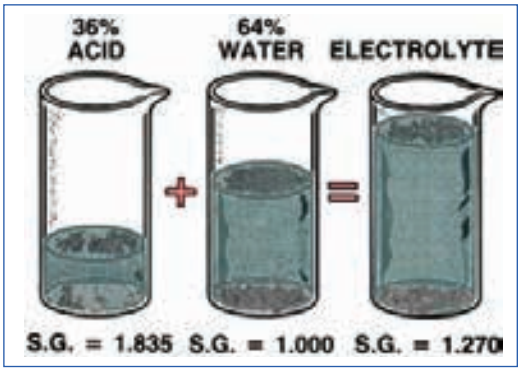
3 Place the acid jar on weighing scale and adjust the level of acid upto the weight of 36% of electrolyte quantity has to be prepared.

4 Take another glass jar and fill with distilled water.

5 Put in the weighing scale and adjust to the weight of 64% of electrolyte quantity has to be prepared.

6 Pour the acid slowly in the distilled water jar and make in to the specific gravity of 1.270.

Note: Never pour distilled water on the acid jar.

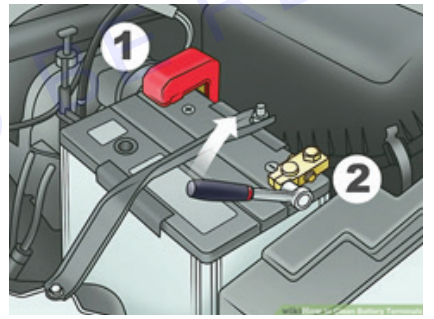


26 Re fix the vent plug and keep the vent holes free from dust deposition.

27 Mount the battery rigidly. It should not be over tightened or loose.

28 Apply petroleum jelly on the terminals.

29 Connect the battery terminal clamp and it should be properly tightened.



30 Run the engine everyday minimum 10 minutes to keep the battery always in charge,

Note:

1 Do not crank the starter motor longer than 5 seconds at a time and a longer rest. Period of 10 seconds between each crank.

2 Battery is not used for long period, remove charge the battery every two weeks. Interval and keep it in dark cold place avoiding direct sunlight.

31 Check the parasitic drain of the battery.

Checking of parasitic battery drain

1 Connect a fully charged battery in vehicle.

2 Switch off all electrical devices in the vehicle.

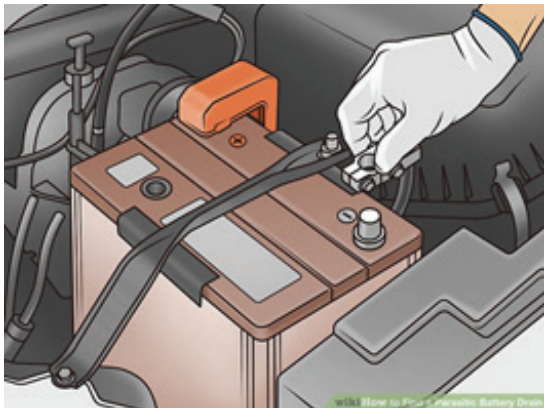
3 Apply emergency brake.

4 Turn the vehicle Ignition key off and remove the ignition key

5 Close all the doors trunk 30 that none of the circuit are activated

6 Ensure GPS, and phone changer un pugged.

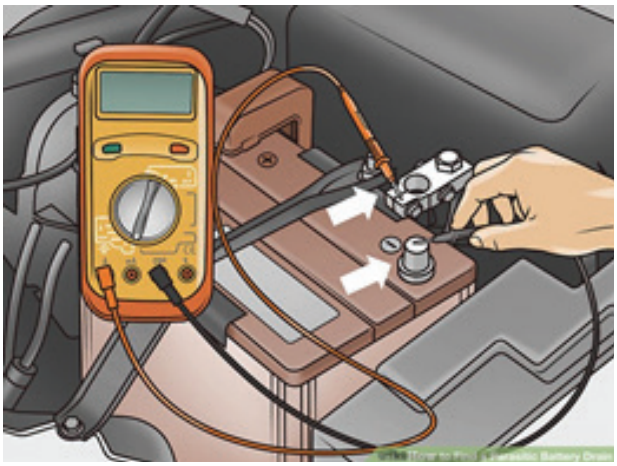
7 Remove the negative battery cable from the negative battery terminal



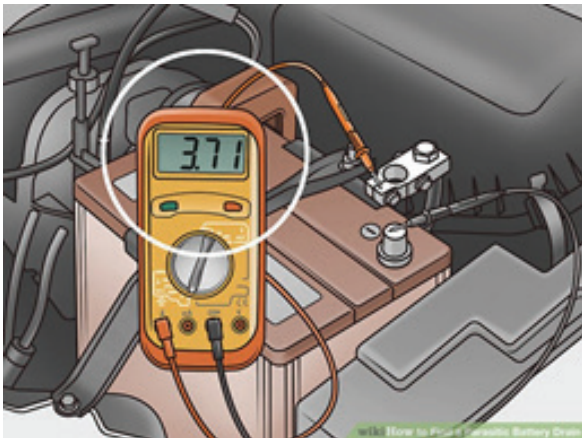
8 Set up a digital multi meter so that negative probe (black colour) connected in common ground and positive probe (red colour) in the amps socket.

9 Put the selection switch on the multi meter DC Amps mode

10 Connect the multi meter to the negative battery cable and negative terminal of battery in series



11 Note down the multi meter reading. If the reading shows in between 20-50 milliamps, it is normal

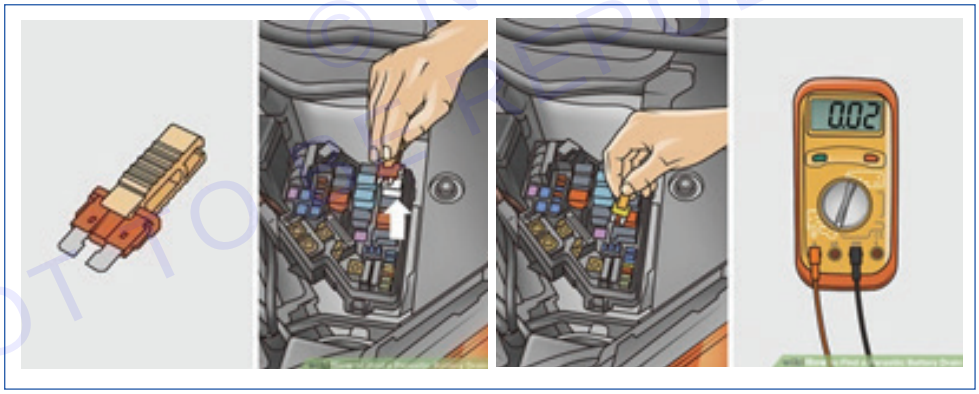


Note: If the parasitic drain is more than the specified limit. Check the trunk glove box and interior lights to see if they are `ON'.

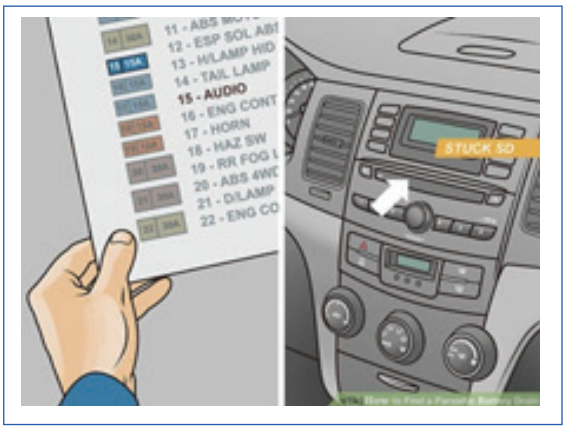
12 Observe whether any light is `ON'. Remove the bulb and note the battery drain. If the drain is now OK, check that circuit.

Check the electrical circuits

13 Pull out the fuses one at a time while watching the multi meter reading. The reading will drop when the fuse on the bad circuit is removed



14 Test the components of that circuit to identify the cause of the drain.



15 Replace the fuse if needed. Disconnect the multi meter.

16 Reconnect the battery negative clamp to the battery terminal post.

EXERCISE 8.5: Practice on jump starting of a battery

Objectives

At the end of this exercise you shall be able to

- perform jump starting of a vehicle.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machines

- A light motor vehicle with full charged 12v battery - 1 No
- A light motor vehicle with discharged 12V battery - 1 No

Materials

- Waste cotton - as reqd.
- Cloth - as reqd.
- Jumper cables
- Positive & negative -1 set
- Safety goggle -1 pair
- Apron -1 No,
- Plastic sheet - 2 No

Procedure

Servicing fuel tank and remounting of fuel tank

1 Park the vehicle to be started on level ground and apply hand brake

2 Open the bonnet and secure with the holding lever

3 Park the full charged battery vehicle close to the hood of battery down vehicle so that jumper cables easily will reach both batteries and apply hand brake.

4 Open the bonnet of booster vehicle and secure with the holding lever

5 Remove the ignition key and turn of all electrical accessories on the both vehicles

6 Connect the jumper cable clamp of the positive jumper cable (Red colour) to the positive terminal on the weak battery

7 Connect the clamp at the end of the positive jumper cable to the positive terminal on the booster battery

8 Connect the jumper cable to the negative terminal (black colour) jumper cable to the negative terminal on the booster battery

9 Connect the clamp at the other end of the negative jumper cable to the ground on the week battery vehicle away from the battery.

Note:

1 **Do not attach negative jumper cable to the battery negative terminal clamp of weak battery because spark may happen which could ignite any hydrogen gas collected rear the top of the battery.**

2 **Ensure that jumper cables should not touch any other parts.**

3 **Always wear safety goggles for eye protection.**

4 **Ensure jumper cables connection positive to positive, negative to negative in parallel connection.**

5 **Put some carpet or plastic sheet cover over the batteries to avoid any damage due to battery bursting on boost starting**.

10 Start the booster vehicle and run at a medium speed for about 05 minutes.

11 Start the engine of the dead battery vehicle. Run at idle speed.

Note:

If the engine still does not start the battery should be replaced.

12 Allow both vehicle engine to run for about 5 minutes.

13 Disconnect the negative jumper cable clamp grounded on the vehicle being jump started at first and then disconnect the negative jumper cable clamp from the booster vehicle.

14 Disconnect the positive jumper cable from the booster vehicle and then from the jumper started vehicle.

15 Close the bonnet in both vehicle.

16 Switch off the booster vehicle.

17 Run the jump started vehicle till the battery is fully charged at least 20 minutes.

MODULE 9: Starting System

EXERCISE 9.1: Check the starting system

Objectives

At the end of this exercise you shall be able to

- check the starting system
- use a jumper start a vehicle.

Requirements

Tools/Instruments

- Trainees tool kit - 1Set
- Test lamp - 1No.
- Multi Meter - 1No.

Equipments/Machines

- Running Vehicle - 1No.

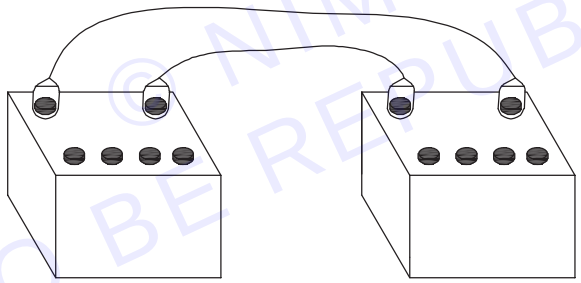
Materials

- Cotton waste - as reqd.
- Emery sheet - as reqd.
- Auto wire with crocodile - as reqd.
- Battery - as reqd.
- Jumper cable - as reqd.
- Insulation tape - as reqd.

Procedure

Check the starting system of the vehicle (Fig 1)

Fig 1



1 Place the vehicle on surface floor.
2 Use wooden choke for front and rear wheels.
3 Check the battery terminal connections for sulfur deposit.
4 If sulfuris deposited on battery terminals, remove the terminals and clean it with hot water.
5 Clean the battery post and cable connectivity by use the emery sheet.
6 Connect the battery terminals and ensure the proper tightness.
7 Check the battery charge condition with help of hydro meter and volt meter.
8 Check the starter motor battery cable connection sand mountings.
9 Switch on the ignition on key.
10 Turn on the glow plug and ensure the combustion chamber warmed up by glow plug light glow off.
11 Turn on the self starter switch and carefully watch the pinion contact with engine flywheel ring gear.
12 Check the fly wheel rotation if fly wheel turning speed is slow that means battery low charge.
13 Take one full charge battery with jumper cable.
14 Place battery and connect by use of jumper cable in parallel connections to the vehicle battery.
15 Check the battery voltage by use of voltmeter.
16 Turn on the starter motor switch and start the engine and check the battery charging system.
17 Disconnect the jumper cables and spare battery.

EXERCISE 9.2: Overhaul the starting motor over running clutch

Objectives

At the end of this exercise you shall be able to

- remove the starter motor
- dismantle the starter motor
- test magnetic switch
- test the armature and commutator
- check continuity of field coils
- check overrunning clutch
- check end cover's shaft bushes
- assemble starter motor
- test the starter motor for performance
- fit the starter motor on the engine.

Requirements

Tools/Instruments

- Trainees toolkit - 1 Set
- Box spanner - 1 No.
- Multimeter - 1 No.
- Growler - 1 No.
- V Block - 1 No.
- Dial test indicator with Magnetic base - 1 No.
- Vernier caliper - 1 No.
- Tap set - 1 No.
- Battery with terminal - 1 No.
- Spring tension tester - 1 No.

Equipments/Machines

- Vehicle - 1 No.

Materials

- Emery paper - as reqd.
- Hacksaw blade - 1 No.
- Knife - 1 No.
- Grease - as reqd.
- Bush bearing - 1 Set
- Magnetic switch - 1 Set
- Circlip - 1 Set
- Battery cable with crocodile clip - 1 Set
- Copper brushers - 1 Set

Procedure

TASK 1: **Remove the starter motor**

1 Disconnect the negative(-) lead at the battery.

2 Disconnect the magnetic switch lead wires and the battery cable from the starting motor terminals.

3 Remove the two mounting bolts.

4 Remove the starter motor.

5 Remove the magnetic switch assembly (Fig 1)

6 Remove the cable terminal nut and disconnect the lead wires from the magnetic switch.

7 Remove the two mounting nuts and then take out the magnetic switch by slight tilting as shown. (Fig 2).

Fig 1

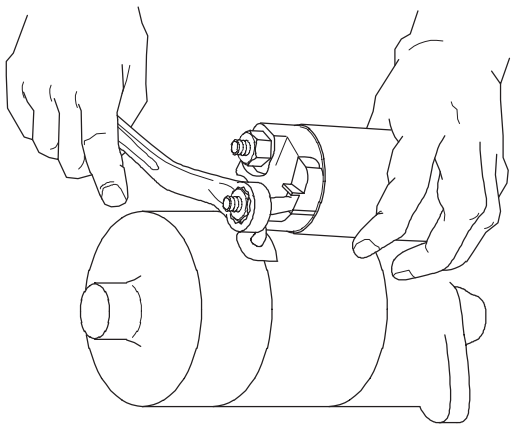
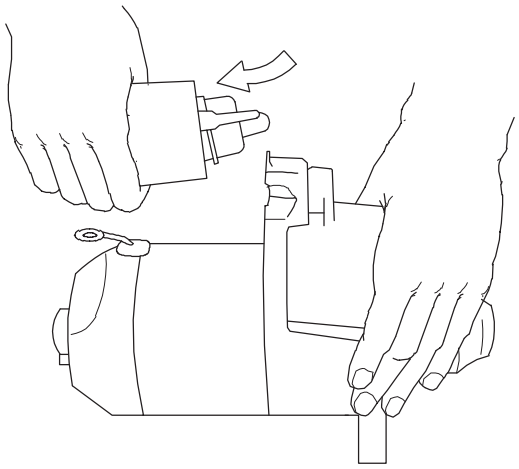


Fig 2



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TASK 2: **Dismantle the starter motor**

1 Remove the through bolts.

2 Take off the commutator end housing (2) (Fig 1)

3 Remove the brush holder cover from the brush holder.

4 Take out the brush springs and brush.

5 Remove the yoke assembly.

6 Remove the armature (2) along with the pinion drive lever(1).(Fig 2)

Fig 1

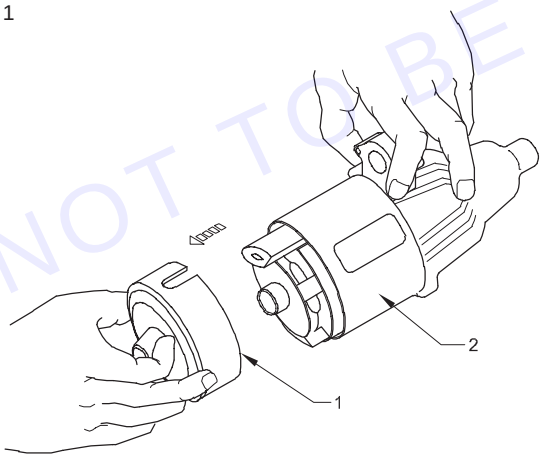
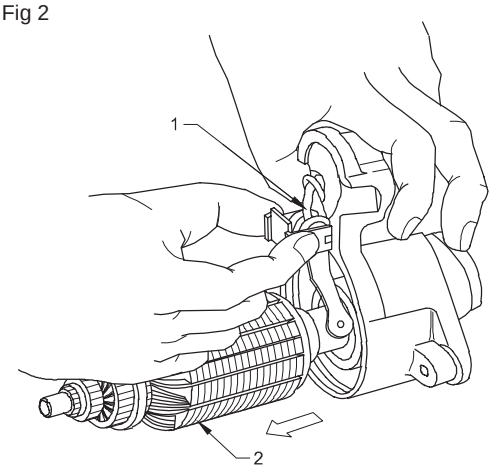


Fig 2



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7 Insert the screwdriver tip in the gap between the two stop collars (1) and (2). (Fig 3)

8 Push the front collar (1) outward.

9 Using a 14mm socket (3) push the rear stop collar (2) downwards.(Fig 4)

10 Remove the armature snap ring (4)by using a snap ring plier, and with the help of a screw driver.(Fig 5)

11 Pull out the rear pinion stop collar (2),and over-running clutch (5). (Fig 5)

Fig 3

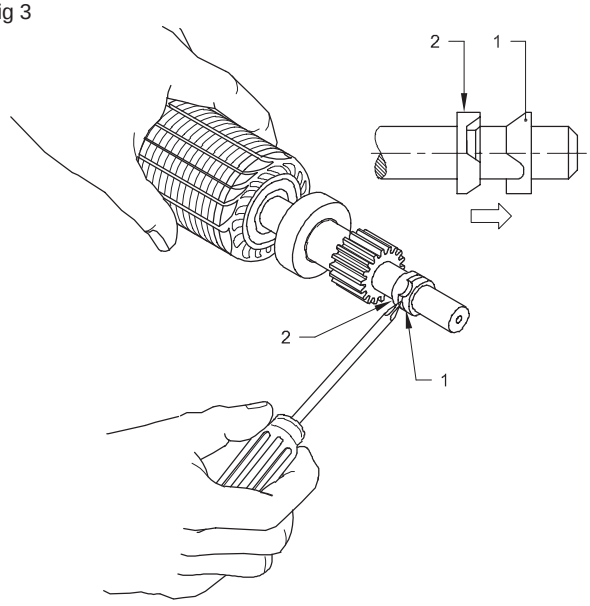

Fig 4

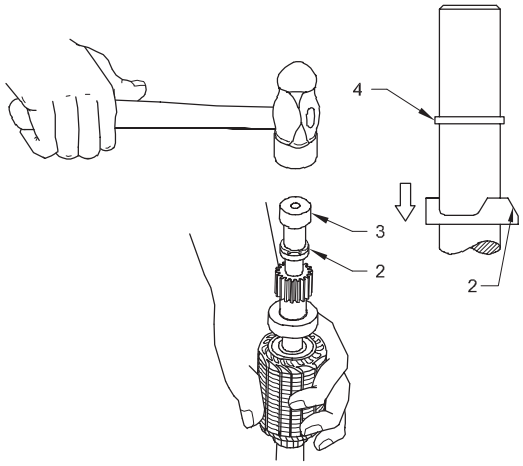

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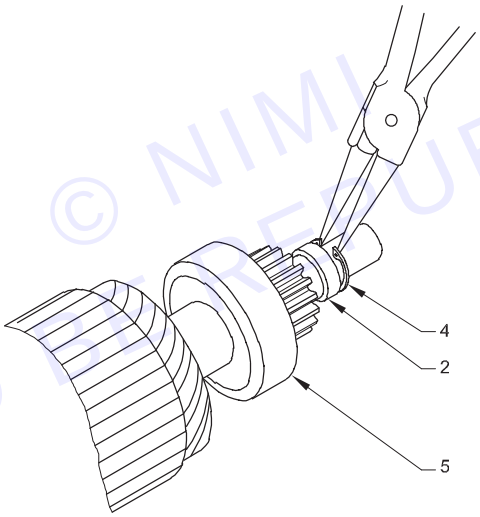
Fig 5



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TASK 3: **Test magnetic switch**

1 Inspect the magnetic switch boot (2) for breakage. (Fig 1)

2 Inspect the plunger (1) for wear or damage. Replace if necessary. (Fig 1)

3 Push the plunger (1) in and release it. The plunger should return quickly to its original position. Replace if necessary. (Fig 2)

4 Check for continuity across the magnetic switch terminals (1) and coil case (2).If no continuity exists, the coil is open and should be replaced.(Fig 3)

5 Check for continuity across magnetic switch terminal and terminals (3). If no continuity exists, the coil is open and should be replaced. (Fig 3)

Fig 1

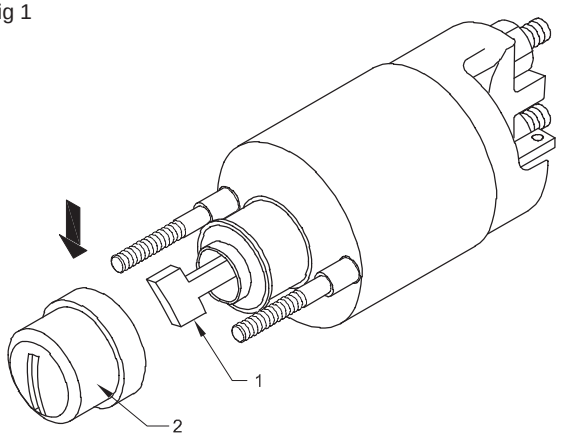


Fig 2

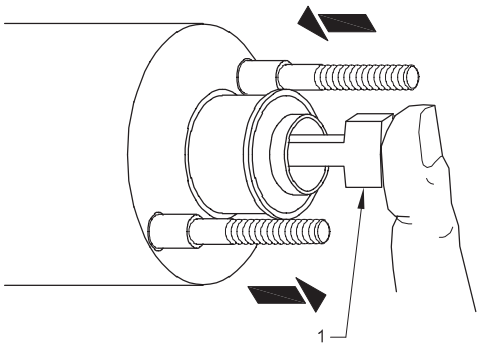
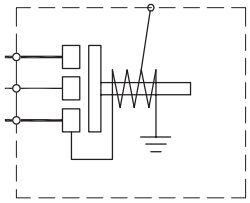
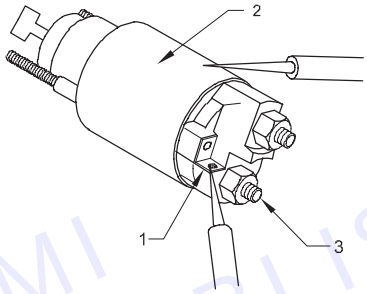


Fig 3





TASK 4: **Test the armature and commutator**

1 Test armature for ground (Fig 1)

2 Using an ohmmeter test for continuity between the commutator (2) and armature core (1).The ohmmeter will indicate infinite resistance if the insulation is in sound condition.

3 Test for open circuit (Fig 2)

Fig 1

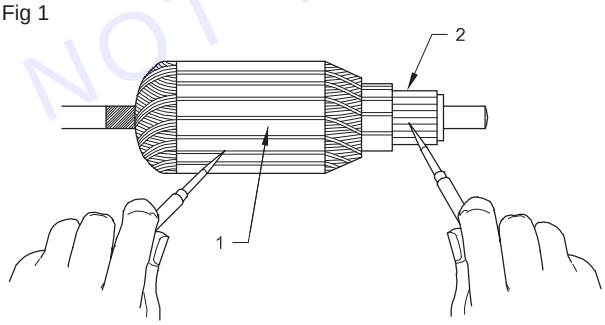
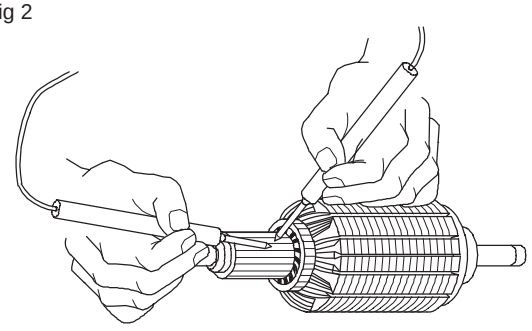


Fig 2



4 Check for continuity between each pair of adjacent commutator segments, using an ohmmeter.

5 If there is any discontinuity the ohmmeter needle will not deflect. Replace the armature assembly.

6 Check commutator run out (Fig 3)

7 Place the armature between two 'V' blocks.

8 Using a dial gauge check the commutator for run out by slowly rotating it by hand.

9 Correct it on lathe if required.

10 Check commutator diameter

11 Check for wear and replace the armature if the diameter is below limit. (Fig 4)

12 Clean the commutator surface by using 400 emery cloth.

Fig 3

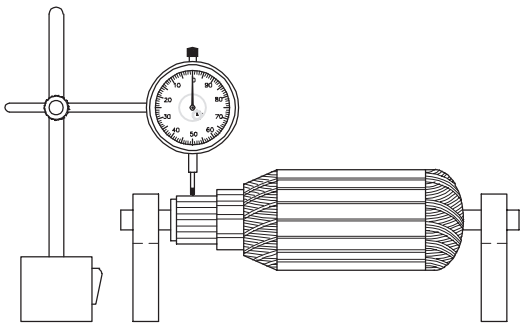
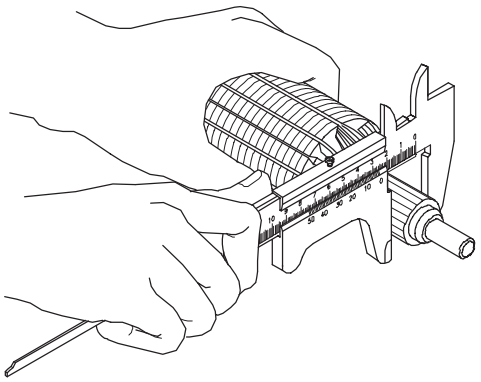


Fig 4



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TASK 5: **Check continuity of field coils**

1 Using an ohmmeter, check for continuity between the field coil and the insulated brush. If continuity is not indicated, the insulation has failed. Replace the insulation between the brush and yoke. (Fig 1)

Brush

2 Measure the length of the brushes. If brushes are worn down to the service limit, replace them. (Fig 2)

Brush spring

3 Check the brush spring for tension, rust or breakage

Fig 1

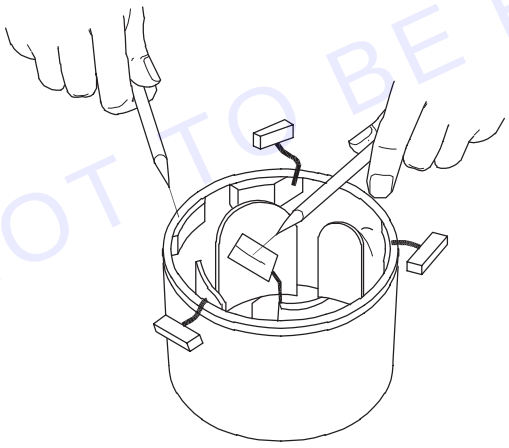
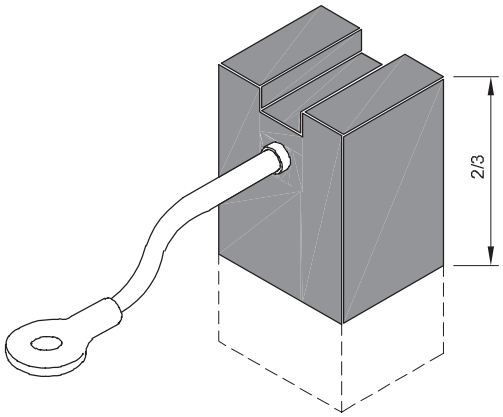


Fig 2



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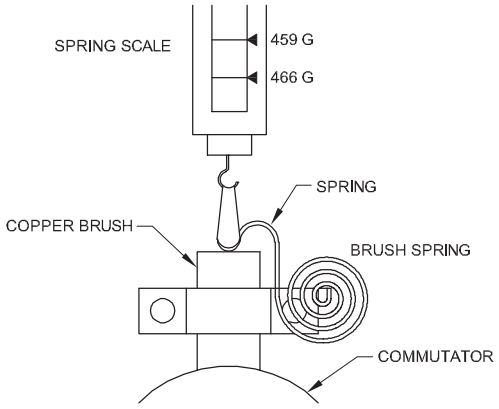
TASK 6 : **Check over-running clutch**

1 Inspect the one way clutch for free rotation indirection ‘A’, and locked up the other way round. (Fig 1)

2 Check the pinion for abnormal wear and replace it as assembly if required.

Fig 1



TASK 7: **Check end cover's shaft bushes**

1 Use a 10mm rod, take out the bush cap.

2 Measure the internal diameter of the drive bush.

3 Measure the outer diameter of the armature shaft at the drive end. (Fig 1)

4 If clearance exceeds the limit, replace the bush.

5 Use the tool as shown in the Fig 2, remove the bush from the drive housing on the arbour press.

Fig 1

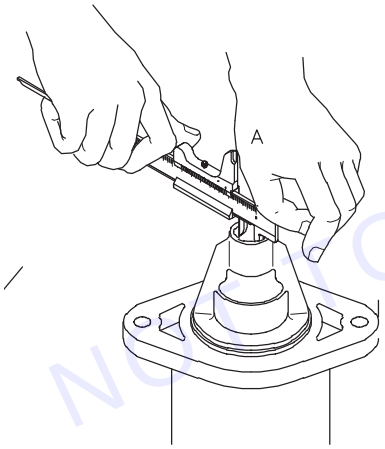
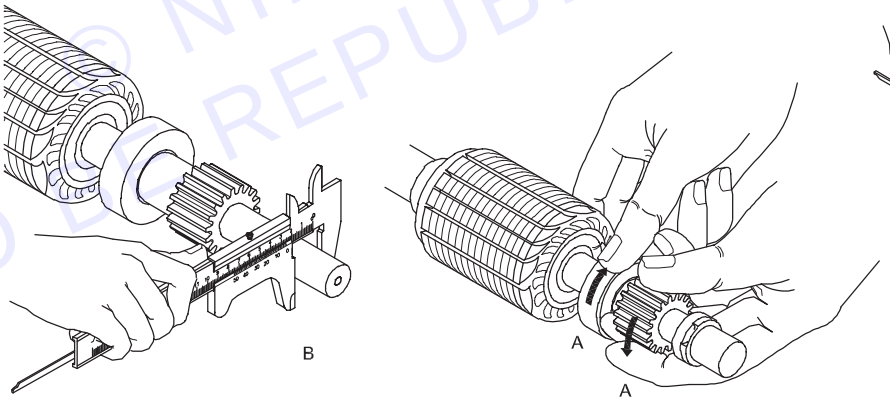


Fig 2



6 Measure the internal diameter of the commutator end bush (2). (Fig 3)

7 Measure the outer diameter of armature shaft at the commutator end.

8 If clearance exceeds the limits, replace the bush.

9 Thread in a 12mm tap (1) in the bush.(Fig 3 & 4).

10 When the end of the tap reaches the bottom of the frame (3), tighten it further.

11 The bush will come out.

12 Fit new bushes as press fit on the arbour press.

13 Ream the inside surface of the bush to obtain oil clearance (0.05mm) between the armature shaft and bush.

Fig 3

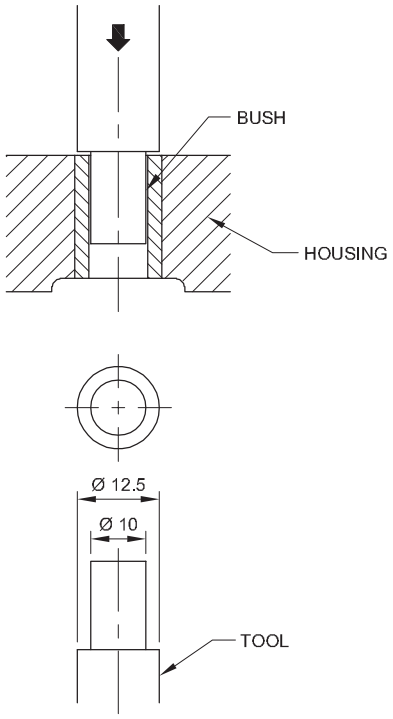


Fig 4

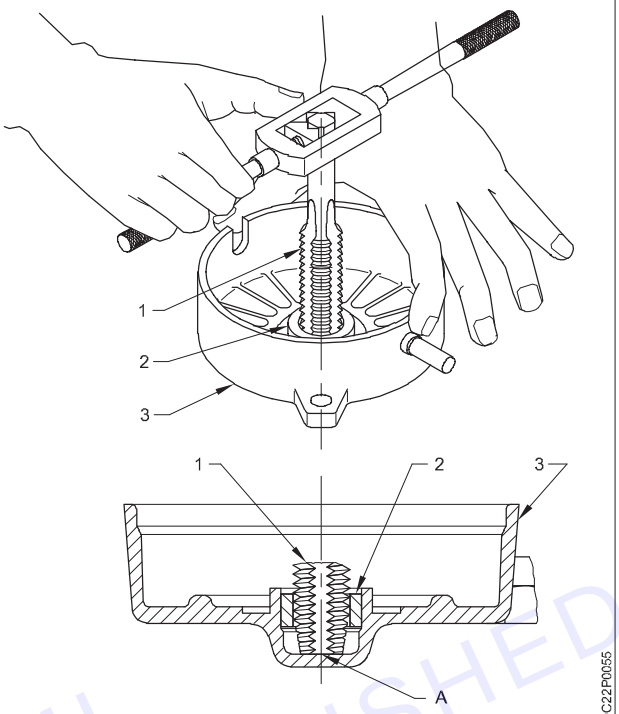
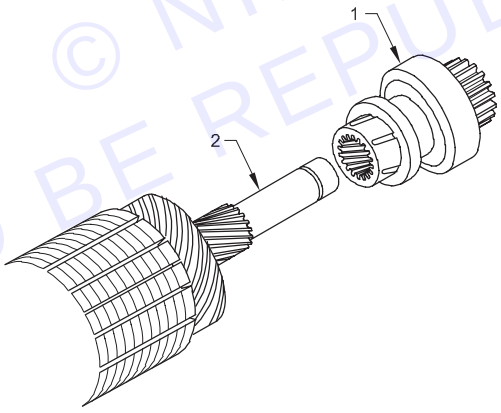


Fig 5



TASK 8 : **Assemble starter motor**

1 Apply grease and install the over-running clutch(1)to the armature shaft (2)

2 Insert the rear stop collar (2) in the armature shaft.

3 Insert as nap ring in the armature shaft.

4 Insert the fronts top collar (3) in the Armature shaft.

5 Press by two pliers (1) as shown in the Fig 1

6 Apply grease to the drive lever (1).

7 Combine it with the armature (2).

8 Assemble them with the drive housing (3) (Fig 2)

9 Install the yoke.

Fig 1

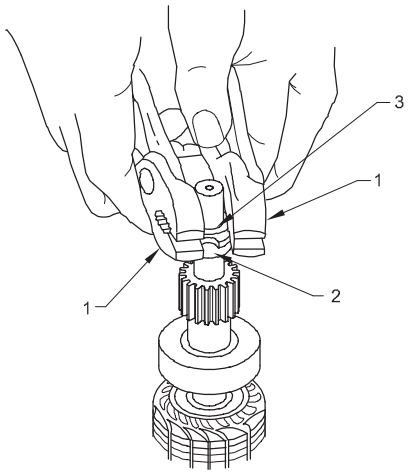
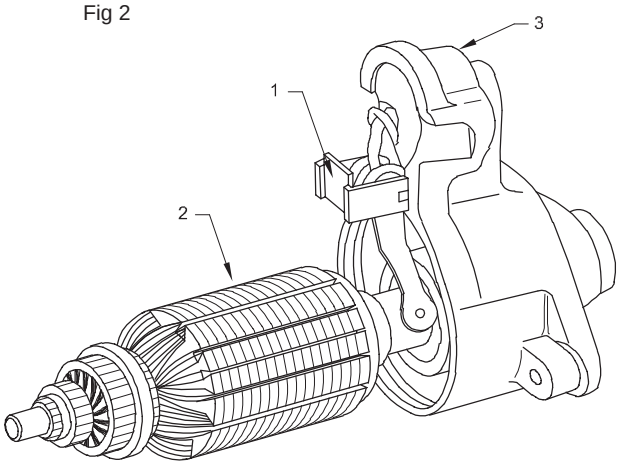


Fig 2



10 Install the brush holder.

11 Install 4 sets of brushes with the springs.

12 Install the brush holder cover.

13 Apply grease and install the commutator end housing (1) as shown in the Fig 3

14 Replace the magnetic switch (3) and its boot (1) with a new one if required. (Fig 4)

15 Apply grease to the plunger's (2) hook.(Fig 4)

16 Hook the switch plunger with the drive lever.(Fig 4)

17 Fasten the switch assembly with nuts.

18 Connect the lead wire.

Fig 3

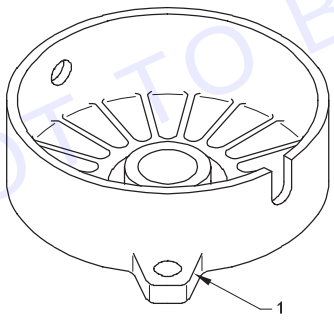
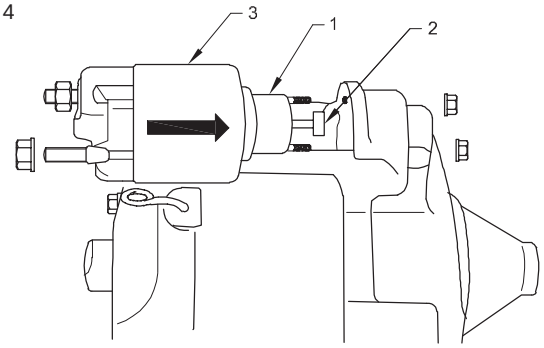


Fig 4



EXERCISE 9.3: Overhaul the Axial starting motor

Objectives

At the end of this exercise you shall be able to

- remove the starter motor
- dismantle the starter motor
- test solenoid switch
- test the armature and commutator
- check continuity of field coils
- check clutch plates
- check end cover's shaft bushes
- assemble starter motor
- test the starter motor for performance
- fit the starter motor on the engine.

Requirements

Tools / Instruments

- Trainees tool kit - 1 Set
- Multimeter - 1 No.
- Box spanner set - 1 No.

Machines

- Axial starter - 1 No.
- Growler - 1 No.
- Arbor press - 1 No.
- Starter test bench - 1 No.
- Axial starter servicing special tools - 1 Set
- Plunger nut spanner - 1 No.
- Plunger nut (inner) spanner - 1 No.
- Extractor clutch outer race - 1 No.
- Socket for checking clutch torque - 1 No.
- Face plate for rebushing drive and shield - 1 No.
- Dolly for pressing clutch housing - 1 No.

Equipments/Machines

- Heavy motor vehicle - 1 No.

Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Soap Oil - as reqd.
- Engine Oil - as reqd.
- Coolant - as reqd.

Procedure

Servicing

1 Disconnect the Battery negative lead

2 Remove the battery solenoid, Positive and Negative cable connections to the starter motor.

3 Remove the starter motor flange bolts and take out the starter

Dismantling

1 Unscrew nuts (25) and take off commutator cover (21)

2 Unscrew brush lead screws, lift brush spring (31) and remove brushes (30) from their holders. It will be seen that removal of the brush lead screw also frees the auxiliary field connections to the brush gear.

Note: At this stage, the leads to the rush gear and solenoid switch (15) should be marked so that they can easily be identified when the starter is reassembled.

3 Remove nut (26) in the commutator end shield (13) from the armature plunger (28) using a box spanner.

4 Remove main fixing bolts, (5) tap drive end shield (40) gently away from yoke (34) with hide of wooden mallet, and withdraw end shield complete with armature (8)

5 Hold the armature in an armature clamping device or in a vice fitted with soft metal or wood jaw clams

6 Remove lubricating plug

7 Remove split pin and nuts (1) and washer from front end of pinion and slide pinion (2) ad drive and shield (40) off the armature shaft

8 Remove pinion spring (37)

9 Collect clutch inner race (39) clutch plates shim washers, back ring, and pressure plates from clutch assembly

Note: The clutch plates (38) should be tried together in the order of removal so that they can be replace in their original positions in the clutch when the starter is reassembled.

10 Withdraw shims and rubber sealing ring from bore of pinion

11 Undo armature plunger retaining nut (32) by means of tubular spanner

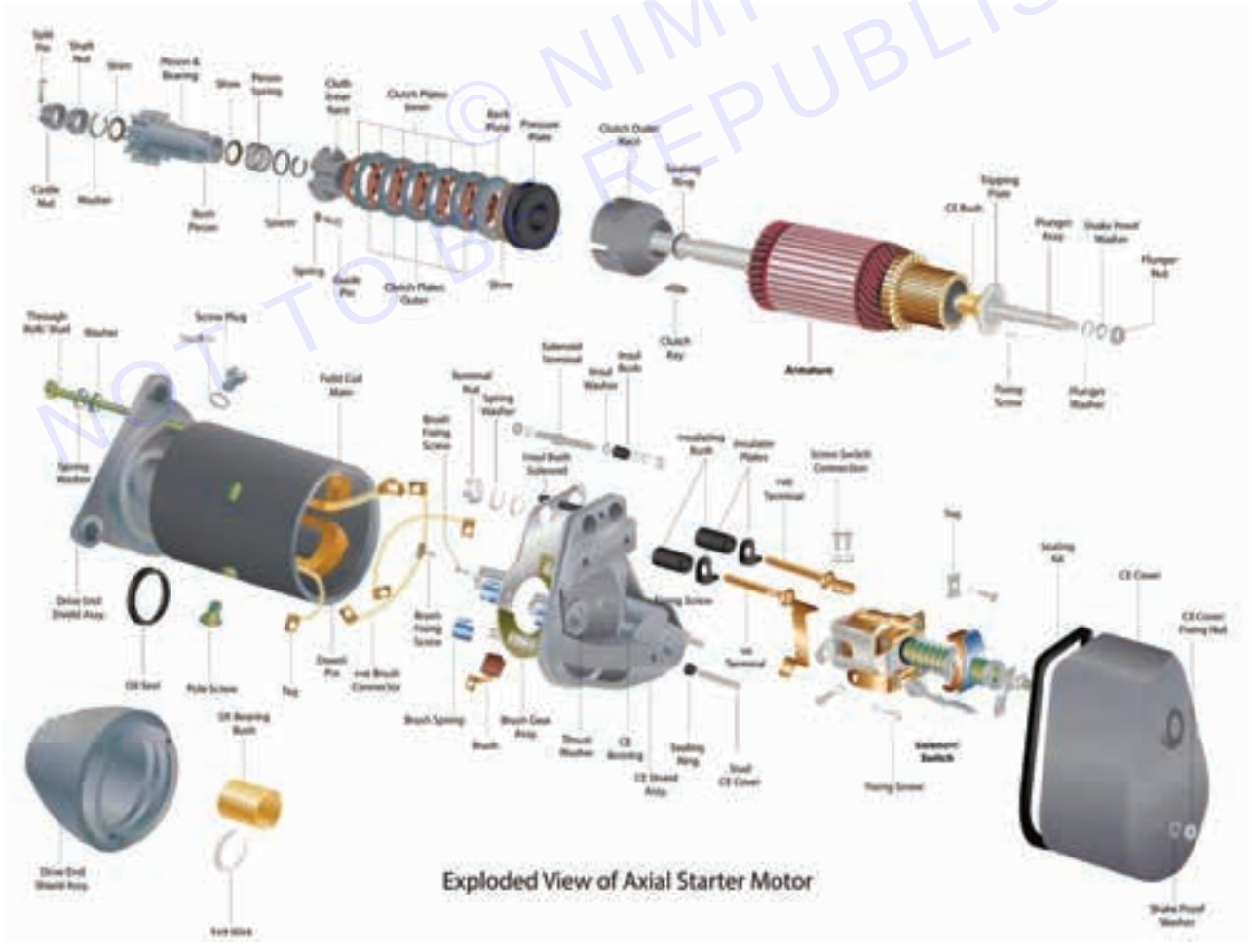
12 Withdraw armature plunger from bore of armature.

13 Remove the screws (16) securing positive terminal connector, main field coil ends and auxiliary field connections to solenoid switch

14 Separate carefully the commutator end shield from the yoke by tapping with a hide or wooden mallet.

15 Disconnect the solenoid coil leads

16 Unscrews solenoid fixing screw (14) and remover solenoid switch (15)



Exploded View of Axial Starter Motor

Inspection and Repair

Checking of commutator

Inspect the surface of the commuter should be clean and free from grooves, pits or uneven dipo colouration. Clean the commutator surface by emery sheet A Coarse cut should first be mate to remove sufficient copper to clear traces of pitting or distortion. Undercut the commutator, that is the insulation should be removed to a depth not exceeding the width of the insulation. Finally, the component should again be set up on the lathe and a fine finishing cut taken using a diamond or tungsten carbide tripped tool to obtain the desired quality of finish. After matching the commutator, armature must be cleaned thoroughly preferably by means of compressed air, or by the use of hand bellows

The minimum dia.to which the commutator can be skimmed and still remain serviceable is 45.6 mm (original dia 48 + 0.15 mm)

Checking of Armature winding

Use a 2.3v AC mains and a 220 15w bulb with two probes one of which is applied to the armature core and the other to all the segment of the commutator in turn. In the vent of the armature being found to be faulty, it must be replaced.

Press the cultch outer race on the shaft of the new or replacement armature,

Checking of field winding

Test field windings for short to the yoke and poles by means of test probes connected to a supply main not exceeding 110 volt and in series with a 15 watt lamp One probe should be applied to the yoke and the other applied to the ends of each of the winding in turn. If the lamp does not light then the insulation is proper.

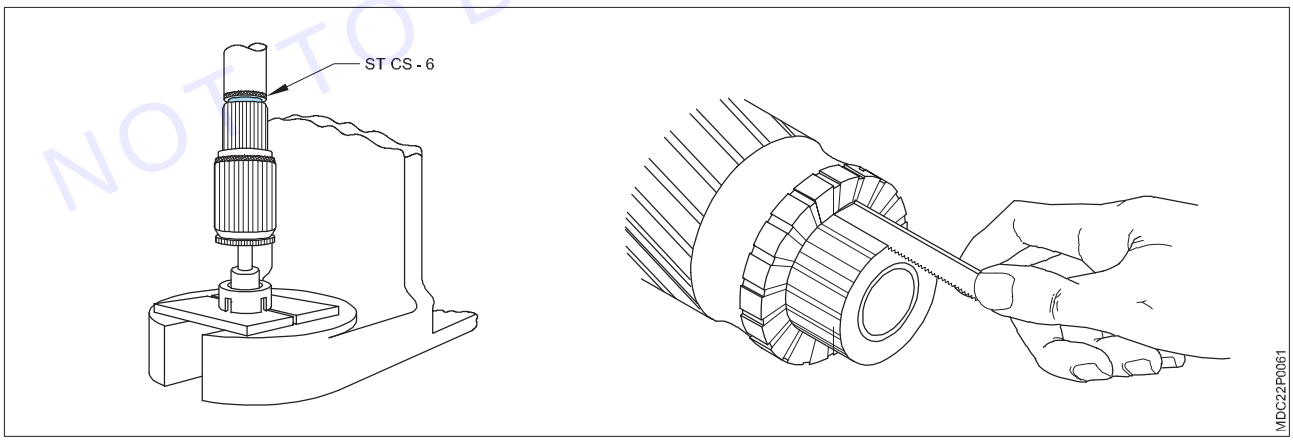
Test open circuits by means of an ohm meter. It should be connected across each of the winding in turn, and if infinity or maximum ohms is obtained, then an open circuits is indicated in the winding being tested.

Test the Internal shorts in the auxiliary coils by means of a low rating ohm meter.

Unscrew pole screws and withdraw poles and windings, Fit the new windings to the pole pieces.

Assemble poles and windings into yoke and insert pole screws

Tighten the screw using a commercial pole screw driver, Care must be taken en that the view are tightened down firmly so that no gap is left between the mating surfaces of the poles and yoke



Note: The windings will Lay down more easily if the yoke, windings and poles are heated gently in an oven before the pole fixing screws are tightened.

Checking of Bearings

Insert the pinion into its bearing in the drive end shield and slide the commutator end of the armature into the bearing in the commutator end shield, then check both bearings for excessive side play.

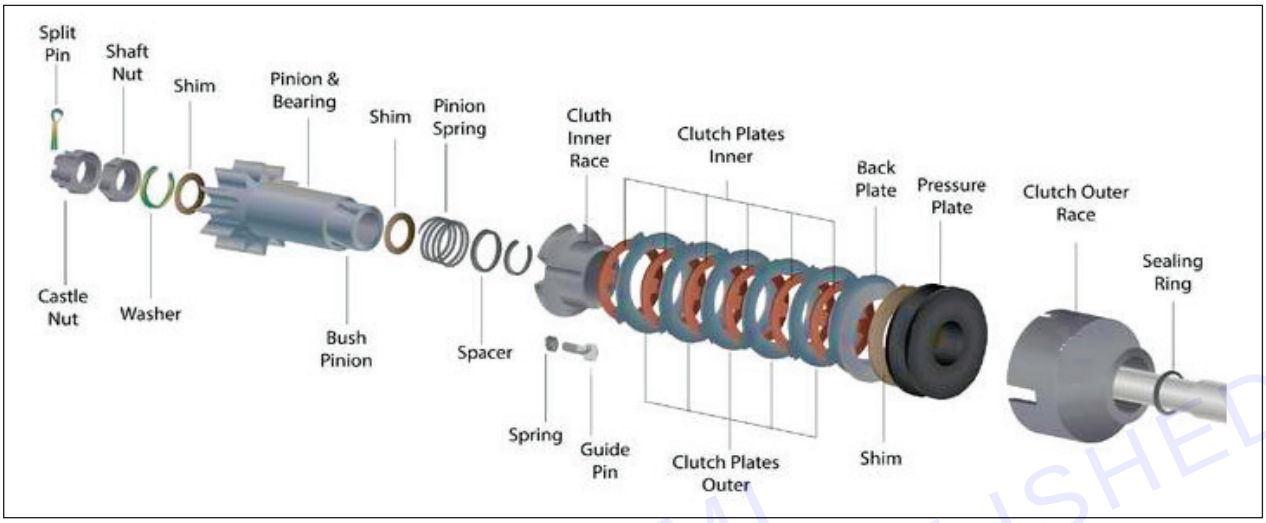
If the bearing pin is worn, recommend replacing the complete commutator end shield assembly as the end shield spigot is machined concentric with the bearing pin after the pin has been assembled Check for wear in the the armature CI Bush.

Remove the drive end bearing from its end shield and the complete drive cut shield and bearing assembly shouldbe replaced

When fitting a new or used pinion, the clearance between the pinion and bearing should be 0.05 to 0.1 mm

Checking of Brush Gear

Check the brush gear insulation, using a 230V supply mains, test probes and a 15W lamp between positive and negative brush holders; positive brush holder and frame; and Negative brush holder and frame, During any of this checks if the lamp lights, the insolation is faulty.

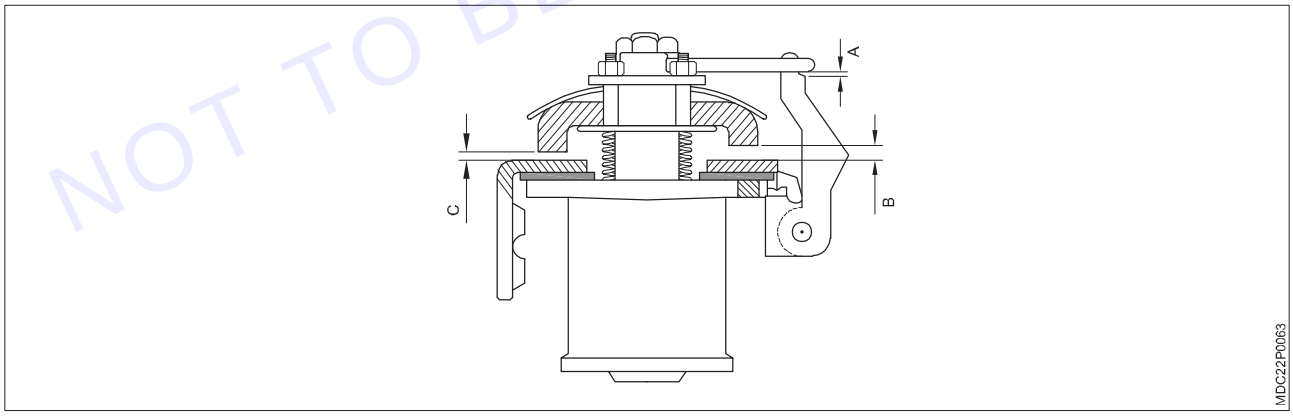


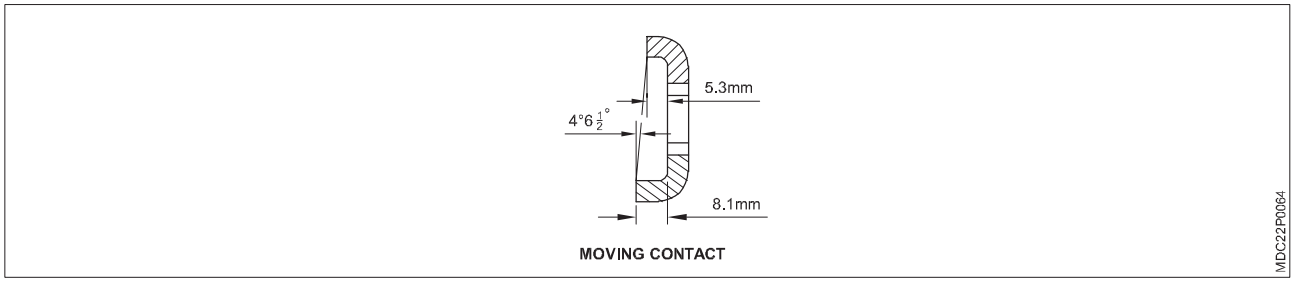
Check If clutch plates are badly worn or discoloured they must be replaced.

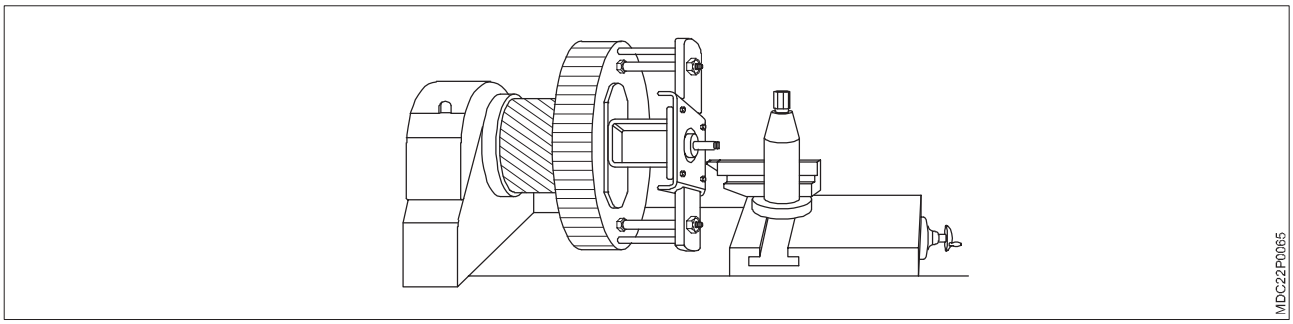
If the pinion teeth are badly worn or damaged the pinion should be changed.

Checking of Oil seal

Check the rubber sealing ring inside the pinion and the oil seal in the drive end shield and replace new one with. The sealing ring inside the pinion must be fitted with a shim on either side. The new oil seal must be fitted with.







Checking of solenoid switch

Dismantling of solenoid switch

Bend back the tags of lock, washer (12) and unscrew nut (13)

Withdraw catch plate (2), contact guide (1), contact leaf spring (11), moving contact (10) adjusting washer (9), insulating washer (8), and return spring (7).

Remove trigger spring

Cleaning of fixed points of solenoid switch

Clean Fixed contacts (4) with spirit or very fine carborundum paper, unless they me in a badly burns pitted condition they should be refaced on a lathe while still in position on the switch. Not more the 0.5 mm should be removed from the contact faces.

Checking of Solenoid Winding

Check the winding if. The winding becoming broken or damaged the complete switch should be replaced.

Checking of Catch plate and trigger of solenoid switch

Inspect the catch plate and trigger for wear. If the shoulder on the trigger and the bottom of the slot in the s plate show sign of “rounding off” the two components must be renewed.

Assembly

- Lightly smear the solenoid plunger at the point of entry into the switch body with petroleum jelly and the leaf spring (11) at the point of contact with moving contact (10). Apply sparingly to avoid surplus contaminating the contact faces.
- Replace return spring (7) and ensure it located over the lip on the periphery of the switch bore Replace trigger spring 5.
- Assemble insulating washer 8 adjusting washers 9 moving contact (10) contact spring (11) contact guide (1) and catch plate (2).
- Locate the end of the trigger in the slot in the catch plate and then replace the lock washer (12) and nut (13) tighten nut securely.

Check the gaps b and c between the contacts are within the limits as per manufactured specification. If not, adjusting washers must be added or removed until the correct gap is obtained.

lock the nut (13)

Sample service setting of solenoid switch

- Push the plunger forwards until the first contacts just touch, the gap between the trigger and catch plate should then be approximately 1m m before the catch plate hits the trigger.
- Trip the trigger and push plunger so that the second contact just touch from this point tell the plunger complete its travel, the distance should be approximately by 1 mm.

Testing of solenoid switch

Electrical tests

1 Check that both contact close when the following voltage is applied to the solenoid winding.

2 Subject the switch to a test of a few seconds duration at twice the normal voltage to ensure that the trigger operation is satisfactory. Any faulty assembly or rounding off of the trigger or catch plate will cause the catch to trip.

3 When these tests have been successfully completed, the commutator end cover should be carefully fitted and the machine subjected to insulation test.

Insulation test

Using the probes connected to a 230v max. supply and in series with a 15watt lamp of suitable voltage, check the insulation of the machine by touching probes on terminal B and frame. If the lamp lights, the insulation is faulty.

Assembly and Adjustment of starter motor

1 Hold the armature (8) in an armature clamping device, or in a vice fitted with soft metal or wood to clamps

2 Liberally smear the spring and thrust washer on armature plunger (28) with grease. Insert the plunger into the bore of the armature and tighten plunger retaining nut (32) using the appropriate tool.

3 Insert pressure plates, back ring and shim washers into clutch outer race (6)

4 Lightly smear initial pressure springs with grease and place them in their holes in clutch inner race, over that guide pin. Each springs should be inserted with it largest diameter first.

5 Lightly grease clutch plates 38 and place them on the splines of the clutch inner race, taking care to it them alternatively bronze and steel. Fit steel plate first so that it take the pressure of the clutch springs.

6 Assembly clutch inner race together with clutch plates and springs in the clutch outer race.

7 Grease pinion spring (37) and side it on the armature shaft.

8 Grease bore of pinion (2) and insert rubber sealing rings and shims.

9 Insert pinion into drive end shield (40). In order not a damage the felt lubricating pads, the pinion should be twisted in the direction of the spiral of the pinion thread whilst the lubricating pad is lifted by one finger from inside the casting. Also a suitable should be used along with the pinion so a not to damage the oil seal

Note: Before fitting a new shield ensure to remove the protective fibre pad which is put there to prevent ingress of foreign materials when the DE shield assembly is stored for service sales.

10 Slide pinion and drive end shield on the armature shaft. Push the pinion forward and rotate it until its thread engages in the internal thread in the clutch inner race. Hold it in this position and replace shims, washer, and nut. Make sure that the shim located over the shoulder of the shaft and tighten the nut securely. After the nut has been tightened the pinion must be capable of a small axial movement on the armature shaft.

11 Where the facilities exist, the slipping torque of the clutch should now be adjust as follows:

- Clamp the armature to the bench using a clamp bracket, or in a vice, the jaws of which are protected by aluminium, wood or soft brass shield and fit sockets. A standard torque spanner calibrated to 150 lb. ft. and half inch square drove shaft should be fitted to the appropriate torque sockets and the applied torque will be shown on the calibrated scale.
- Adjust the clutch to slip at 100-115 lb.ft (13.8-15.9 kgm). This should be done by removing adding shims between the clutch plates and the back plates. The shims are made in two thickness 0.1 and 0.15 mm Adding shims will increase the slipping torque and vice versa
- Slip the clutch about 10 times and then adjust the clutch to slip at 80-100 lb.ft(11.06 to 13.8kg
- If torque socket is available only for one type of pinion (say 11 teeth) to check starters having other pinion the following procedure is to be adopted
- Fit a eleven tooth pinion on the starter and then use the correct socket. Carry out setting of clutch as given above. After checking and resetting place the original pinion in starter.

12 Replace castellated nut (1), tighten securely and then insert split pin.

13 For approximately 5 cc of oil into the oil filter hole in the drive end shield. Allow sufficient time lubricating pad to absorb the oil then replace the lubricating plug. Wipe off any surplus oil which may have run into the inside the drive end shield

14 Fit solenoid switch (15) to commutator end shield and secure in position with fixing screws (14)

15 Reconnect the solenoid winding leads to their respective terminals

16 Fit commutator end shield to yoke ensuring that the dowel in the yoke is correctly located

17 Replace screws (16) securing the main field coil ends, positive terminal connector and auxiliary field connections to the solenoid switch.

18 Assemble armature and drive end shield to yoke

19 Replace fixing bolts (5) and tighten

20 Spin the armature to see it is not blinding and is free to rotate

21 Fix washers and nut (26) to armature plunger and tighten

22 Replace brushes (30) taking care that each brush is replaced in its original position. If the new brushes are also to be fitted they must be bedded to the commutator as described in the section head maintenance

23 Connect brush leads and auxiliary field leads to the brush gear

24 Check that the relationship between trigger and tripping disc. Is covered by pulling the armature forwards until the trigger is raised to its highest extend by the tripping disc. When the trigger is raised there should be an ample gap between the shoulder on the trigger and the button of the slot in the catch plate.

Testing of starter motor

Engagement mechanism test

1 Connect the starter to a battery

2 Insert a strip of insulating material between the moving contact and the second stage contact of solenoid switch to prevent the second stage contacts of solenoid switch to prevent the second stage contacts closing

3 Operate the starter push switch. The fist stage contact of the solenoid switch should close and the pinion should revolve in its normal directions of rotation. At the same time the pinion should move forward for a distance of approximately on inch (25.4mm)

Caution

Do not keep the starter button depressed longer than is necessary to check that the starter is functioning satisfactorily otherwise winding may be a damaged by overheating

4 Remove insulating strip from the second stage contact.

Performance tests

- Fit the starter to a starter test rig and connect the power supply. The out of mesh clearance between the starter pinion and test rig wheel must be set at 3.4mm
- Check the lock torque, the running torque the light running current and RPM at specified voltage. Refer Test Data for value

Insulation Test

Using test probes connected to a 110 volts (maximum) supply mains and in series with a 15 watt lamp of suitable voltage check the insulation of the machinery between

i Positive terminal and frame and

ii Negative terminal and frame (for insulated version only)

Sample test data for Axial Starters

If the lamp lights during any of these tests, the insulation is faulty.

		SP5-12	BS5-12	BS5-24	SL5-24
Lock Torque	TORQUE	3.8 kg.m (281b-ft)	3.75 kg.m (271b-ft)	4.6 kg.m (33 1b - ft)	8.2 kg.m (min)
	CURRENT	1400 Amps max.	900 Amps max.	780 Amps max.	1370 Amps max.
	VOLTAGE	5 volts	5.5 volts	9.0 volts	10.5 volts
Running Torque	TORQUE	1.66 kgm (121b-ft)	1.53 kg-m (11 1b-ft)	2.1 kg.m (15.2 1b-ft)	3.5 kg.m
	CURRENT	700 Amps max.	420 Amps max.	400 Amps max.	650 Amps max.
	VOLTAGE	8.0 volts	8.0 volts	16.0 volts	18.8 volts
	SPEED	1400-1600 rpm	1200 rpm	1450-1650 rpm	1200 rpm
Light Running	CURRENT	140 Amps max.	60 Amps	70 Amps max.	120 Amps max.
	VOLTAGE	11.6 volts	11.0 volts	24 volts	23 ± 0.5 volts
	SPEED	3800-4200 rpm	2600 rpm	3800-4200 rpm	3500 rpm

EXERCISE 9.4: Remove the starter motor from vehicle and test its performance

Objectives

At the end of this exercise you shall be able to

- pull in and hold in test performance
- pinion return test
- no-load performance test.

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Box spanner set - 1 No.
- 10 mm rod - 1 No.

Equipments/Machines

- Running vehicle - 1 No.

Materials

- Emery paper - as reqd.
- Hacksaw blade - as reqd.
- Grease - as reqd.

Procedure

TASK1: **Test the starter motor for performance**

1 Remove starter motor assembly from vehicle

Pull in test

- Connect the test leads as shown in the Fig 1.
- Check that the pinion (over-running clutch) jumps out; if it does not, replace it.

Pinion return test

- Disconnect the negative lead.(Fig 2)
- Check to make sure that the pinion returns inward quickly.

Fig 1

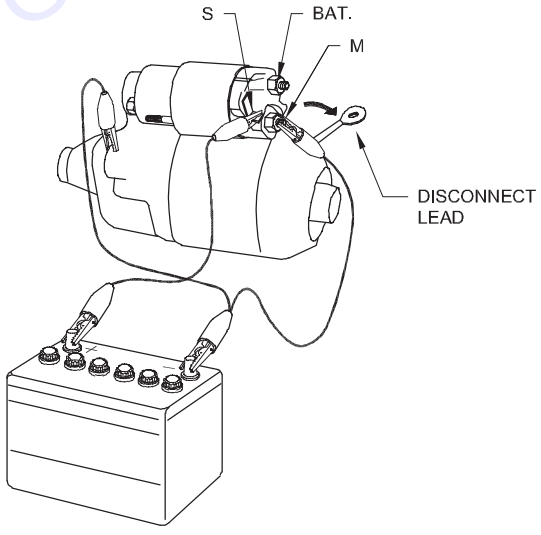
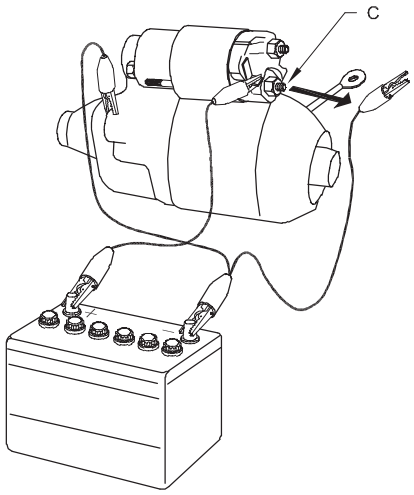


Fig 2



MDC22P0066

Hold in test

- While connecting as stated above with the pinion out, disconnect the negative lead from terminal 'C'
- Check that the pinion remains out; if not, replace the magnetics witch.

No-load performance test

- Connect the test leads as shown in the figure. (Fig 3)
- Check the motor runs without fail with the pinion moved out.
- Check that the ammeter indicates the specified current. (No - load current - less than 53A at 11.5V) (Fig 3 & 4)

Fig 3

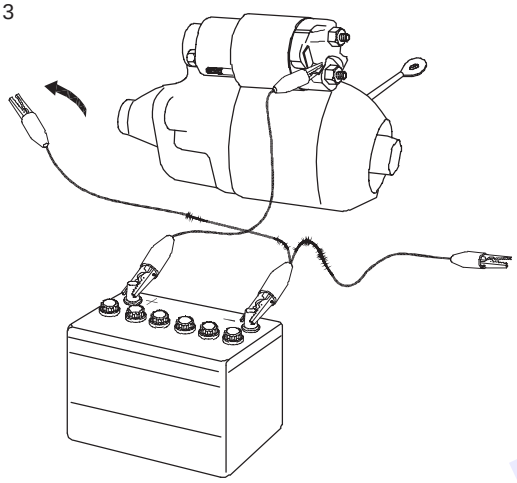
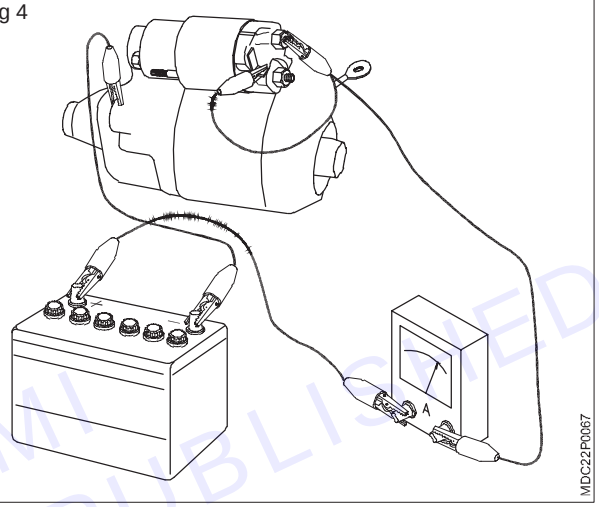


Fig 4



TASK 2: **Fit the starter motor on the engine**

1 Place the starter motor in its position. Tighten the two mounting bolts.

2 Connect the battery cable and magnetics witch lead wires to the starter motor terminals.

3 Connect the negative lead to the battery.

EXERCISE 9.5: Perform trouble shooting in starting system

Objectives

At the end of this exercise you shall be able to

- rectify problem of “engine not cranking
- rectify problem of “engine crank too slowly to start”
- rectify problem of “starter spins but engine is not cracking”
- rectify problem of “starter not engaging or disengaging properly.

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Multimeter - 1 No.

Equipments/Machines

- A light motor vehicle - 1 No.

Materials

- Cotton waste - as reqd.
- Magnetic switch - as reqd.
- Petroleum jelly, brush - as reqd.

Procedure

Refer to the chart below for the possible causes and needed actions, for each symptom and follow the action as per sequence, till the cause identified and do rectification

Symptom (TASKS)	Possible cause	Action needed
Starter motor not running.	• Melting off usable link • loose connections • If battery is dead • For faulty ignitions witch • Faulty magnetics witch	• Replace fusible link • Clean and lighten connections • Check battery and charge as needed • Checks witch operation; replace as needed. • Replace
Engine cranks toos lowly to start	• weak battery • loose or corroded connections • Check mechanical problems with engine or starter • Faulty starter motor	• Check battery and charge as needed. • Clean and tighten connections • Check engine and starter; worn out parts • Test starter/replace
Starter keeps running	• Binding ignition key • Faulty control components • Damaged pinion or ring gear • Faulty plunger in magnetics witch	• Check key for damage/replace • Checks witch and circuit • Replace • Replace
Starters pins,but engine not for cranking	• Faulty over-running clutch • Check for damaged or worn pinion gear or ring gear	• Repair the over-running clutch proper operation • Replace as needed
Starter does not engage/ disengage properly	• Faulty magnetics witch • Damaged or worn pinion gear or ring gear;	• Replace • Replace as needed.
Starter motor noise	• Pinion worn out • Bearing worn out • Mounting loose • Ring gear worn out	• Replace • Replace • Tighten • Replace
Starter motor does not stop running	• Starters witch short circuited • Starter in relay contact • Binding ignition switch	• Replace • Replace • Replace

EXERCISE 9.6: Perform testing of Actuators

Objectives

At the end of this exercise you shall be able to

- test the Fuel pump relay and Radiator fan relay
- test the EGR valve
- test the Fuel injector.

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Multimeter - 1 No.
- Fuel injector leak measuring pipes - as reqd.
- Scan Tool - 1 No.
- Oscilloscope 20 MHZ - 1 No.

Equipments/Machines

- A light motor vehicle with CRDI Engine - 1 No.

Materials

- Tray - 1 No.
- Banian cloth - 1 No.
- 12V battery - 1 No.

Procedure

Test the fuel pump relay

1 Turn off the Ignition key.

2 Connect the scan tool to DLC and Turn On Ignition switch.

3 Check the fuel pump operating sound is heard by actuating the scan tool actuation test. If the sound is not heard, go to the next step.

4 Turn the Ignition switch off and Remove the fuel pump relay from fuse box.

5 Check the continuity between terminal '3' an '4'. If there is continuity shows replace the Relay.

6 Connect a battery positive terminal to terminal '2' of relay. Connect battery negative terminal to terminal 1 of relay. Check for continuity between Terminal "3" and "4". If there is no continuity when relay is connected to the battery, replace relay.

Test the Radiator Fan relay

1 Turn off the Ignition key.

2 Connect the scan tool to DLC and Turn On Ignition switch.

3 Turn ignition switch ON.

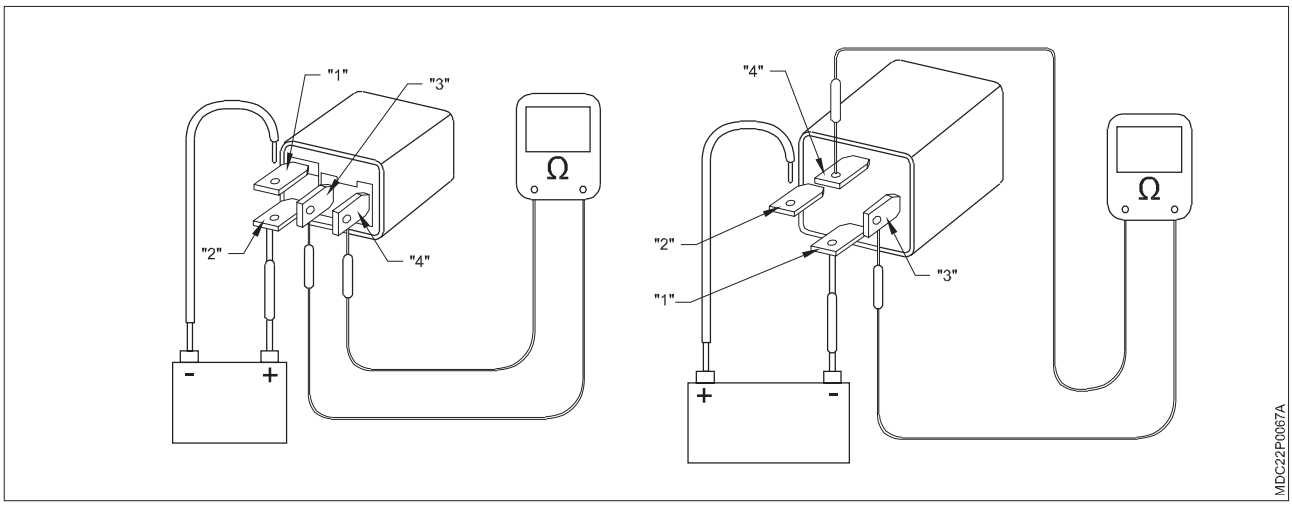
4 Check the cooling fan operates at low speed by using actuating the scan tool actuation test. If it is not working, go to the next step.

5 Check the cooling fan operates at high speed by using actuating the scan tool actuation test. If it is not working, go to the next step.

6 Turn the Ignition switch off and Remove the cooling fan relay from fuse box.

7 Check the continuity between terminal '3' an '4'. If there is continuity shows replace the Relay.

8 Connect a battery positive terminal to terminal '2' of relay. Connect battery negative terminal to terminal "1 "of relay. Check for continuity between Terminal "3" and "4". If there is no continuity when relay is connected to the battery, replace relay.



Test the EGR valve

1 Disconnect battery negative cable.

2 Remove EGR valve connector.

3 Remove EGR valve.

4 Check the resistance between terminals of EGR valve. If resistance is out of specification, Replace EGR valve

5 Connect a battery positive terminal to power supply terminal and Negative terminal to ground terminal of EGR valve.

6 Check the valve operation, If it is not operated, Replace EGR valve.

Test the fuel Injector

1 Disconnect battery negative cable.

2 Remove the first cylinder Fuel Injector wire connector.

3 Connect the multi meter test leads to fuel injector terminals.

4 Measure the resistance value of Injector and compare the resistance value with manufactures specified value. If it is low or high or replace the Injector.

5 Check the resistance value of other injectors and replace if necessary.

6 Reconnect the wire connectors and Battery negative cable.

7 Connect the oscilloscope test probes to the first cylinder injector wires and set the voltage and Time as specified by the manufacturer service manual.

8 Start the engine and check the wave pattern of Injector.

9 Compare the wave pattern with manufacturer's service manual data. If it is not matching replace the Injector.

10 Test the other fuel injectors with oscilloscope.

MODULE 10: Charging System

EXERCISE 10.1 : Checking of charging circuit and alternator output on vehicle

Objectives

At the end of this exercise you shall be able to

- check Charging circuit continuity
- remove the alternator
- check Alternator Output voltage
- check circuit voltage-Drop
- check charging Circuit Relay
- do trouble shooting charging system.

Requirements

Tools/Instruments

- Digital multimeter - 1 No.
- Continuity meter - 1 No.
- Ohm meter - 1 No.
- DE spanner 6 to 32 - 1 No.
- Electrical tester - 1 No.
- AC alternator slip ring puller - 1 No.
- Executive auto electrical toolkit - 1 No.
- Electrical test bench - 1 No.
- Pulley set universal for bearing & bushes - 1 No.

Equipments/Machines

- Alternator Tester - 1 No.
- Running condition of LMV vehicle - 1 No.

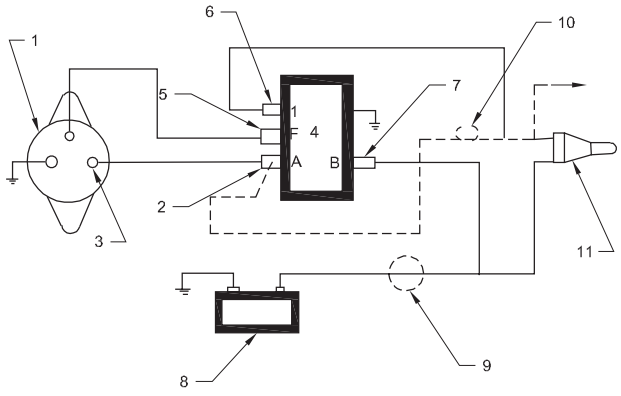
Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Electrical wires - as reqd.
- Engine Oil - as reqd.
- Coolant - as reqd.
- Insulation tape - as reqd.
- Battery Jumper cutter with crocodile clips - as reqd.

Procedure

TASK 1: **Locate alternator circuit and check continuity**

1 Locate the circuit from the alternator's (1) output terminal (5) to the voltage regulators (2) terminal A (3) and check the continuity



ALTERNATOR WIRING CIRCUIT IN A VEHICLE

2 Locate the feedback circuit from the voltage regulator's (2) 'F' terminal (4) to the alternator's (1) field terminal (6) and check the continuity.

3 Locate the circuit from the voltage regulator's (2) 'B' terminal (7) to the ammeter (8) and check the continuity.

4 Locate the circuit from the ammeter (8) to the battery (9) and check the continuity.

5 Locate the circuit from the voltage regulator's (2)'A' terminal (3) to the indicator lamp (12) and check the continuity.

6 Locate the circuit from the indicator lamp (12) to the ignition switch (11) and check the continuity.

7 Locate the ground connection (13) and check the continuity.

8 Locate the circuit from the ammeter (8) to the ignition switch (11) and check the continuity.

— — — — —

TASK 2: **Remove alternator**

1 Disconnect the earth cable of the battery.

2 Disconnect the wires from the alternator.

3 Loosen the bolts which secure the alternator with the bracket.

4 Take out the alternator

— — — — —

TASK 3: **Alternator Output Test**

1 The alternator output test checks the ability of the alternator to deliver its rated output of voltage and current

2 This test should be performed whenever an overcharging or undercharging problem is suspected.

3 Output current and voltage should meet the specifications of the alternator. If not, the alternator or regulator (IC or external) may require replacement.

4 An Alternator tester, similar testers, or a separate voltmeter and ammeter can be used.

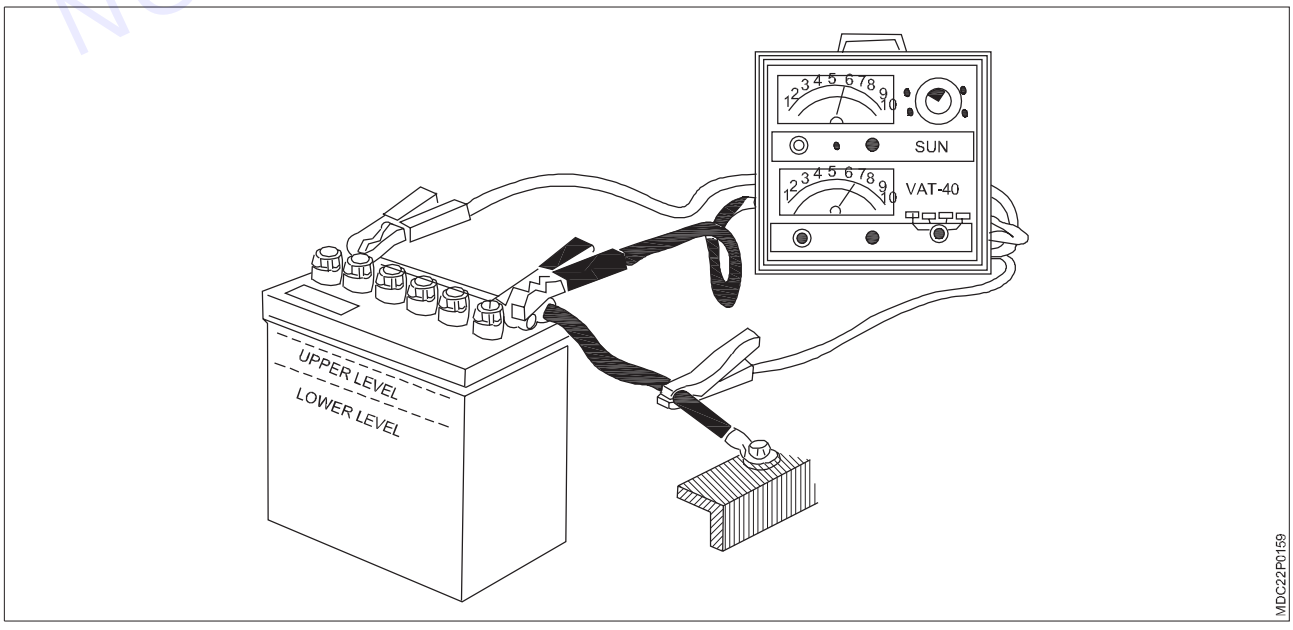
5 Vehicle repair manuals detail the testing procedures with an ammeter and voltmeter.

6 Follow the manufacturer's instructions when using special testers, although most are operated similarly. The following steps outline a typical procedure for performing the

Alternator output test using an alternator tester:

Charging Without Load

1 Prepare the tester



Rotate the Load Increase control to OFF.

Check each meter's mechanical zero. Adjust, if necessary.

Connect the tester Load Leads to the battery terminals; RED to positive, BLACK to negative.

Set Volt Selector to INT 18V.

Set Test Selector to #2 CHARGING.

Adjust ammeter to read ZERO using the electrical Zero Adjust control.

Connect the clamp-on Amps Pickup around the battery ground (-) cables.

2 Turn the ignition switch to "ON" (engine not running) and read the amount of discharge on the ammeter. This a base reading for current the alternator must supply for ignition and access ones before it can provide current to charge the battery.

Note: The reading should be about six amps

3 Start the engine and adjust the speed to about 2000 rpm. Some models may require a different speed setting

4 After about 3-4 minutes, read the ammeter and voltmeter. Add this ammeter reading and the reading found in step2 (engine not running).

Note: The total current should be less than 10 amps. If it is more, the alternator may still be charging the battery. Once the battery is fully charged, you should get specified results.

The voltage should be within the specs for the alternator This is usually between 13 and 15 volts. Refer to the appropriate repair manual. If the voltage is more than specified, replace the regulator. If the voltage is less than specified, ground the alternator field terminal "F" and check the voltmeter reading. This bypasses the regulator, so do not exceed the specified test speed. If the reading is still less than specified, check the alternator.

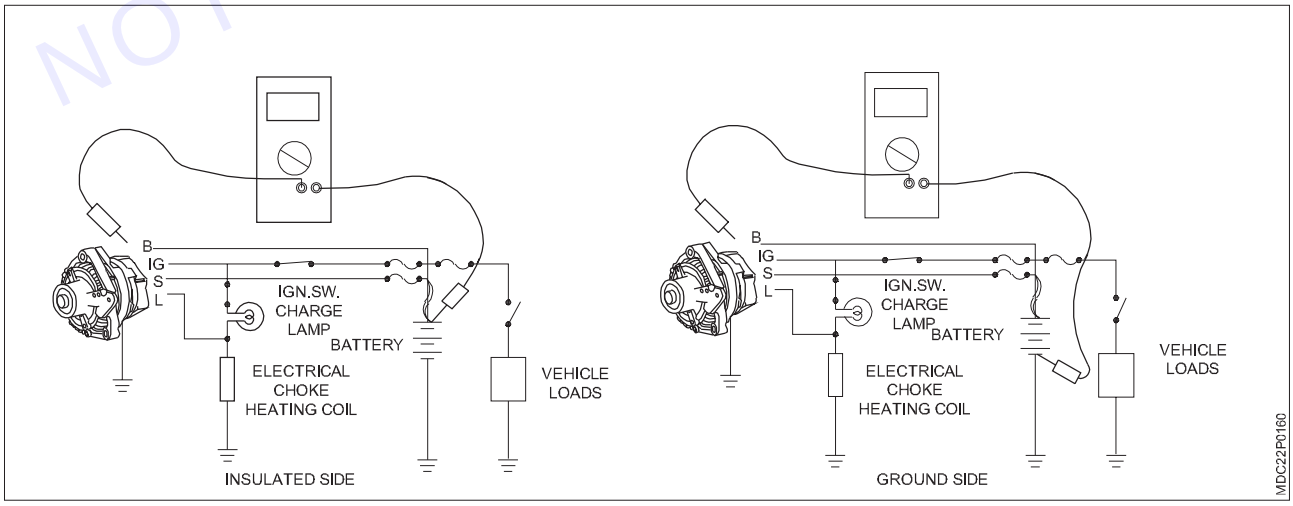
5 Remove ground from terminal

Charging With Load

6 With the engine running at specified speed, adjust the Load Increase control to obtain the highest ammeter reading possible without causing the voltage to drop lower than 12 volts.

7 Read the ammeter.

Note: The reading should be within 10% of the alternator's rated output. If it is less, the alternator requires further testing or replacement.



TASK 4: **Voltage-Drop Tests**

Both sides of the circuit should be checked insulated side as well as ground side. Excessive voltage drop caused by high resistance in either of these circuits will reduce the available charging current. Under heavy electrical loads, the battery will discharge

An alternator tester or a separate voltmeter can be used. The following steps outline a typical procedure for performing voltage-drop tests using a voltmeter:

Output Circuit - Insulated Side

1 Check relay continuity.

Connect the ohmmeter positive (+) lead to terminal “4,” the negative (-) lead to terminal “3. Continuity (no resistance) should be indicated

1 Connect the voltmeter positive lead to the alternator’s output terminal “B” and the voltmeter’s negative lead to the battery’s positive (+) terminal

2 Start the engine and adjust the speed to approximately 2000 rpm.

3 Read the voltmeter. The voltage drop should be less than 0.2. If it is more, locate and correct the cause of the high resistance.

Output Circuit - Ground Side

1 Connect the voltmeter’s negative lead to the alternator’s frame and the voltmeter’s positive lead to the battery’s negative (-) terminal.

2 Start the engine and run at specified speed (about 2000 rpm).

3 Read the voltmeter. The voltage drop should be 0.2 volt or less. If it is more, locate and correct the cause of high resistance

4 Excessive resistance is most likely causes loose or corroded connections.

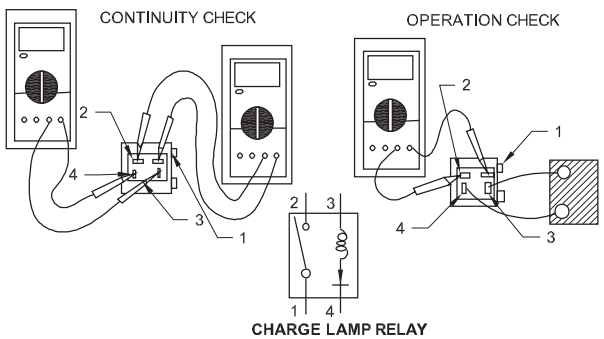
— — — — —

TASK 5: **Charging Circuit Relay Tests**

- The indicator lamp circuit may or may not be control a relay. Depending on the model, when a relay ismay be a separate lamp relay, the ignition main relay of the engine main relay. Each is checked using an ohm meter
- Charge Lamp Relay
- When used, the charge lamp relay is located on the cowl side of the vehicle. The following steps are check this relay.

1 Check relay continuity

- Connect the ohmmeter positive (+) lead to terminal “4,” the negative (-) lead to terminal “3. Continuity (no resistance) should be indicated
- Reverse the polarity of the ohmmeter leads No continuity (infinite resistance) should be indicated.
- Connect the ohm meter leads between terimal’s “1” and “2” No continuity (infinite resistance) should indicated.
- If the relay continuity is not as specified, replacement relay.



2 Check relay operation

- Apply battery voltage.

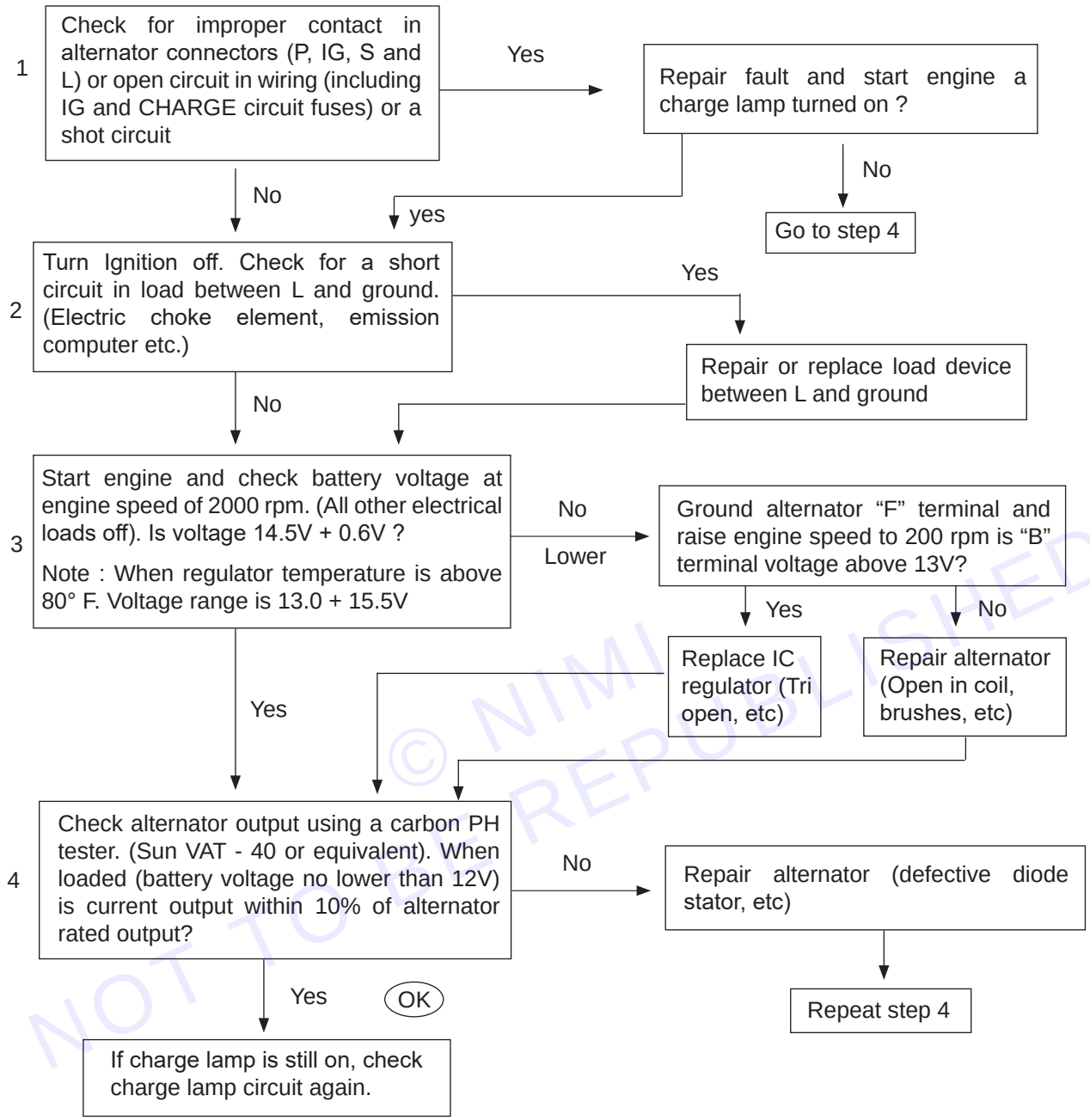
Note: Make sure polarity is as shown

- Connect the ohmmeter leads between terminals"1" and "2." Continuity (no resistance) should be indicated.
- If relay operation is not as specified, replace the relay.

Charging System Troubleshooting

Problem	Possible Cause	Action
Warning lamp does not light, with ignition ON and engine off.	1 Blown Fuse	1 Check CHARGE, IGN and ENGINE fuse replace as needs after correcting cause
	2 Lamp burned out	2 Replace lamp
	3 Wiring Connections loose	3 Check voltage drop in circuit, lighten
	4 Defective relay	4 Check relays, if used for continuity and proper operation
	5 Defective regulator	5 Check alternator output
Warning lamp does not go out with engine running; battery overcharged or undercharged	1 Loose or warn drive belt	1 Check drive belt; adjust or replace as needed after correcting cause
	2 Defective battery or battery connections	2 Check battery and its connections
	3 Blown fuse or fusible link	3 Check fuse and fusible link; replace as needed
	4 Defective relay regulator or alternator	4 Check charging system output and components operation as needed
	5 Defective wiring	5 Check voltage drop
Noise	1 Loose or worn drive belt	1 Check drive belt adjust or replace as needed
	2 Worn alternator bearings	2 Replace the alternator
	3 Defective diode	3 Replace the alternator
No charge when engine running	Blown fuse wire in regulator	Locate cause and rectify and then replace fuse
	Drive bell loose	Adjust belt tension
	Broken drive belts	Replace
	Worn out or sticky brush	Replace
	Open field circuit	Rectify
	Open charging circuit	Rectify
	Open circuit in stator winding	Rectify
	Open rectifier circuit	Rectify
	Defective diodes	Replace
	Worn or dirty slip rings	Replace
	Loose connections	Tighten

Diagnostic Flow Chart



EXERCISE 10.2: Overhaul and test alternator

Objectives

At the end of this exercise you shall be able to

- remove the alternator
- dismantle the alternator
- check the stator
- check the rotor
- check the diodes
- check the condition of the brushes
- check the slip-rings
- assemble the alternator.

Requirements

Tools/Instruments

- Trainee's tools kit - 1 No.
- Socket spanner set - 1 No.
- 12 volt lead acid battery - 1 No.
- Test lamp and cables - as reqd.

Equipments/Machines

- Diesel Engine - 1 No.

Materials

- Kerosene - as reqd.
- Emery paper - as reqd.
- Rotor - as reqd.
- Banian cloth - as reqd.
- Grease - as reqd.
- Diodes - as reqd.
- Bearing - 2 Nos.

Procedure

TASK 1: **Removing alternator**

1 Disconnect the earth cable of the battery.

2 Disconnect the wires from the alternator.

3 Dismount the bolts which secure the alternator with the bracket.

4 Take out the alternator

— — — — —

TASK 2: **Dismantling (Fig 1)**

1 Mark a line across both the end shields (14 & 9) and the stator to facilitate alignment during reassembling.

2 Remove the cover securing studs and nuts (1 & 2) and lift the cover. (Fig 1)

3 Disconnect the regulator leads (3) and (5) (+ve, -ve).

4 Remove the screw securing the regulator(4) to the brush box and remove the regulator (4).

5 Remove both the brushes (6) & (7). Note down the position of the sealing pad.

6 Remove the screws securing the brush-box (8) to the slipping end bracket (11) and lift out the brush-box (8).

7 Release the stator winding cable ends from the rectifier by applying a hot soldering iron to the terminal tags of the rectifier.

8 Gently pull out the cable end when the solder melts.

9 Remove the screws securing the rectifier assembly (11) to the slip-ring end bracket and lift out the rectifier assembly.

10 Remove the fixing bolts.

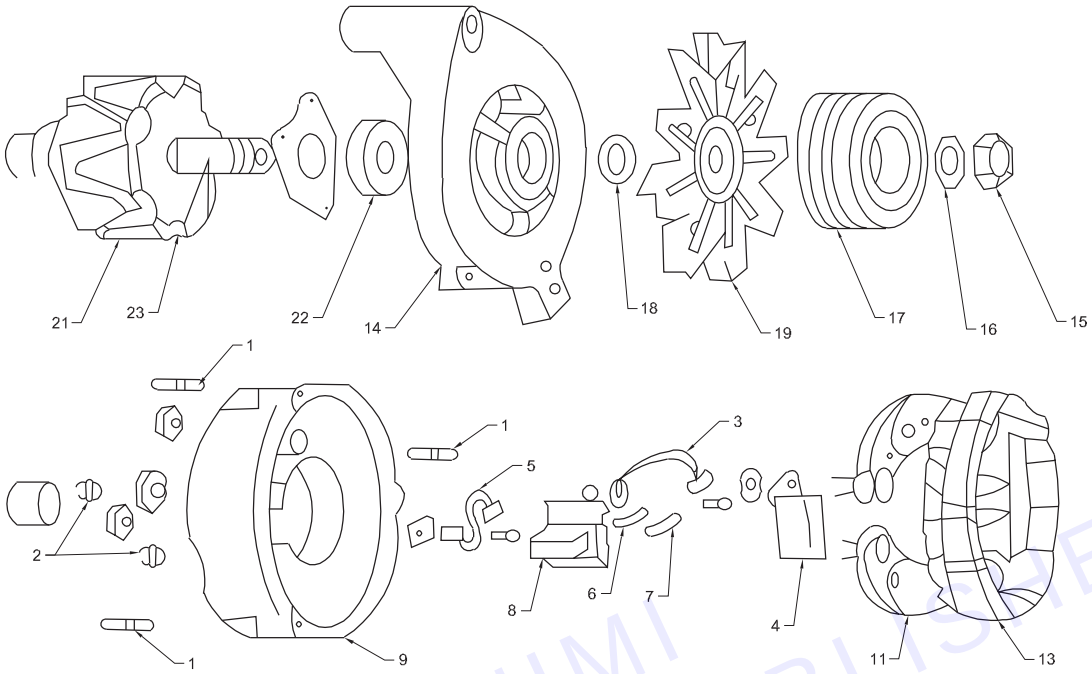
11 Take out the slip-ring end bracket (11).

12 Take out the stator assembly (13) from the drive end bracket (14).

13 Remove the shaft nut (15), washers (16) and take out the pulley (17), fan (19), woodruff key (20) and spacers(18).

14 Push at the rotor shaft (23) end with your thumb to separate the drive end bearing (22) and rotor assembly(21).

Fig 1



TASK 3: **Cleaning and inspection**

1 Clean all the parts with kerosene and a nylon brush except the carbon brushes.

2 Clean the slip-ring (12) with fine emery-paper and wipe with a clean rag.

3 Clean the brushes with petrol.

4 Check the bearings visually for any damage. If necessary, replace the bearing with a new one.

5 Check the brushes for correct dimension, according to the manufacturer's specification; replace, if required.

6 Check the brush spring tension; replace if required.

7 Check for the external crack on drive end bracket and slip end bracket.

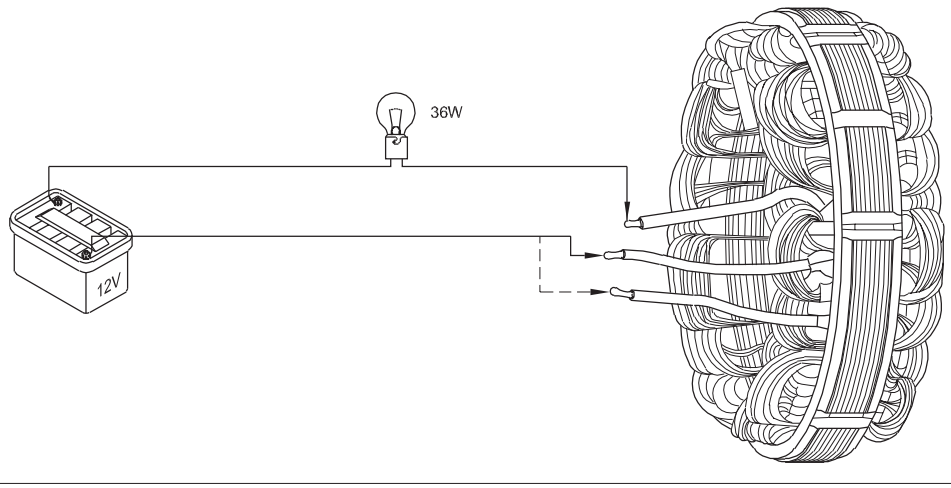
TASK 4: **Test for open circuit in the stator**

1 Check the continuity of the stator windings (Fig 1). First connect any two of the stator winding leads to a 12 V battery in series with a 36 W test lamp.

2 The lamp should glow. If the first part of the test is satisfactory, transfer one of the test lamp leads, to the third lead in the stator.

3 The test lamp should glow. If there is any damage or burning or overheating of the winding, renew the stator assembly.

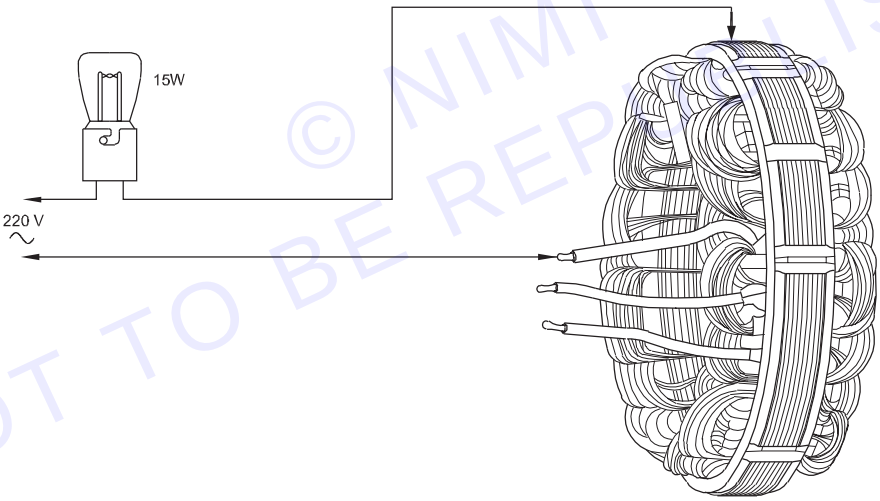
Fig 1



TASK 5: **Test for short circuit in stator**

1 Check the insulation of the stator windings by connecting a 220 V AC mains with a 220 Volt. 15 W test lamp in series between the stator laminators and each one of the three stator lead one by one. The lamp should not glow. It the test lamp glows then the stator winding is defective, renew the same (Fig.1).

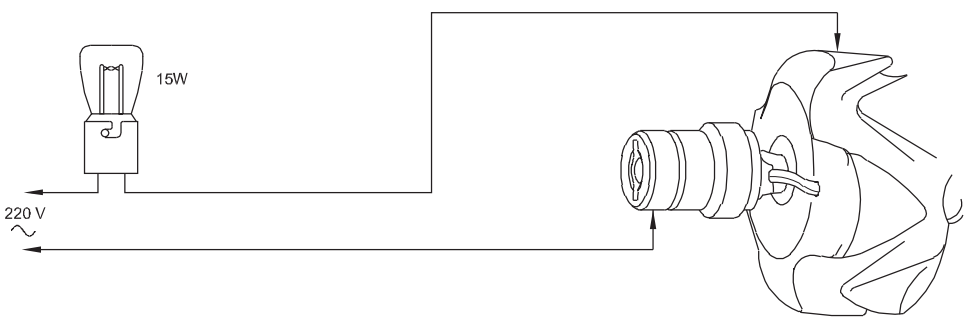
Fig 1



TASK 6: **Test for short circuit in rotor**

1 Check the rotor winding insulation by connecting to a220 V AC mains with a 220 V 15 watt test lamp in circuit between either of the slip-rings and the rotor body. The lamp should not glow. If the lamp glows then the rotor winding is defective; rotor assembly need renewal (Fig 1).

Fig 1



TASK 7: **Test for open circuit in Rotor winding**

1 Check the motor winding continuity by connecting a12 V/ 24 V battery and the moving coil ammeter between the slip-rings.

The current should be 2 to 2.5 Aapproximately for 12 V. If it is not of the correct value then renew the rotor.

2 Check the resistance of the rotor winding with an ohmmeter.

3 The resistance should be 9.6 to +/- 1 ohms for a 24 V alternator and 3.2 +/- 0.5 ohms for a 12 V alternator. If the readings are not within the limit, renew the rotor assembly.

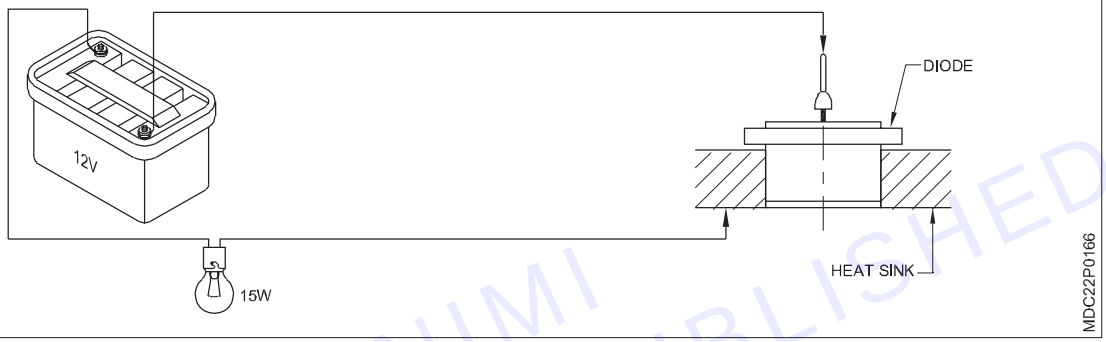
— — — — —

TASK 8: **Testing diodes**

1 Test each diode separately by connecting a 12 V battery and 12 V, 15 W bulb in series with the diode.

Connect one test lead to the diode connecting pin and the other lead to the heat sink. (Fig 1)

Fig 1



2 Watch if the lamp glows. Then reverse the test lead connections. The lamp should glow during one direction of the test connection only.

3 Replace the diode if required.

— — — — —

TASK 9: **Check the slip rings**

1 Check the slip-rings(12) for their trueness in a lathe and with a dial test indicator. Check the surface of the slip-ring for burnt or dirt. Replace the slip-ring, if required.

While assembling ensure that the scribed reference lines are in alignment.

2 Assemble the rotor assembly (21) with the drive and bearing (22) to the drive end bracket (14) and fix the bearing retainer (24) with screws.

3 Assemble the spacer (18) woodruff key (20), fan (19) and pulley (17) on the rotor shaft (23).

4 Assemble the stator assembly (13) to the drive end bracket (14).

5 Place the rectifier assembly to the slip-ring end bracket and fix the screws.

6 Place the slip-ring end bracket (9) and fix the fixing bolt/stud.

7 Solder the stator winding cable ends to the rectifiers.

8 Place the brush-box on the slip-ring end bracket (9) and fix the screws.

9 Place the sealing pad and place both the brushes.

10 Place the delivery brush mounting plate in position and fix the screws.

11 Place the regulator (4) on the brush-box and connect the regulator leads (3) & (5) and fix the screws.

12 Place the cover and fix the cover securing studs (1) and washer (10) and tighten the nuts (2) firmly.

Alternator Bench Tests

If the on-vehicle checks have indicated that the alternator is defective, it should be removed for bench testing and replacement. Specific procedures for removal, disassembly, inspection, and assembly are noted in the appropriate repair manuals. Only the electrical bench tests are covered here.

- Always disconnect the battery ground (-) cable before removing the alternator.
- Refer to the appropriate repair manual for test specifications.

An ohmmeter is used for electrical bench tests on the rotor, stator, and diode rectifier. The following steps are typical.

Rotor Tests

- Check the rotor for an open circuit by measuring for resistance between the slip rings.
- Some resistance (less than 5 ohms) indicates continuity.
- If there is no continuity (infinite resistance), replace the rotor.
- Check the rotor for grounded circuits by measuring for resistance between the rotor and slip ring.
- Any amount of resistance indicates a ground (continuity). The resistance should be infinite.
- If not, replace the rotor.

— — — — —

MODULE 11: Ignition System

EXERCISE 11.1: Overhauling magneto assembly

Objectives

At the end of this exercise you shall be able to

- remove the flywheel of the magneto assembly
- dismantle the magneto assembly
- check the CB points, condenser cam and adjust CB points gap
- check the magneto coils
- assemble the magneto assembly.
- set ignition timing

Requirements

Tools/Instruments

- Digital multimeter - 1 No.
- Continuity meter - 1 No.
- Ohm meter - 1 No.
- DE spanner 6 to 32 - 1 Set
- Electrical tester - 1 No.
- Executive auto electrical toolkit - 1 Set
- Pulley set universal for bearing & bushes - 1 No.
- Flywheel holding tool - 1 No.

Equipments/Machines

- Single cylinder four stroke petrol engine - 1 No.
- Ignition timing light - 1 No.
- Spark plug gauge - 1 No.
- Spark plug spanner - 1 No.

Materials

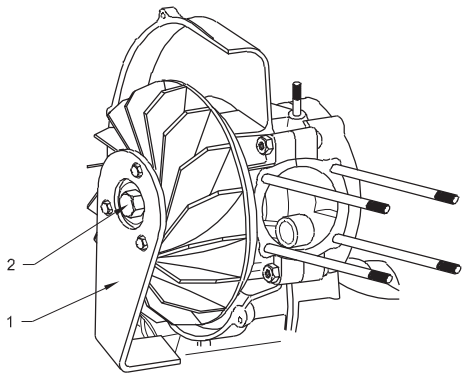
- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Petrol - as reqd.
- Engine Oil - as reqd.
- Coolant - as reqd.
- Insulation tape - as reqd.
- Test lamp - 1 No.
- Spore magnetic coils - 1 Set
- Spore CB point assembly - 1 Set
- Spare condenser - 1 No.

Procedure

Dismantling

- Remove the magneto cover by unscrewing the screws.
- Remove the dust cap by removing the circlip with the help of a screwdriver.
- Lock the magneto flywheel by means of the holding down tool (1). (Fig 1)

Fig 1



- Unscrew the flywheel lock-nut (2) in clockwise direction as the threads are left hand.
- Take out the spring washer and remove the flywheel (3) with a flywheel puller.
- Unscrew the clamping plate which has the wiring grommet and gasket. (Refer to figure)
- Disconnect the wiring from the junction box. Unscrew the bolts from the starter plate (4) with a suitable spanner and withdraw the starter plate.
- After removing the flywheel place a soft iron strip like a bridge across the flywheel magnet to prevent demagnetisation.
- Remove the screws holding the coils (6) and take out the coils. (Fig 2)
- Remove the screws holding the CB point plate assembly and take out the assembly (5).
- Remove the ignition cam ring after removal of its lock screw.
- Remove the spring (7) and separate the counterweights (8) of advance retard mechanism.

Cleaning and inspection

- Clean all the parts using kerosene and a nylon brush and allow some time for them to dry up.
- Check the contact breaker point for pitting and burning. If necessary, replace the CB assembly.

Condenser checking (Fig 3)

Fig 2

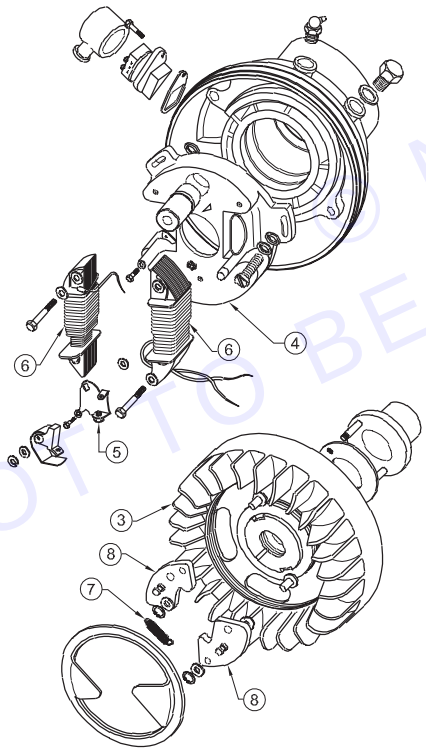
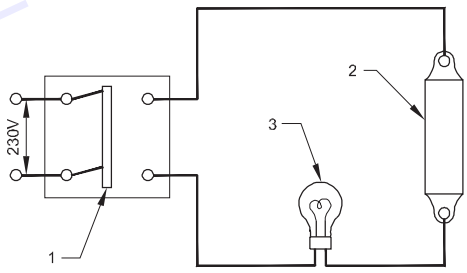


Fig 3



CONDENSER CHECKING

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- Check the fibre head for wear; if necessary replace it. Connect the condenser as shown in the figure. One side of the double plate, double throw switch (1) must be connected to the main, and the other side must be connected to the condenser (2) and test bulb (3) in series.
- Put on the switch (1). If the bulb glows the condenser must be replaced by a new one.
- If the bulb is not glowing then the condenser is in proper condition.
- Visually, check the cam, and replace, if required.

- Check the magneto coils for open and short circuit with the help of an AVO meter. If found damaged replace the coil with a new one.

Assembling the magneto assembly

- Refit coils and tighten the screws.
- Fix CB point assembly with its screws firmly. base and tighten mounting
- Fix the ignition cam ring on the flywheel hub (extended and lock it.
- Assemble the counterweights with tension spring inter posed on its lugs.
- Insert the counterweights (8) with spring (7) and place on the starter plate.
- Place the starter plate with the flange in its position are screw the bolts firmly.
- Connect the wires in the junction box.
- Connect the clamping plate with screws.
- Fix the flywheel by tapping with a mallet (wooden) so that it can be fitted properly. Ensure that the key is fitted in its groove.
- Place the spring washer and lock-nut in their position.
- Tighten the lock-nut in anticlockwise direction by locking the flywheel using a flywheel holding down tool. Fix the circlip in its position. Place the magneto cover and tighten it with screws.
- Fix the junction box and connect the wires.
- Fix the dust cap and lock with a circlip.
- Fit the magneto cover and lock it with screws.
- Crank the engine crankshaft and test for spark.

Setting the gap

- Remove the magneto distributor cover and rotor.
- Rotate the engine crankshaft until the ignition cam is in the position of giving maximum opening of the contacts.
- Observe the tip of the fibre piece of CB points assembly resting on the toe (highest point) of the cam.
- Insert the feeler blade of recommended thickness and measure the points gap.
- If not, adjust the gap as below.
- Slacken the CB points gap adjusting screw (small screw) and move the fixed contact plate by inserting the screwdriver in the slot and twist in a clockwise or anticlockwise direction and then finally lock the screw
- Once again check the gap with a feeler blade of specified thickness.

Setting the timing

- Remove the spark plug (use a plug spanner
- Turn the engine crankshaft and bring the piston to TDC of compression stroke.
- Observe the timing marks at the flywheel housing and base plate of magnets (use a hand lamp if not visible)
- Turn the engine once again slowly and align the timing mark on flywheel with mark on flywheel housing.
- Observe the CB joints whether they are in just opening position. (Note: The fibre tip should rest on the releasing face of the cam.)
- Make sure that the exact point of opening of CB points by the tip of the screwdriver. (If it is open, there will be a spark.)
- Refix the spark plug. Connect the ignition timing light
- Start the engine
- Pass the light on timing marls Ensure the timing marks coincide with each other. If not adjust the CB points and recheck it.

EXERCISE 11.2: Overhauling distributor

Objectives

At the end of this exercise you shall be able to

- remove distributor from engine
- strip a distributor
- clean a distributor
- Assemble a distributor
- mount a distributor on an engine.

Requirements

Tools/Instruments

- digital multimeter - 1 No.
- continuity meter - 1 No.
- ohm meter - 1 No.
- DE spanner 6 to 32 - 1 Set
- electrical tester - 1 No.
- executive auto electrical toolkit - 1 Set
- pulley set universal for bearing & bushes - 1 No.

Equipments/Machines

- Multi cylinder four stroke Petrol engine - 1 No.

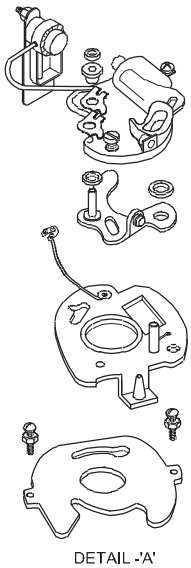
Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Soap Oil - as reqd.
- Engine Oil - as reqd.
- Coolant - as reqd.

Procedure

Dismantling

- Remove high tension wires from the distributor cap; note the order in which they are assembled.
- Remove the primary lead.
- Remove the distributor cap.
- Note the position of the rotor.
- Remove the screws and lift the distributor assembly from the engine.



DETAIL -'A'

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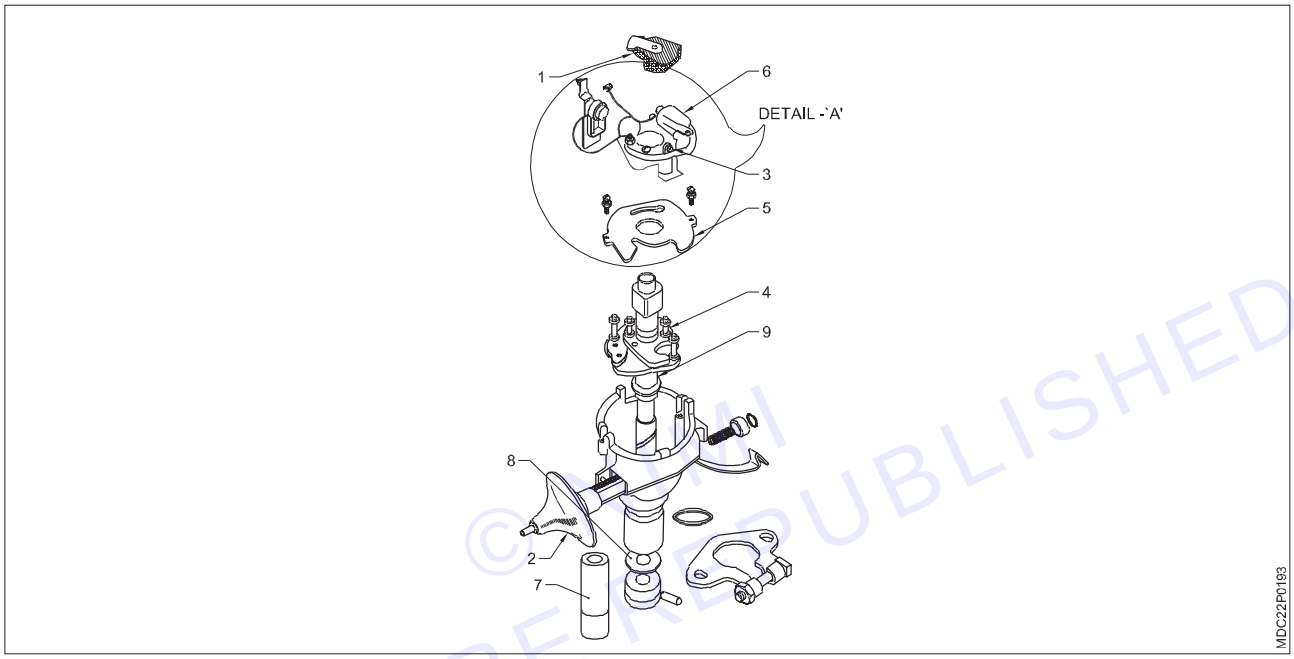
- Remove the rotor (1).
- Disconnect the vacuum unit (2) linkages.
- Remove the screws and lift the C.B. point assembly (3).
- Remove the centrifugal timing control assembly (4).
- Remove the C.B. point base plate (5).
- Remove the condenser (6).
- Dismantle the centrifugal timing control mechanism (4).
- Remove the bush (7) by press.



Inspection

- Check visually the C.B. point for pitting.
- Check the centrifugal weight springs for tension.
- Check the vacuum unit diaphragm for damage.
- Check the rotor arm play on the distributor shaft by rotating it by hand.
- Check the bearing bush (7) and thrust washer (8) for wear.
- Replace the parts which are damaged or worn out.

Assembly

- Assemble the bearing bush (7) by push fit. Smear engine oil over the shaft and place the distance collar (9).
- Refit the vacuum unit (2).
- Reassemble the centrifugal timings control unit (4). Smear grease on the base plate and fit the C.B. point base plates.
- Refit the condenser (6).
- Replace the C.B. point assembly (3).
- Fit the rotor on the shaft.
- Refit the distributor assembly to the engine.
- Adjust the C.B. point gap.

EXERCISE 11.3: Trouble tracing in the ignition circuit and components

Objectives

At the end of this exercise you shall be able to

- check continuity in ignition circuit
- check open circuits in ignition circuit
- check short circuits in ignition circuit
- check the spark plug for proper functioning
- check the ignition coil for proper voltage build up
- set ignition timing
- check a condenser for proper functioning
- set and adjust the ignition timing.

Requirements

Tools/Instruments

- digital multimeter - 1 No.
- continuity meter - 1 No.
- ohm meter - 1 No.
- DE spanner 6 to 32 - 1 Set
- electrical tester - 1 No.
- executive auto electrical toolkit - 1 Set
- pulley set universal for bearing & bushes - 1 No.
- Spark plug feeler gauge - 1 No.
- Spark plug spanner - 1 No.

Equipments/Machines

- Multi cylinder four stroke Petrol engine - 1 No.
- Ignition timing light - 1 No.
- Spark plug testing m/c - 1 No.

Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- petrol - as reqd.
- Engine Oil - as reqd.
- Coolant - as reqd.
- Test lamp - 1 No.
- Spark ignition coil - 4 No.
- Spark spare plug - 1 Set
- Spare HT wire set - 1 No.

Procedure

1 Check the battery terminals and tighten them if found loose

2 Using a AVO meter (multimeter) in 12 volts range, connect the leads on both the +ve terminals of the battery (1) and the ammeter (2) input lead to check continuity. Fig.1

3 Check the continuity between:

- Ammeter (2) and the ignition key (3).
- Ignition key (3) and ignition coil (4).
- Ignition coil (4), ignition point (5) and condenser (6)
- Ignition coil (4) and the distributor cap (7) motor.
- Distributor outer terminal (7) and each spark plug (8).

4 If there is any open circuit replace the defective leads. If any loose connections are found in the above circuit tighten them.

5 Check the ignition coil by (Fig 2) connecting the DC voltmeter (1) in parallel with the primary circuit and switch “ON” Note the reading in the voltmeter

Fig 1

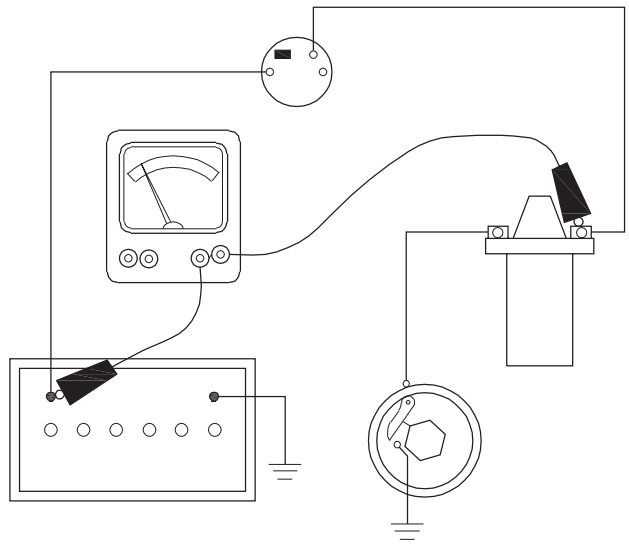
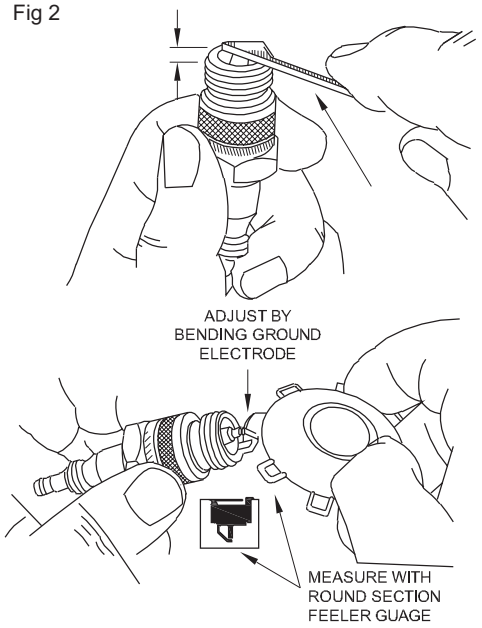


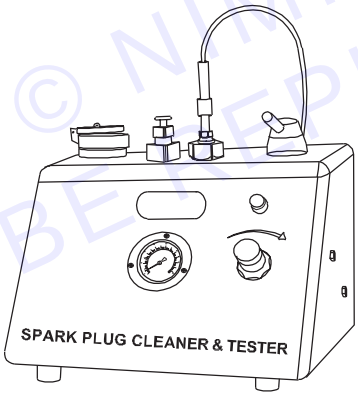
Fig 2



6 Clean the spark plug

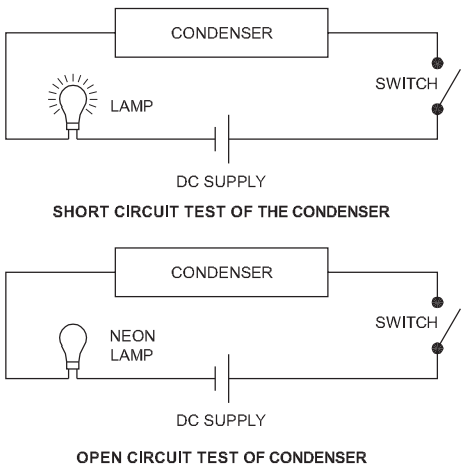
7 Check the spark plug in a standard spark plug tester shown in Fig 3. Check the spar plug Air gap and adjust it properly. If the spark plug invitation got damage replace the spark plug.

Fig 3



8 Check the condenser by connecting it in a circuit shown in Fig 4 If the circuit is shorted then the bulb should not glow If bulb glows replace the con- denser if the circuit is opened the bulb should glow or else replace the condenser.

Fig 4



9 Ignition coil windings check up

a Connect the multimeter and select the resistance mode

b Connect the multimeter lead to the primary coil terminal. If primary winding resistance is between 0.5 to 2.0 ohms. It means it is in good condition. If the multimeter reading is less than 0.5 ohms that primary windings is short circuited. If the reading is infinite value, it indicates the primary winding is open.

c Connect the multimeter leads from secondary coil terminal to one of the primary winding terminal. If the resistance value is 8000-20000 ohms, it is in good condition and if it is less than 8000 ohms secondary winding is short circuited. Infinite reading value is shown in the multimeter the secondary winding is open circuit.

10 Set the ignition Timing

- Rotate the crank shaft till TDC marks on the pulley.
- Flywheel coincides with the timing mark pointer.
- Open the distributor cover.
- Ensure the 1st cylinder piston at TDC compression stroke. If it is not in compression stroke, rotate the flywheel one complete turn.
- Turn the flywheel /Pulley in anticlockwise direction and match the timing mark at before TDC 5° position.
- Note down the CB point is just open condition in the distributor. If not adjust it properly by turning the distributor.

11 Checking of ignition timing using timing light

- Connect the timing light to battery and HT wire of 1st cylinder spark plug
- Start the engine
- Pass the timing light on timing marks and check the timing marks coincides before TDC 5° at Idle speed of engine. If not adjust the distributor.
- Recheck the ignition timing using ignition timing light.

MODULE 12: Emission Control System

EXERCISE 12.1: Checking exhaust gas in petrol engine using exhaust gas analyser

Objectives

At the end of this exercise you shall be able to

- use of 4/5 gas analyser
- installation of 4/5 gas analyser
- setup of instrument for measuring emission parameter
- perform leak test
- measure CO, HC, CO 2 , O2 , X, AFR/NOx
- examine the result.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- 4/5 gas analyser - 1 No.
- Screw Driver - 1 No.

Equipments/Machines

- Petrol Engine vehicle - 1 No.

Procedure

TASK 1: **Installation**

Note: Safety instructions

1. **Verify the use of power source AC 220V only before prior use.**
2. **This procedure applies to the product of 4/5 gas analyser (Fig 1).**
3. **It should not be used in polluted environment**
4. **It should be used less than 1000m in height and less than 85% in relative humidity**
5. **The emitted gas normally has co which may lead to fatal damage to a human body. Hence it must be used in well-ventilated area.**
6. **The probe gets too hot by exhaust gases, so, be careful while inserting or removing from the exhaust pipe**
7. **It should be set up atleast 25 cm from the ground surface.**

- Fit end of the probe hose into the measuring probe and the other end of the hose into the gas inlet in the rear of the analyzer (Fig 2). If the fitting condition is not good and the air comes into flow from outside, it may yield an incorrect measured value. Therefore, please carefully verify the fitting condition before use.
- Turnoff the power switch and then connect the power cable to the power socket located in the rear of the analyzer
- Verify the fitting conditions of measuring probe filter and various filters located in the rear of the analyzer. Change the filters if necessary
- Verify again the connection status of the analyzer and then turn on the power switch.

Fig 1

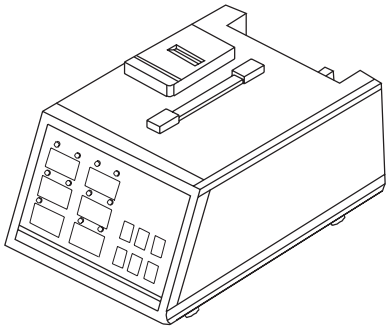
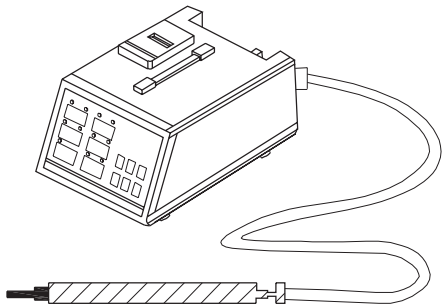


Fig 2



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TASK 2: **Measurement**

Measurement Mode

1 Place the probe in the clean air to perform the [Zero calibration].

2 Start the vehicle and run the engine. Push the probe deep into the exhaust outlet of the vehicle at least ¾ length of probe and measure exhaust gas by pressing measurement key (Fig 1 & Fig 2).

3 The measurement operates for 30 minutes and the pump is automatically stopped by the activation of the power-saving mode. Press MEAS (Macro Economic Application System) key again to measure the exhaust gas for more than 30 minutes.

4 Pull the probe out of the exhaust outlet of the vehicle. Then clean the inside of analyser with the clean air by pressing the PURGE key until the measurement values drop to 0. (Fig 1)

5 If all the measurements fall close to 0, press STAND- BY key to maintain instrument in a stand by mode.

6 Press the ZERO key for a series of measurement. Then, repeat the steps 2,3& 4.

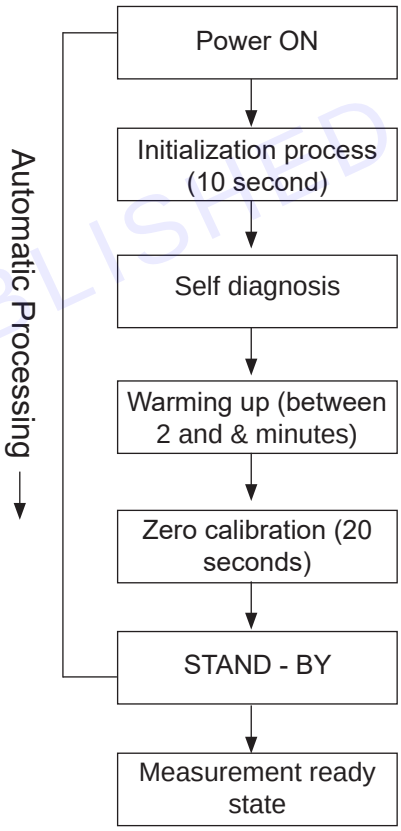


Fig 1

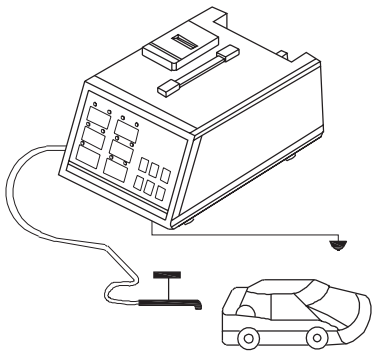
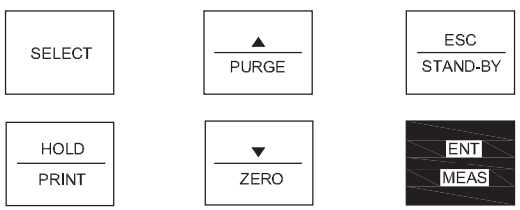


Fig 2



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TASK 3: **Leak test**

1 Press the SELECT key (Fig 1) once in the stand-by mode to select the Leak Test mode

2 If the message 'Leak test' is indicated on the indication window as shown above (Fig 2) mount the leak test cap on the front side of the probe.

3 Press ENT key. The pump operates and the count values decrease by 1 from 20 during the 20-second leak test

4 If the test turns out normal without any leak after 20 seconds, a message is indicated as 'PASS". If the leak is identified, the message is indicated as 'FAIL'.

Fig 1

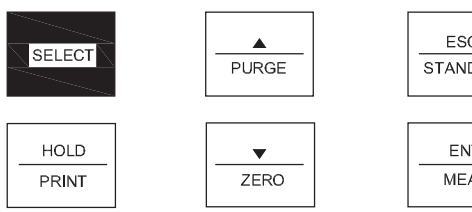
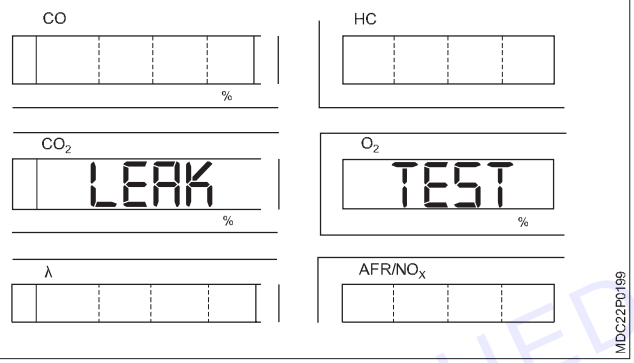


Fig 2



TASK 4: **Selection of fuel**

1 Select fuel. Use, keys until it indicates the fuel to select.

2 Press ENT key to setup the selected fuel.

3 For Example, If the "LPG" fuel is selected, the window indicates as shown in the below (Fig 2)

Fig 1

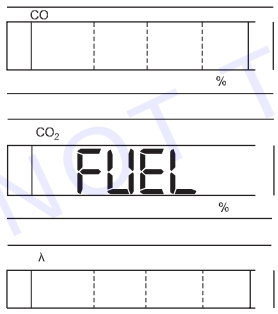
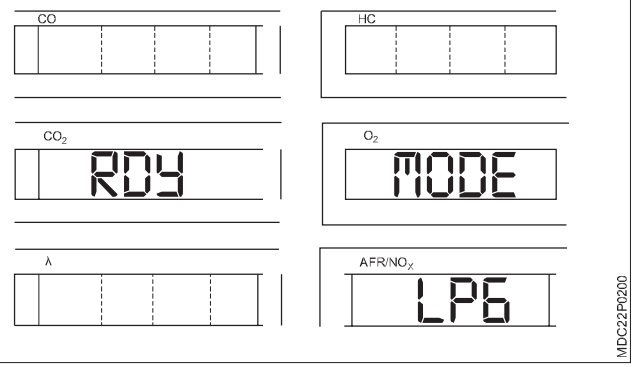


Fig 2



TASK 5: **NO X setup**

1 Press select key for eight times in standby mode

2 Key changes display to YES or to NO.

3 Select YES for NOX display mode, NO for non- NOX display mode, then press ENT

TASK 6: **Examine the results**

Compare the test results with std value of emission standards and identify the cause of a drive-ability problem as shown in the table below .

	IDLE	2500 RPM	Probable cause
HC ppm Co% CO2 O2% NOx ppm	0-150 1-15 10-12 0.5-2.0 100-300	0-75 0.0.8 11-13 0.5-1.25 200-1,000	Normal reading
HC ppm Co% CO2 O2% NOx ppm	0-150 3.0+ 8-10 0.-0.5 0-200	0-75 3.0+ 9-11 0-0.5 100-500	Rich mixture
HC ppm Co% CO2 O2% NOx ppm	0-150 0-1.0 8-10 1.5-3.0 300-1000	0-75 0-0.25 11 1.0-2.0 1000+	Lean mixture
HC ppm Co% CO2 O2% NOx ppm	50-850 0-0.3 5-9 4-9 300-1000	50-750 0-0.3 6-10 2-7 1000+	Lean misfire
HC ppm Co% CO2 O2% NOx ppm	50-850 0.1-1.5 6-8 4-12 0-200	50-750 0-0.8 0-10 4-12 100-500	Misfire

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EXERCISE 12.2: Checking exhaust gas in Diesel engine using smoke meter

Objectives

At the end of this exercise you shall be able to

- use of smoke meter
- installation of smoke meter
- setup of instrument for measuring emission parameter
- perform free acceleration test
- measure Light absorption co efficient and Opacity in hat ridges
- examine the result.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Smoke tester - 1 No.
- Screw Driver - 1 No.

Equipments/Machines

- Diesel Engine vehicle - 1 No.

Materials

- Cotton cloth - as reqd.
- Diesel - as reqd.

Procedure

Installation of smoke meter

Before switching on, ensure that

- The preselected mains voltage indicated on the rating plate is correct for the local voltage
- There is enough printing paper
- The correct sampling probe is connected to the exhaust pipe of the engine being tested
- The flexible exhaust gas hose is connected to both the probe and the unit. (optional)

Note: Hose should lie at an ascending gradient to the unit

- Check that the operating units properly connected to the control unit.
- Position the equipment where strong vibrations, heavy dust or soiling cannot affect it.
- The equipment should be placed on an even surface where there is no danger of it tipping over.

Note: Diesel fumes are noxious. Ensure adequate air circulation in the test room and proper ventilation for exhaust fumes.

Pre-measurement preparations

The vehicle must attain the manufacturer's specified operating temperature before measurement can begin.

- Carefully clean the glass of the light and detect or assemblies with as of cloth.
- Place the sampling hose at an ascending gradient from probe to sensor unit.
- Plug into mains power socket.
- Switch the equipment ON by pressing the Power Key.

- Observe the instantaneous measuring chamber temperature is continuously displayed on the operating unit. A temperature of 70°C is reached after approx.20 minutes (assuming operation at 220V). The equipment is then ready for use and the equipment switches automatically to CAL mode.

  NB: Each key of the operating unit has a green LED which does not light up until1 to 2 seconds after the key is pressed. If the LED does not light up immediately after the key is pressed, this does not indicate any functional deficiency. Press that Key again.

- Note down the fans are switched on immediately after power up. The light source and the detector are like wise activated. A “0.0” appears on the digital display (which means 0% opacity). Gently push the lever placed on the left side on the unit till the green LED light sand keep it pressed till dead end for minimum 5 sec as per instruction given on 10-1. The equipment carries out an internal check using a calibration plate of around 49% opacity and then automatically prints out the measured opacity value.
- Note down If” Err” appears on the display when CAL is pressed, clean the detect or and light assembly glass with a soft cloth

Linearity check

Ensure The actual value should conform with the instrument –specific value indicated on the linearity label at the front panel.

Figure: Protocol print out after LINEAR CHECK

Performing free acceleration tests

Note: Make sure before each test that the high idle speed is not exceeded, e.g. due to mal functioning of governor

Procedure to operate the Smoke meter With RPM and Oil Temperature

1 Switch off the engine.

2 Take out the dipstick.

3 Adjust the oil temperature sensor equal to the length of Dipstick.

4 Plug the oil temperature sensor in to oil sump and other side to Smoke meter.

5 Connect RPM Sensor on Vehicle Engine

6 Now switch on the Smoke meter by inserting power ON of the Smoke meter.

7 After switching on the Smoke meter shows the value 0.0 and CALLED glows. Now the equipment is in CAL mode.

8 Press the TEST key given on the remote.

9 Now press the AUTO key given on the remote.

10 Now you will see 1 written on the remote screen.

11 Select the band width by pressing the Display Select button. If you select band width as1 then the actual readings will be processed on the basis of band width as 1 then the actual readings will be processed on the basis of band width decided as average of the maximum and minimum RPM+/- 300-RPM. If you select band width as 2 then the actual readings will be processed on the basis of band width decided as average of the maximum and minimum RPM+/-500-RPM, for accepting the selection press AUTO key again.

12 After selecting the rpm range, again press AUTO key.

Display screen will again show one, which correspond to first reading of the Flushing cycle.

13 Accelerate the vehicle from minimum to maximum smoothly till the AUTO LED starts blinking.

14 Press the AUTO key to go to second reading and continue the six flushing cycles.

15 As soon as the six threading complete, pressing the AUTO key will give the print out of the readings of the three flushing cycles.

Eg.

501	5018
501	5017
501	5019

Mean Value

501	5018

16 Press again the AUTO key to start the actual test.

17 Actual test procedure:

- Note down the value1 appears on the digital display indicating that the unites ready for the first free acceleration test during the next 5 sec the gate to the micro processor or memory is open and scans for the peak opacity and stores it.
- Depress the accelerator pedal smoothly and completely and keep it there.
- The engine will be accelerated from low idle to high idle (govern or cut off speed).
- Keep the engine at high idle for about 5 sec and then release the accelerator pedal. The gate to the memory of the micro processor is closed for 3 sec after the initial 5 sec have elapsed. The peak value of this test is indicated at the digital display.The flashing of the LED at AUTO key indicates the next cycle can start.
- Press AUTO-key. The value 2 indicates the readiness of the unit for the second free acceleration test.
- Continue as pre scribed above.
- Repeat procedure until 3 valid free acceleration tests have been performed.
- Press AUTO again For 3 sec (“....”) appears then the mean value of the 3 valid test peak values is indicated and the test report is printed.

Be interrupted by not pressing the indication test for minimum 30 sec sand thus gives a protocol printout indicating the results of the tests taken.

18 As the test completes you will again get the printout of the actual readings. Eg.

Smoke meter

Pre scr.value:2.45m-1 As per CMVR

Date:Mon,17-May-2004 Time:02:53

Vehicle:……

Model:……...

TEST CONDITIONS

Voltage: OK

SmokeTemp.: 40° C

RPM MIN	RPM Max	T °C	HSU %	K m-1
*501	5018	69	18.5	0.47
*501	5017	69	19.3	0.49
*501	5018	69	19.1	0.49

Valid Readings

Smoke Mean Value

18.9%0.47m-1

19 Switch off the engine.

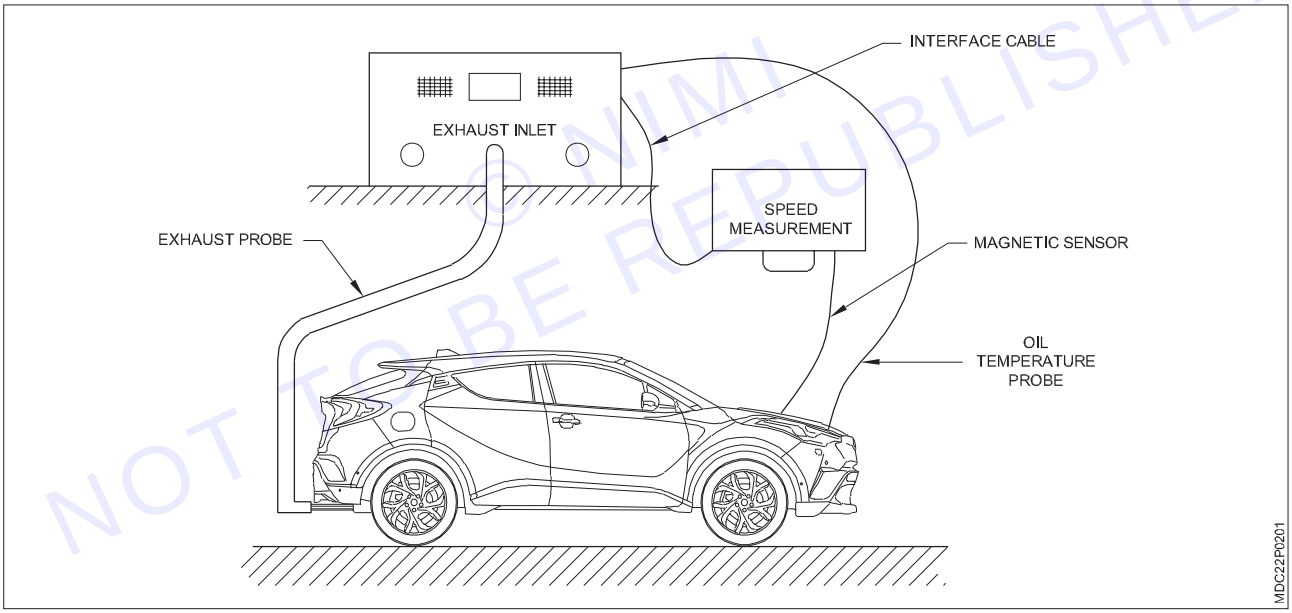
20 Remove the hose.

21 Remove the oil temperature probe.

22 Remove the rpm sensor.

23 Compare the actual readings with Test Limits:

Method of Test	Maximum Smoke Density	
	Light absorption co-efficient (1/m)	Hartidge units
Free acceleration test for turbo charged engine and naturally aspirated engine	2.45	65 Before BSIV
Free acceleration test for turbo charged engine and naturally aspirated engine	1.62	50 BS IV



EXERCISE 12.3 : Checking of positive crankcage ventilation system

Objectives

At the end of this exercise you shall be able to

- inspect PCV hose
- inspect PCV valve.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Digital multimeter - 1 No.
- 12V battery - 1 No.
- Scan tool - 1 No.

Equipments/Machines

- Diesel Vehicle -1No.

Materials

- PCV solvent / lacquer thinner - as reqd.
- Baniyan cloth - as reqd.
- PCV valve - 1 No.
- EVAP - 1 No.

Procedure

TASK 1: **PCV HOSE Inspection**

1 The PCV valve is usually located next to the valve cover of the engine, or in the intake manifold.

2 If you cannot identify it quickly, check with the work shop manual.

3 Check hoses for connection, leakage, clog and deterioration. Replace as necessary.

TASK 2: **PCV valve inspection**

1 Switch on the ignition and start the engine. With the engine idling, pinch the hose attached to the PCV valve hard enough to shut off the supply of air through it. If the valve is working correctly, the idle speed should drop enough for you to be able to hear the change.

2 Or Disconnect PCV valve from cylinder head cover and install plug to head cover hole. (Fig 1)

3 Run engine at idle speed.

4 Place your finger over end of PCV valve (1) as shown in Fig 2 to check for vacuum. (Fig 2)

Fig 1

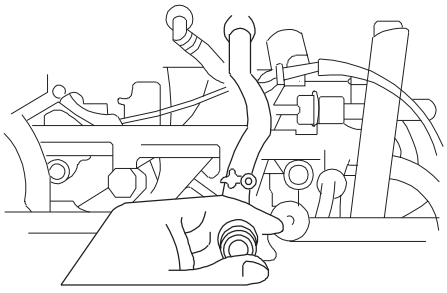
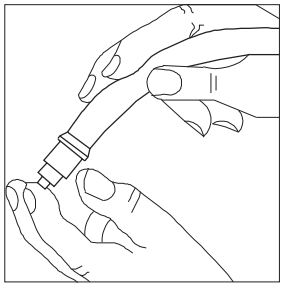


Fig 2



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5 If there is no vacuum, check for clogged valve.

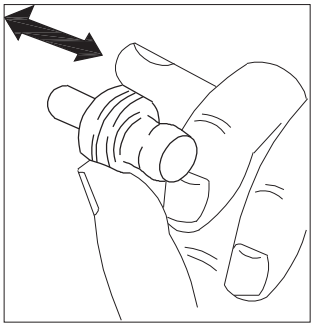
6 Try cleaning it and to observe if it is working by with PCV solvent or lacquer thinners or immersing it in carburetor cleaner. There should be no gummy deposits or discoloration on a clean valve.

7 If your PCV valve must be replace, buy a new valve, remove the old one, and insert the new one in its place.

8 After checking vacuum, stop engine and remove PCV valve Fig 3 (1) Shake valve and listen for the rattle of check needle inside the valve. If valve does not rattle, replace it.

9 After checking, remove plug and install PCV valve.

Fig 3



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EXERCISE 12.4: Remove and Refit EGR Valve

Objectives

At the end of this exercise you shall be able to

- identify EGR Valve
- disconnect EGR valve connection
- measure EGR Valve Resistance
- remove EGR Valve
- inspect EGR valve
- replace EGR Valve.

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Screw Driver set - 1 No.
- Box Spanner set - 1 No.
- Digital Multimeter/Ohmmeter - 1 No.

Equipments/Machines

- Diesel Vehicle - 1 No.

Materials

- Tray - 1 No.
- Cotton waste - 1 No.
- Kerosene - as reqd.
- Vacuum hose - as reqd.
- EGR valve - 1 No.

Procedure

1 Locate the EGR Valve (Fig1)

2 Disconnect negative terminal cable from battery.

Warning: Work must be started after 1min from the time ignition switch is turned on to LOCK position and the negative (-) terminal cable is disconnected from the battery.

3 Disconnect exhaust gas recirculation valve connector (Fig 1)

4 Inspect exhaust gas recirculation valve resistance

5 Using an ohmmeter measure the resistance between terminal B1 (or B2) and other terminals (S1, S2,S3 and S4) (Fig 2)

Fig 1

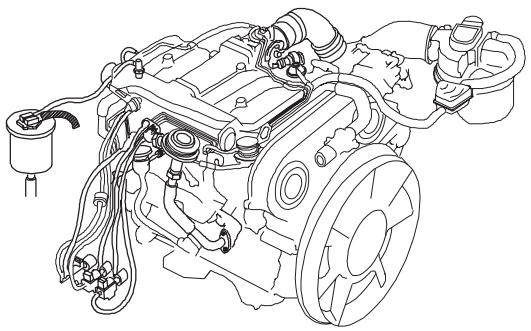
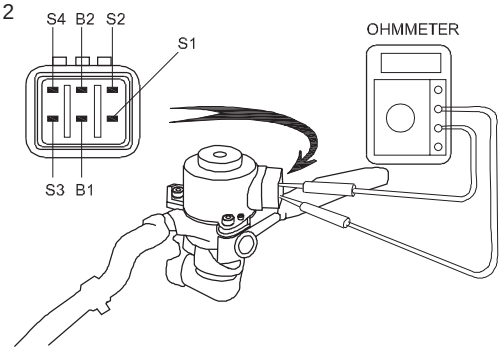


Fig 2



6 Resistance (Cold) should be 19.9 to 23.4 Ohms

7 Drain engine coolant

8 Remove exhaust gas recirculation valve

9 Disconnect the water bypass hose (from IAC Valve (Fig 3) (1)

10 Disconnect water bypass hose (from rear water bypass joint) (Fig 3) (2)

11 Remove the nuts of exhaust gas recirculation valve and gasket (Fig 4)

Fig 3

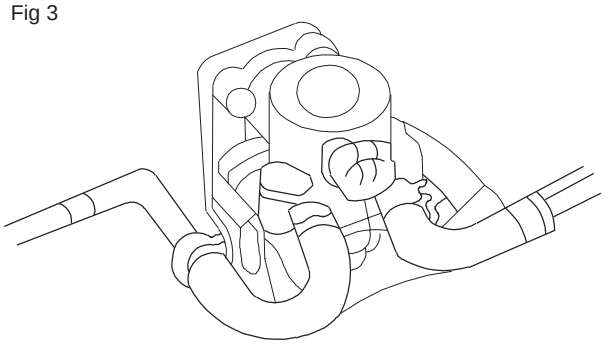
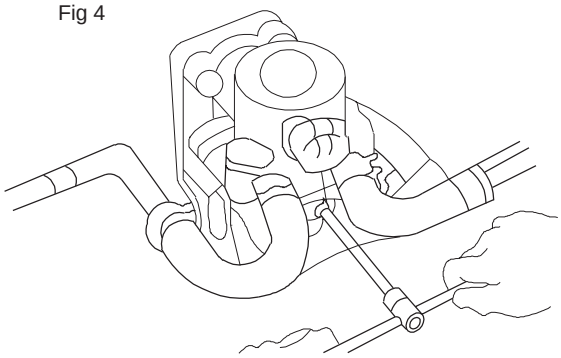


Fig 4



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12 Visually inspect EGR valve for sticking and heavy carbon deposits (Fig 5)

13 If problem is found replace the EGR valve assembly.

14 If not, Inspect EGR valve operation.

15 Apply battery voltage to terminal B1 and B2,and while repeatedly grounding (Fig 6) (*S4) - (S4 and *S3)-(S3 and *S2)- (S2 and *S1) - (S1 and *S4) in sequence, and check that the valve moves towards the open position. (Hint: Keep the terminal marked with an asterisk (*) grounded to the next grounding.)

Fig 5

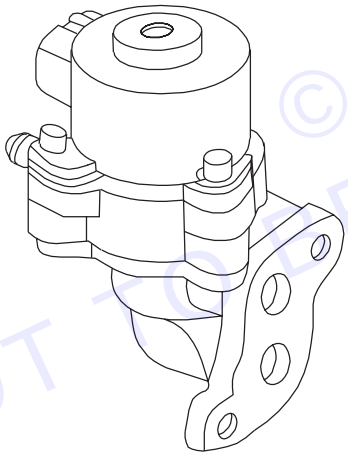
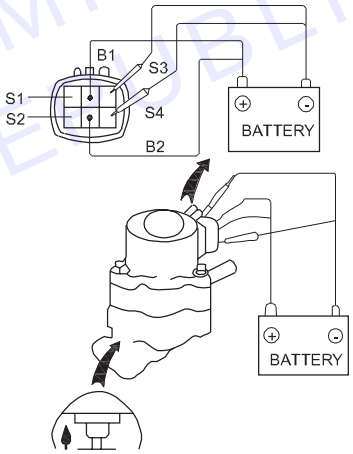


Fig 6



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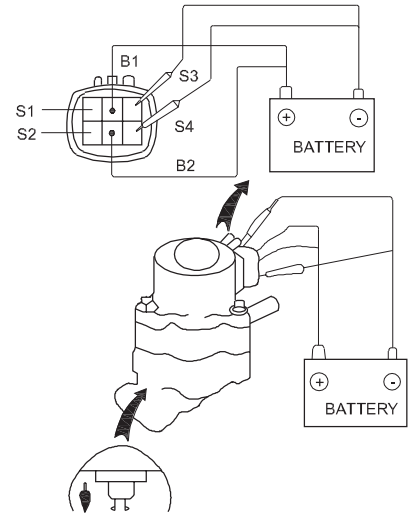
16 Apply battery voltage to terminal B1 and B2,and while repeatedly grounding (Fig 7) (*S1) - (S1 and *S2)- (S2 and *S3)- (S3 and *S4) - (S4 and *S1) in sequence, and check that the valve moves towards the closed position.(Hint: Keep the terminal marked with an asterisk (*) grounded while proceeding to the next grounding.

17 Perform this operation after opening the valve by performing the step above.

18 If operation is not as specified, replace the EGR Valve assembly.

Fig 7



MODULE 13: Trouble Shooting of HMV

EXERCISE 13.1: Check the performance of running engine by observing the dash board meters/ warning lights

Objectives

At the end of this exercise you shall be able to

- prepare the engine for starting
- start the engine
- observe the dashboard meters and warning lights
- replace the instruments and gauges
- stop the engine.

Requirements

Tools/Instruments

- Trainee's toolkit - 1 No.
- Lead acid battery12V with cables - 1 No.

Equipments/machines

- Running condition of Diesel HMV - 1 No.

Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Soap Oil - as reqd.
- Engine Oil 20W 40 - as reqd.
- Coolant - as reqd.

PROCEDURE

TASK1: **Prepare the engine for starting**

- Check the water level in the radiator and top-up if needed.
- Check the engine oil level and top-up if needed.
- Check the electrolyte in the battery and top up with distilled water.
- Insert the key in the mains switch and turn the key to the 'ON' position.
- Check whether glow plug is ON for 10-15 seconds and goes off.

Note down the warning lights in dashboard.

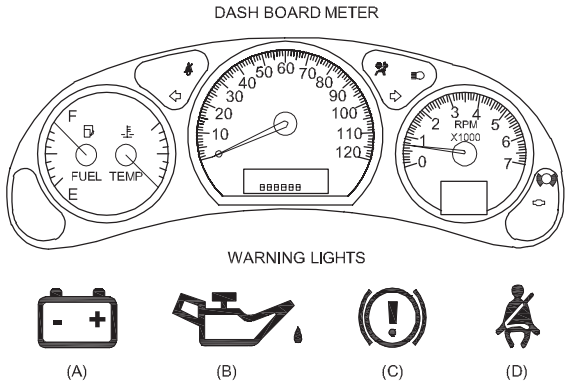
- Battery lights glows in red (i.e. battery discharging) (Fig1A)
- Malfunction Indication lamp glows
- Engine oil light glows in red(i.e.oil is low(or)nil)(Fig 1B)
- Parking brake light glows in red(i.e parking brake is applied) (Fig 1C)
- Seat belt light glows in red (i.e. driver not wear the seat belt) (Fig 1D)
- Release the parking brake (now light not shown red)

— — — — —

TASK 2: **Start the engine (Fig 1)**

- Press the starter push button Fig 1 or turn the ignition key further to start the engine.
- Wear the seat belt properly(now light not shown red)
- Shift the gear to neutral position.
- Observe the fuel gauge reading it shows empty to full.

Fig 1



- Observe the temperature gauge reading it shows minimum temperatures
- Release the starter button / ignition key as soon as the engine has started

If the engine does not start immediately do not keep starter button (pressed (or) key turned) beyond 10 seconds. This leads to the battery will get discharged and over- heated.

- Check the idling speed R.P.M in R.P.M meter.
- Press the accelerator pedal to increase engine r.p.m steadily and allow the engine to warm up.

— — — — —

TASK 3: **Observe the dashboard meters/warning lights during engine run**

- Start the engine and check the warning lights fitted in panel boards
- Observe the battery warning light it's not glow (ie. Battery is charging)
- Observe the malfunction indication lamp goes off(All electronic circuit is ok)
- Observe the engine oil warning light it's not glow(i.e. oil pump is working)
- Observe the oil pressure gauge.
- Observe the water temperature in temperature gauge.
- Observe the reading of tachometer.
- Observe the odometer reading during vehicle (moving) running.
- Observe the trip meter reading.

— — — — —

TASK 4: **Replace the defective gauges and instruments**

1 Note down If any warning lights is not glow, check the connection and bulbs if defective replace the bulb and rectify the loose wire connections

2 Check RPM meter if defective replace it.

3 Check the fuel gauge and temperature gauge for defects and replace the defective gauges

4 Move the vehicle and check the speedometer of RPM meter during vehicle run

5 If odometer & RPM meter is found defective, check the wire and cable connections, and replace the defective gauge sensor wire connections.

6 After replacing the defective gauges and instruments check the all gauges and warning lights functions (before starting and after starting the engine)

— — — — —

TASK 5: **Stop the engine**

1 Remove the foot from accelerator pedal.

2 Turn the ignition key to the OFF position to stop the engine.

— — — — —

EXERCISE 13.2: Tuning up the engine

Objectives

At the end of this exercise you shall be able to

- check battery capacity
- test for compression
- check & replace air filter, oil filter & Engine oil
- check the injector function and replace injector.

Requirements

Tools/Equipments

• digital multimeter space	- 1 No.
• continuity meter	- 1 No.
• ohm meter	- 1 No.
• DE spanner 6 to 32	- 1 set.
• compression tester	- 1 No.
• executive auto electrical toolkit	- 1 set.
• Battery tester	- 1 No.

Equipments

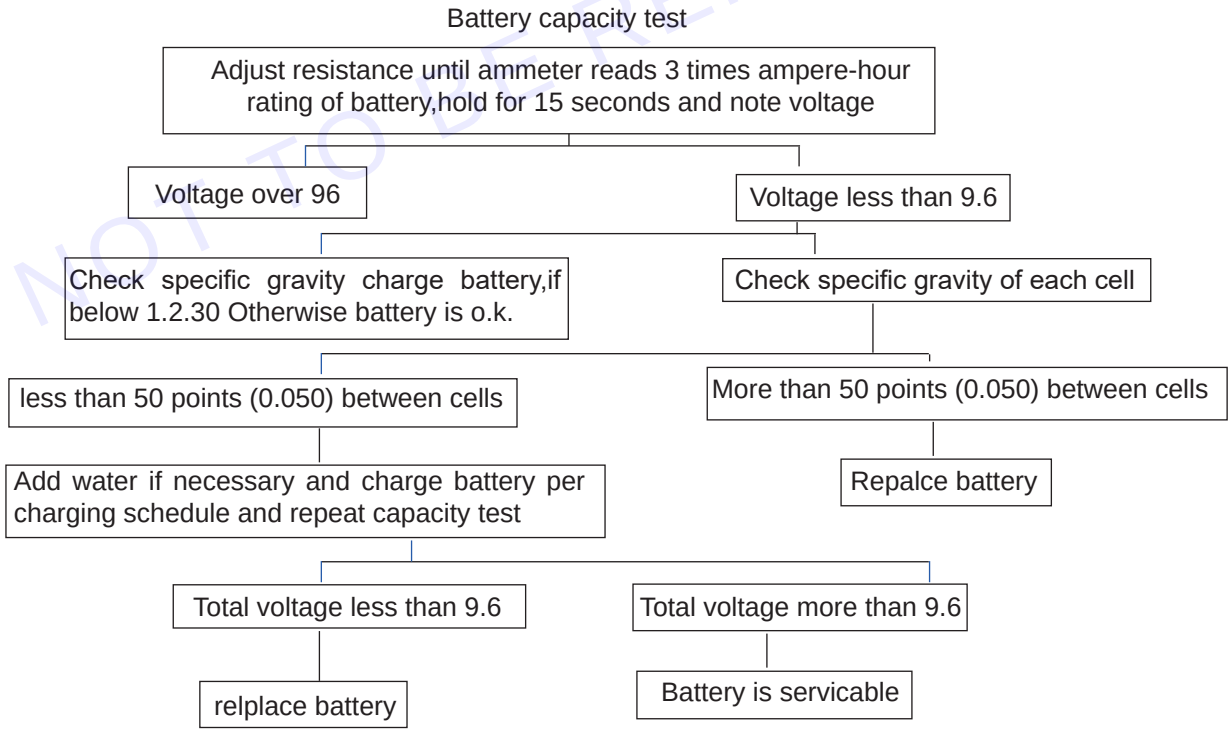
• Running condition of Diesel HMV	- 1No.

Materials

• Tray	- as reqd.
• Cotton cloth	- as reqd.
• Kerosene	- as reqd.
• Diesel	- as reqd.
• SoapOil	- as reqd.
• EngineOil 20 W 40	- as reqd.
• Coolant	- as reqd.
• Air filter	- 1 No.
• Oil Filter	- 1 No.
• Injector	- 4 Nos.

Procedure

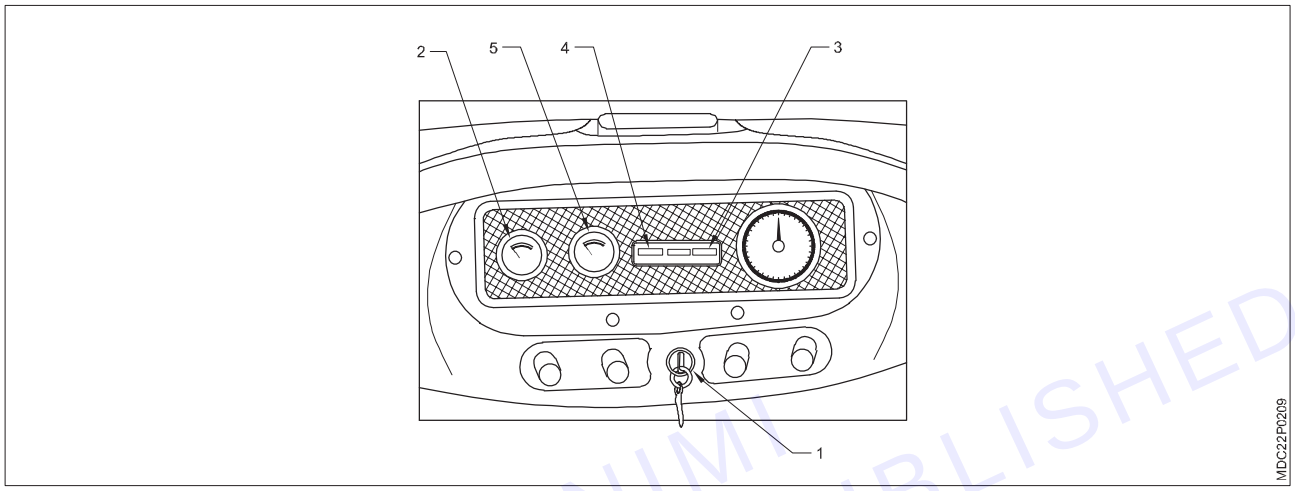
Battery check up



Disconnect the battery terminals remove & lift the battery. from vehicle clean and follow the test

Prepare the engine for test

- Check the water level in the radiator and top up if needed.
- Check the engine oil level and top up, if needed.
- Check the electrolyte level in the battery and top up with distilled water if needed.
- Insert the key in the main switch (1) and press fully in and turn the key to the “ON” position.
- Observe the ammeter (2) on the instrument pannel. The indicator of the meter will show slightly on the discharge side (-ve side) of the meter and the ignition bulb (3) will glow red and also the oil pressure indicator (4) will glow.



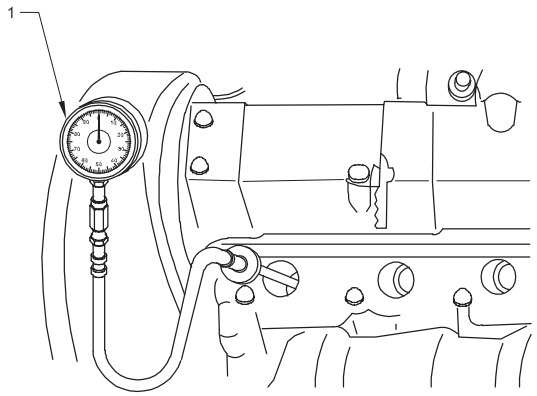
- Observe the fuel gauge (5). The indicator indicates the fuel in the tank from empty to full. Note down the quantity of fuel in the fuel tank
- Depress the accelerator lever fully
- Press the starter button or turn the ignition key further and crank the engine Release the starter button/key as soon as the engine has started
- Once the engine starts do not touch the starter switch
- It the engine does not start immediately do not keep the starter button pressed or key turned beyond 10 seconds otherwise, the battery will get discharged or the teeth of the flywheel ning and pinion will get damaged or the self- starter motor will get damaged.
- Raise the engine r.p.m. steadily and allow the engine to warm up.
- Observe the ammeter. The indicator on the positive side shows charging of the battery.
- Observe the oil pressure indicator.
- Note down the temperature of the water on the temperature gauge
- Note down the oil pressure at full throttle.
- Compare the observations made with the manufacturer’s specification.
- Depress the accelerator steadily to full throttle, and observe the exhaust smoke.
- Note down the colour of the smoke as black/white/blue.

Compression test

- Start the engine and run it at idle speed for a few minutes to bring it to operating temperature.
- Loosen the Injector
- Remove all the Injectors.

Dry test

Fig 2



- Install the compression gauge '1' on the first cylinder.
- Press the accelerator lever.
- Crank the engine with the starter motor and read the highest pressure on the compression gauge.
- Note the reading and release the pressure from the compression gauge.
- Repeat the procedure for all the remaining cylinders and note down the reading.

Wet test

- Put 10 ml of engine oil in the first cylinder.
- Crank the engine to circulate the oil around the piston and piston rings.
- Repeat the procedure to take the compression pressure reading as given in the above steps.
- Take the reading for all cylinders by pouring oil in each cylinder.
- Note down the difference of the readings in the dry and wet tests.
- Put back all the Injectors and tighten at the recommended torque.
- Confirm the engine does not have any leaks at the cylinder head.If any leak happens at valve side or gashet,get it repair

Check the air filter,oil filter and engine oil

- Check the engine oil for colour change and viscosity change if oil is thick or thin or colour is changed,change the engine oil.
- Remove the oil filter and change the oil filter during oil change.
- Check the air filter clogging indicator on the air filter casing.If the red band appears.Replace the air filter.
- Change the fuel filter in periodic interval or change fuel filter during oil service.

Check the injector function

- Start the engine and run at Idle speed.
- Observe any engine hunting (or) engine erratic running (or) vibration (or) laggins of power. If it happens then check the injector function.
- Disconnect the each injector fuel supply one by one and notice the change of engine sound at which injector fuel supply disconnection the engine sound remains same that may be the faulty injector.
- Remove the faulty injector.
- Repair or replace the faulty injector.

EXERCISE 13.3: Troubleshooting of Engine mechanical, electrical problems and abnormal noises

Objectives

At the end of this exercise you shall be able to

- diagnose the engine mechanical problems and rectify it
- diagnose the engine electrical problems and rectify it
- diagnose the engine abnormal noises and rectify it.

Requirements

Tools/Instruments

- Digital multimeter - 1 No.
- Continuity meter - 1 No.
- Ohm meter - 1 No.
- DE spanner 6 to 32 - 1 Set
- Electrical tester - 1 No.
- Executive auto electrical toolkit - 1 Set
- Pulley set universel for bearing & bushes - 1 No.

Equipments/machines

- Running condition of Diesel HMV - 1 No.

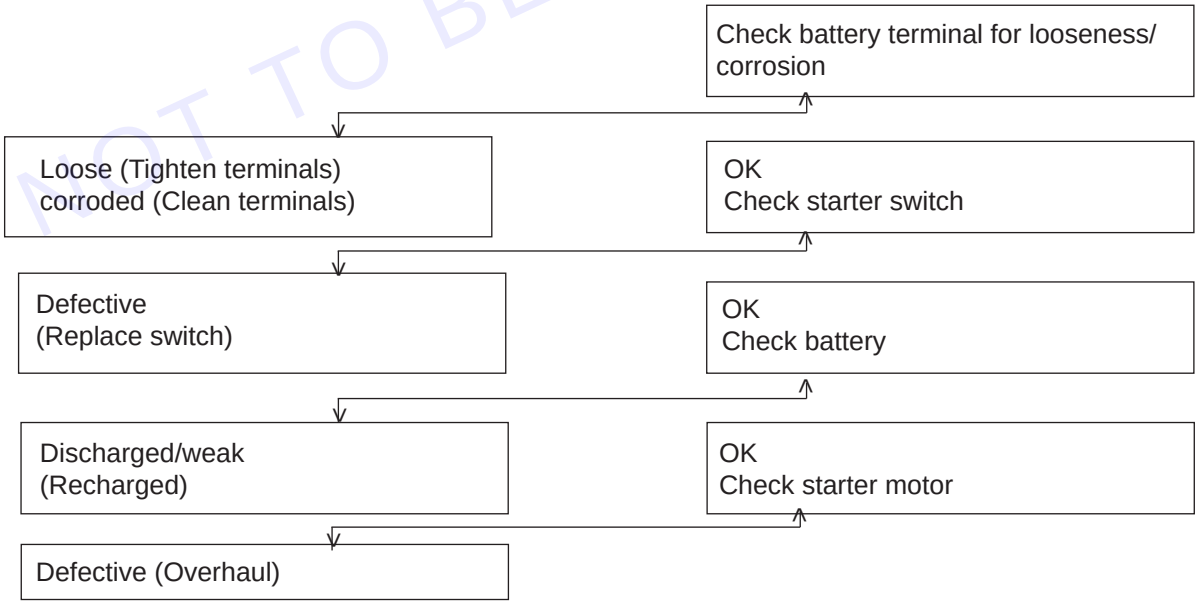
Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Soap Oil - as reqd.
- Engine Oil - as reqd.
- Coolant - as reqd.
- Engine bearings - as reqd.

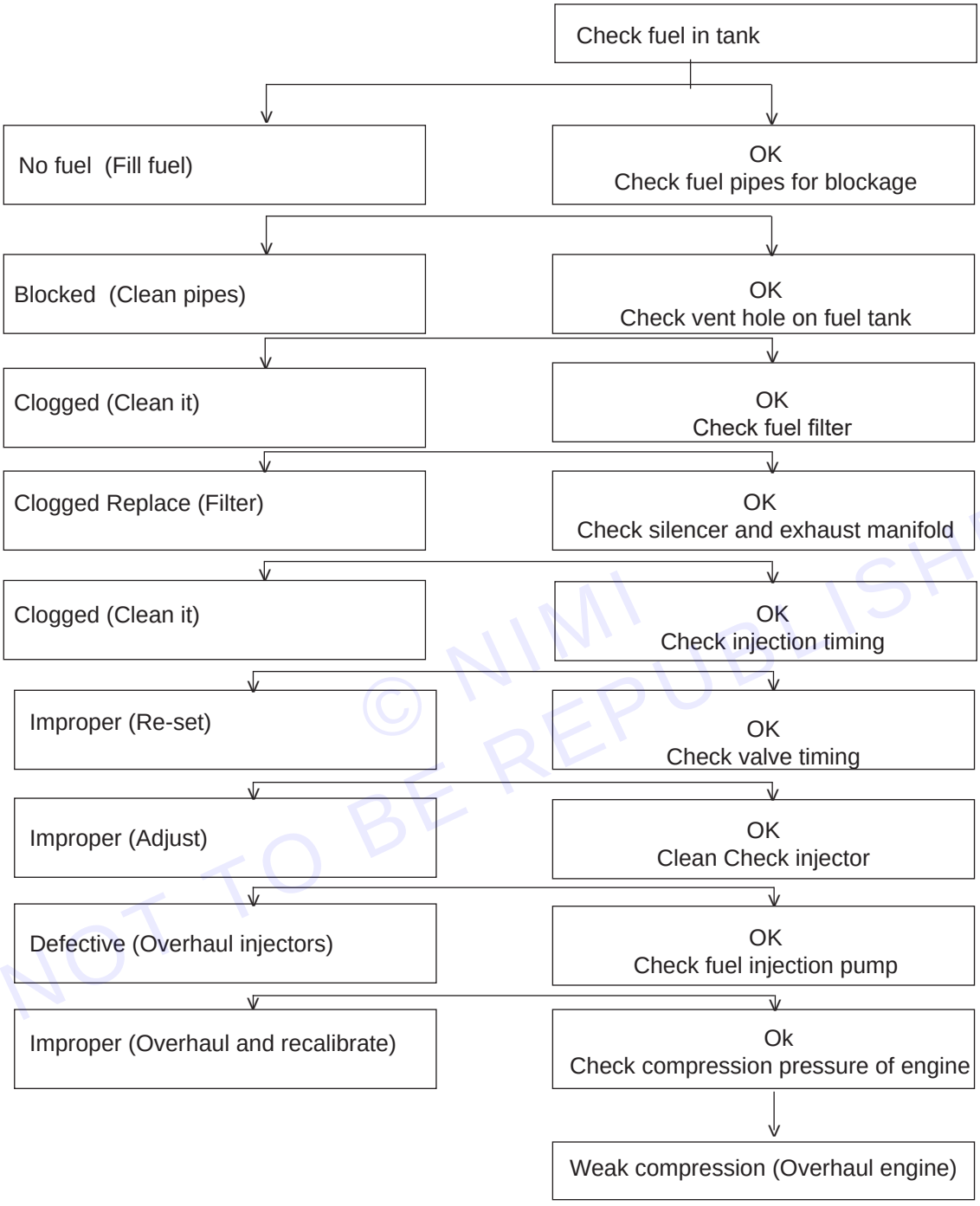
Procedure

Diagnose the engine electrical problems in step by step as shown in the chart

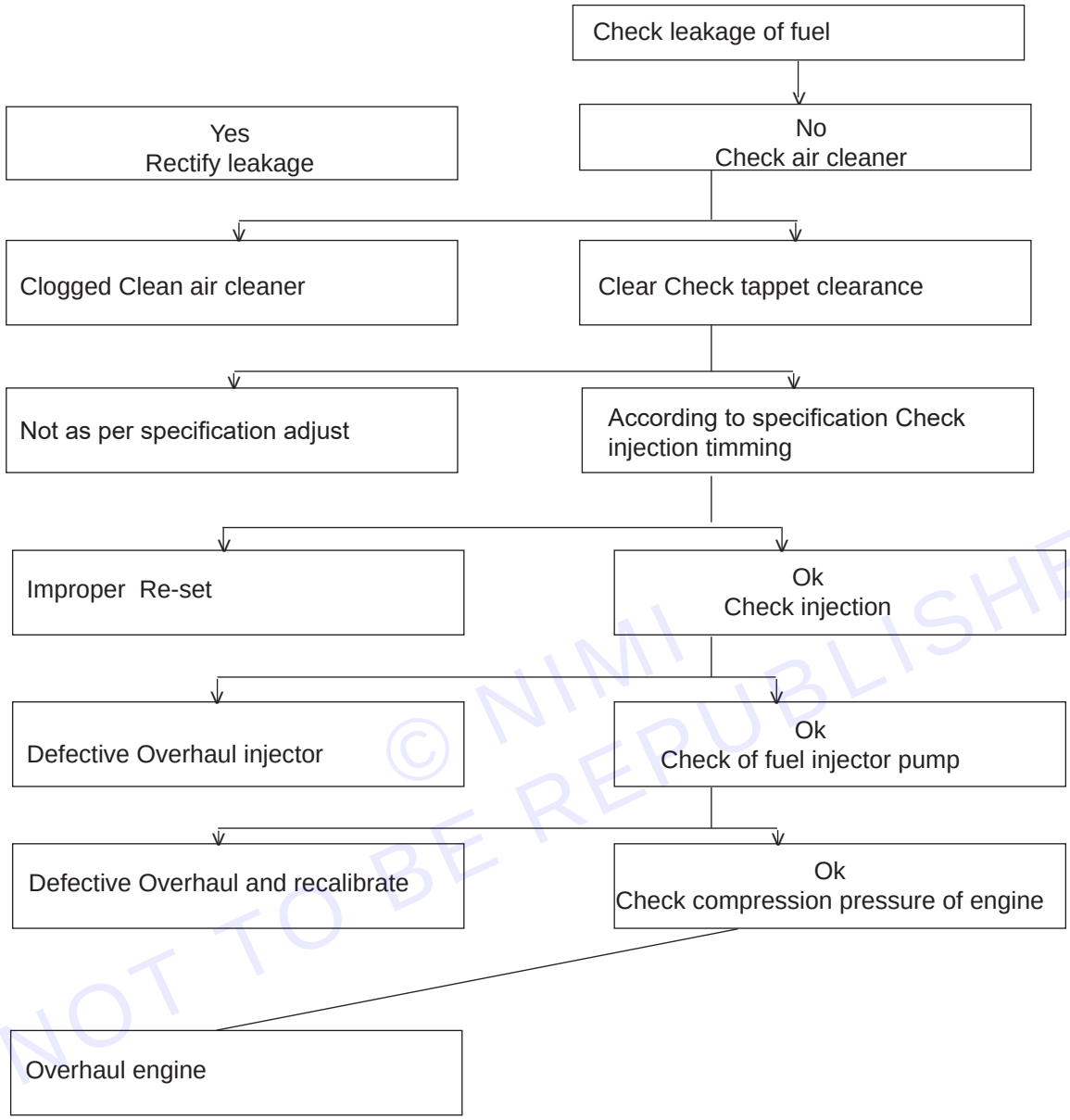
(I) Engine does not start (electrical causes)



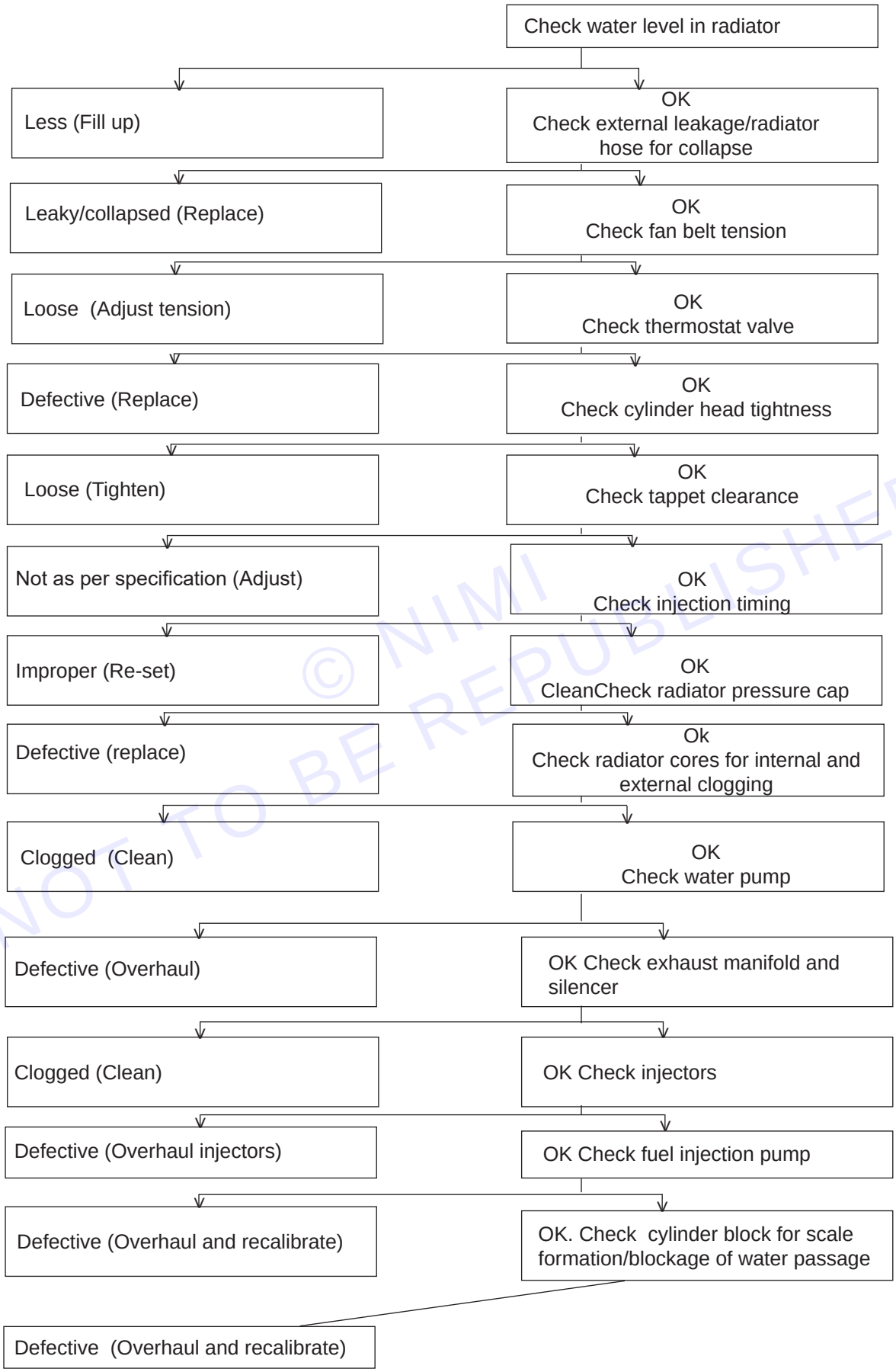
(II) Engine does not start (mechanical causes)



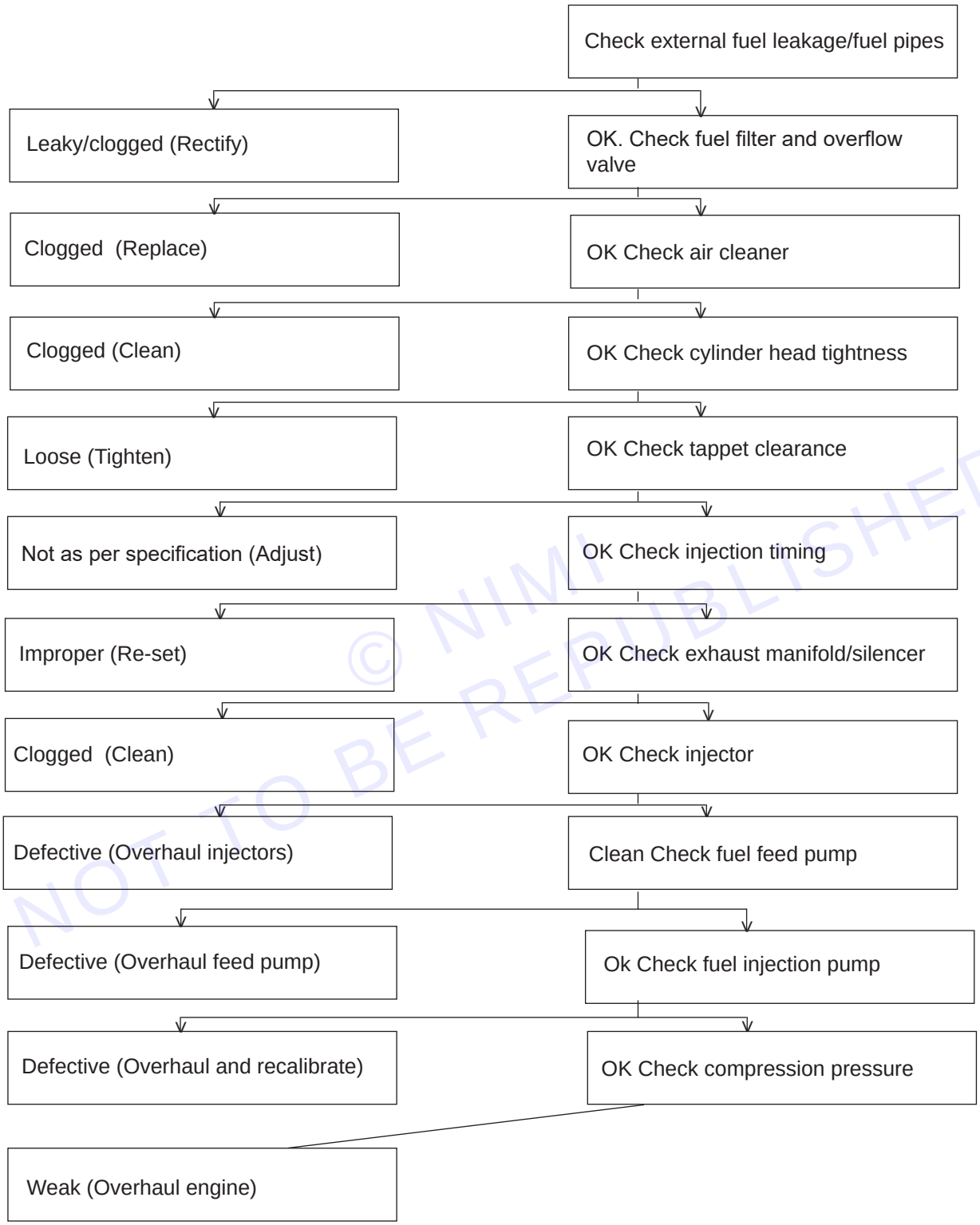
(III) High fuel consumption (diesel)



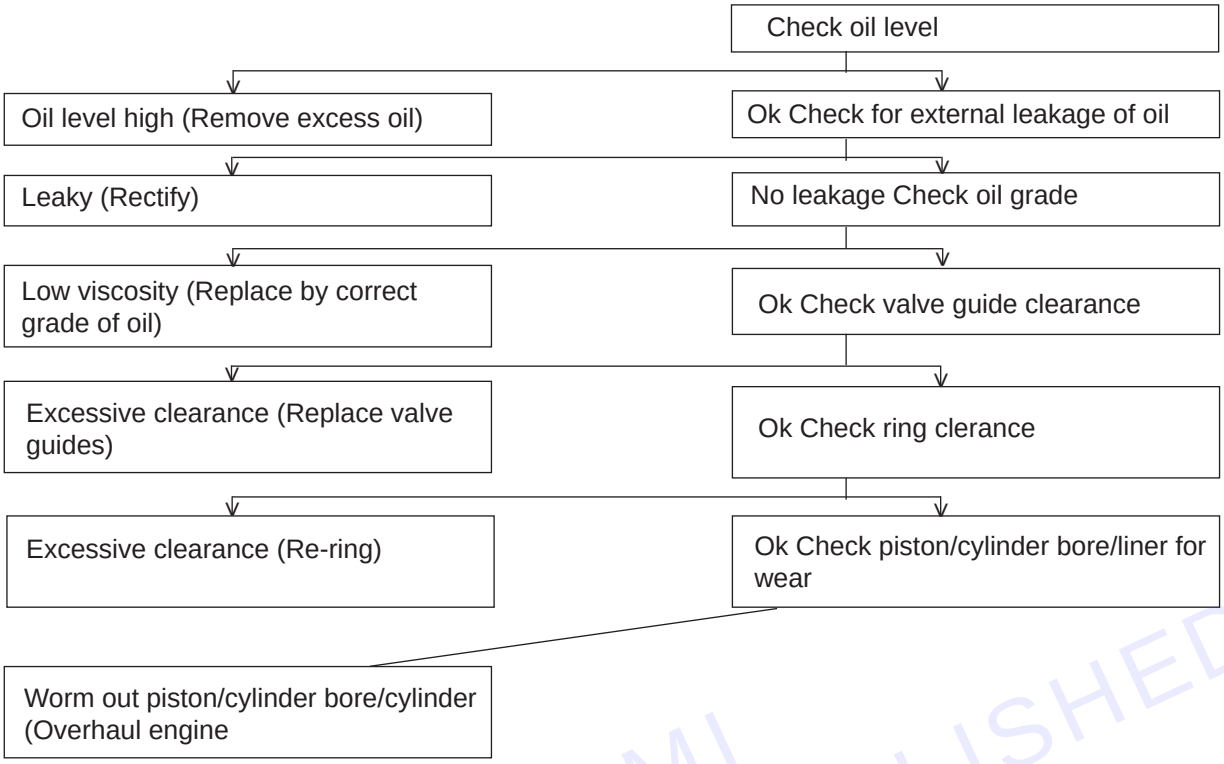
(IV) Engine over heating



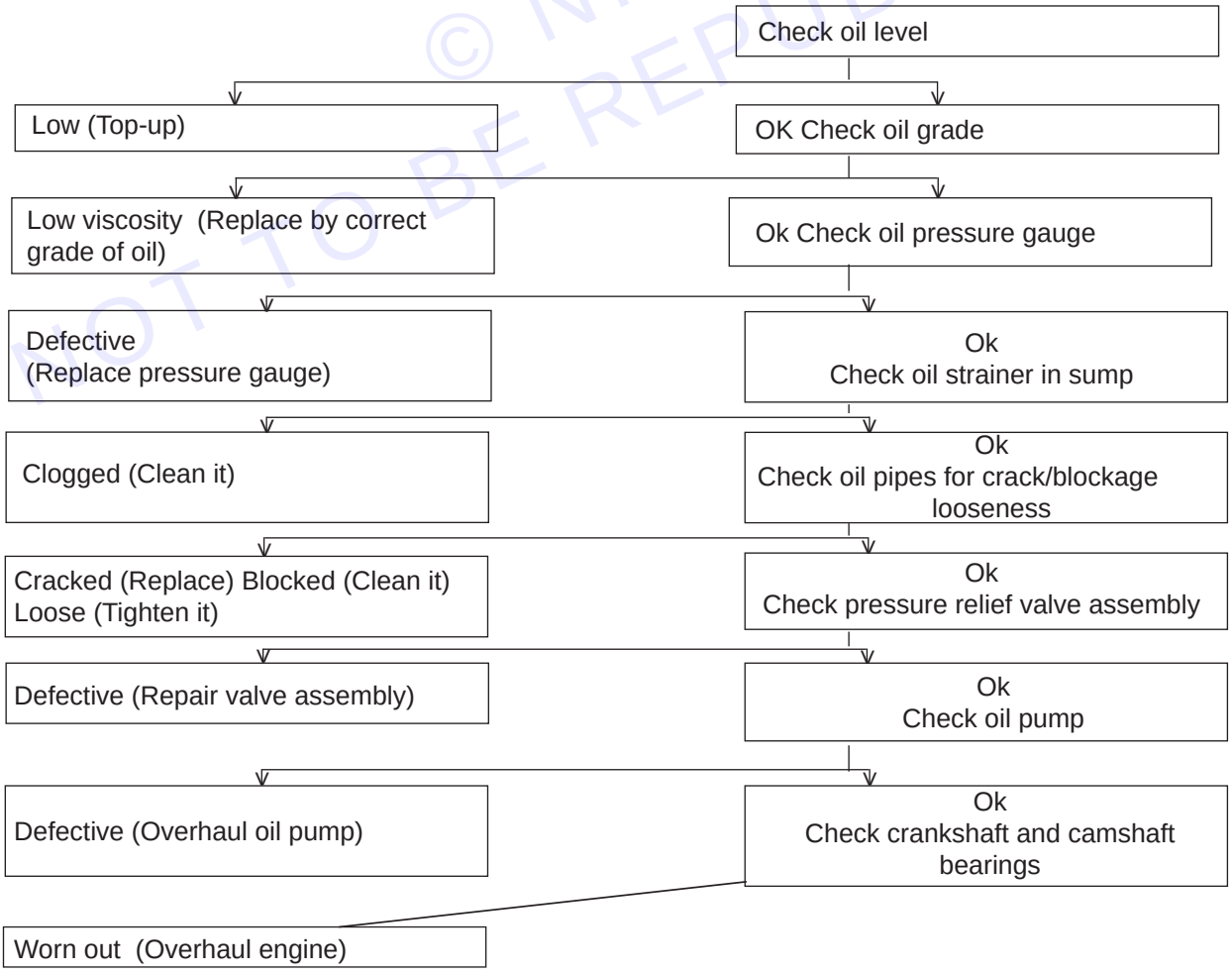
(V) Low power generation



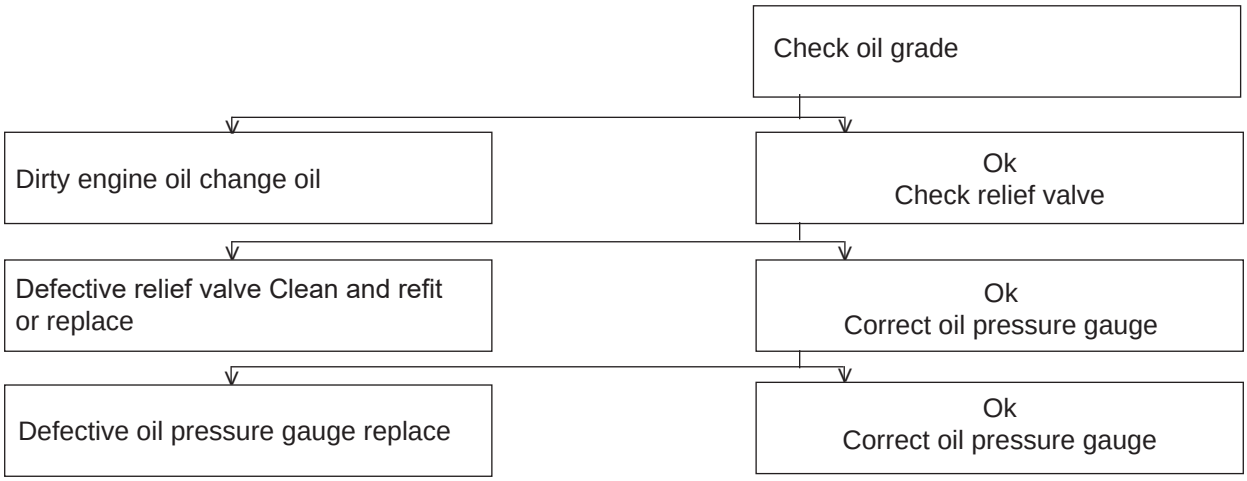
(VI) Excessive oil consumption



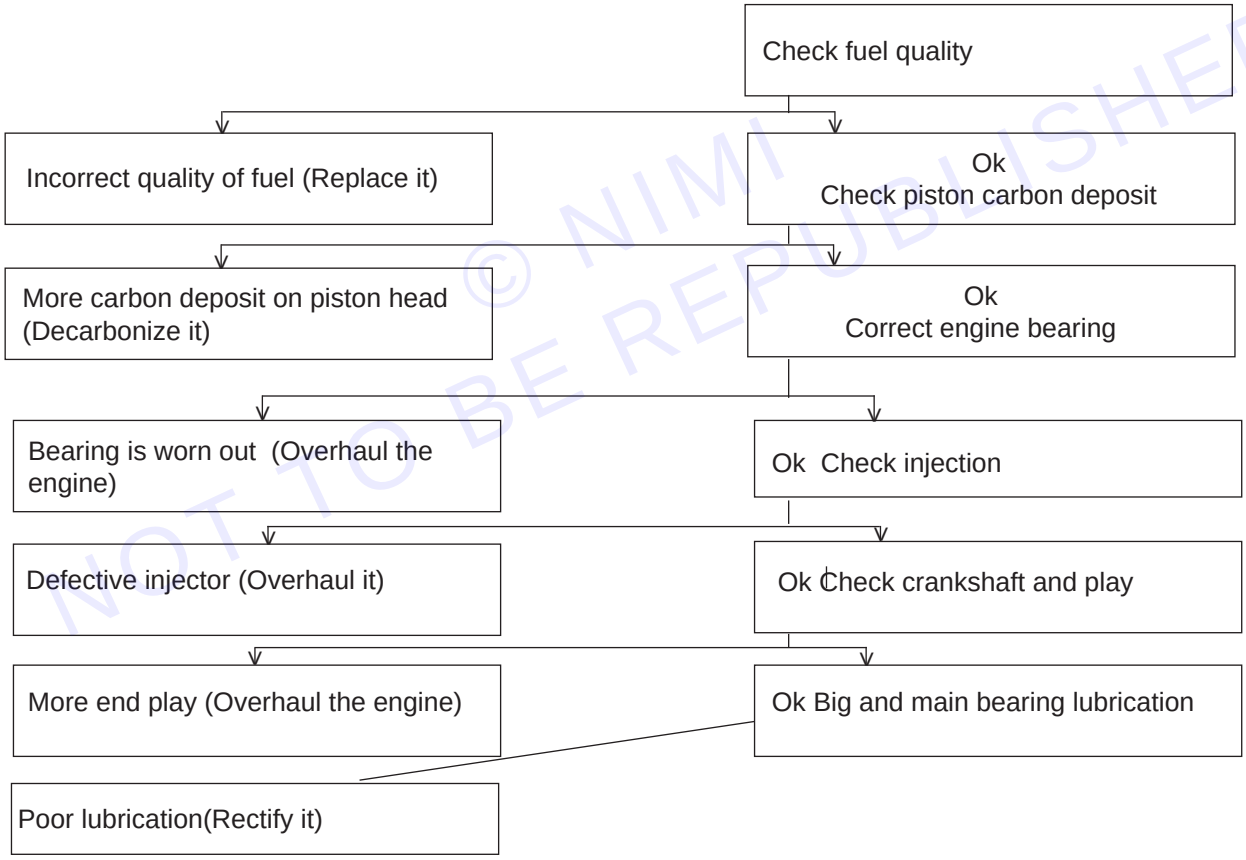
(VII) Low oil pressure



(VIII) High oil pressure



(IX) Engine noise



Causes	Engine Problems										
	Engine Running hot	Poor Transient Response	Smoke	Engine Lacks Power	Black Exhaust Smoke	Blue Exhaust Smoke	High Oil Consumption	Turbocharger Noisy	Cyclic Sound from the Turbocharger	Oil Leak from compression seal	Oil Leak from Turbine Seal
Dirty air Cleaner Clean or replace element according to manufacturer`s recommendations	•	•	•	•	•	•	•			•	
Restricted Compressor intake duct Remove restriction or replace damaged parts are required	•	•	•		•	•	•	•	•	•	
Restricted air duct from compressor to intake manifold Remove restriction or replace damaged parts as required	•	•	•		•	•			•		
Restricted intake manifold Refer to engine manufactures manual and remove restriction	•	•	•	•	•	•	•	•			
Air leak in feed from air cleaner to compressor Remove seals, gasket of tighten fasteners as required	•		•	•	•	•	•	•			
Air leak in feed from compressor to intake manifold Remove seals, gasket of tighten fasteners as required				•	•	•	•	•		•	
Foreign object in exhaust manifold (from engine) Refer to engine manufacture`s manual and replace gaskets or tighten fasteners as required	•			•	•					•	
Restricted exhaust system Remove restriction or replace damaged parts as required		•	•	•	•			•			
Exhaust manifold cracked, gasket blown or missing Refer to engine manufacture`s manual and replace gasket or damaged parts as required											

	Engine Running hot	Poor Transient Response	Smoke	Engine Lacks Power	Black Exhaust Smoke	Blue Exhaust Smoke	High Oil Consumption	Turbocharger Noisy	Cyclic Sound from the Turbocharger	Oil Leak from compression seal	Oil Leak from Turbine Seal
Gas leak at turbine inlet/exhaust manifold joint Replace gasket or tighten fasteners as required		•	•	•	•			•			
Gas leak in ducting after turbine outlet Refer to engine manufacture`s manual and repair leak		•						•			
Restricted turbocharger oil drain line Remove restriction or replace damaged parts as required						•	•			•	•
Restricted engine crankcase breather Refer to engine manufacture`s manual and clean restriction						•	•			•	•
Turbocharger bearing housing sludged or coked Change engine oil and oil filter, overhaul or replace turbocharger as required		•	•	•	•						
Fuel injection pump or fuel injectors incorrectly set Refer to engine manufacture`s manual and replace or adjust faulty components as required				•	•						
Engine valve timing incorrect Refer to engine manufacture`s manual for correct settings and adjust as required				•	•	•	•			•	•
Worn engine piston rings or liners Refer to engine manufacture`s manual and repair as required				•	•	•	•			•	•

Burnt valves and/or piston Refer to engine manufacture`s manual and repair as required				•	•	•	•	•	•	•	•
Excessive dirt build up on compressor wheel and/or diffuser vanes Contact your local approved dealer											
Turbocharger damaged Fine and correct cause of failure, or replace turbocharger as necessary				•	•	•	•	•		•	•

EXERCISE 13.4: Determining engine efficiency by Morse Test using Dynamometer

Objectives

At the end of this exercise you shall be able to

- find the indicated power(ip) on four stroke four cylinder petrol engine by morse test.
- determine engine mechanical efficiency.

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.

Machines

- Multi cylinder four stroke Petrol engine - 1No.
- Engine hydraulic dynamometer - 1No.

Materials

- Cotton waste - as reqd.
- Engine oil - as reqd.
- Engine coolant - as reqd.
- Diesel - as reqd.

Procedure

Formulae used to calculate engine bp,ip& mechanical efficiency

1 BrakePower,BP=2ΠNT/60000KWIndicatedPower(IP)ofeachCylinders:

IP1=(BPT-BP2,3,4) KW

IP2=(BPT-BP1,3,4) KW

IP3=(BPT-BP1,2,4) KW

IP4=(BPT-BP1,2,3) KW

2 Total IP of the Engine, IPT=(IP1+IP2+IP3+IP4) in KW

MechanicalEfficiency, η mechanical=BPT/IPT

Morse test

1 Before starting the engine check the fuel supply, lubrication oil,and availability of coolingwater.

2 Set the dynamo meter to zero load.

3 Run the engine till it attains the working temperature and steady state condition. Adjust the dynamometer load to obtain the desired engine speed. Record this engine speed and dynamometer reading for the BP calculation.

4 Now cutoff one cylinder.Disconnect the fuel supply to the injector can do this.

5 Reduce the dynamometer load so as to restore the engine speed as at step 3.Record the dynamometer reading for BP calculation.

6 Connect the cut off cylinder and run the engine on all cylinders for a short time.This is necessary for the steady state conditions.

7 Repeat steps 4,5, and 6 for other remaining cylinders turn by turn and record the dynamometer readings for each cylinder.

8 Bring the dynamometer load to zero,disengage the dynamometer and stop the engine.

9 Do the necessary calculations.

Tabulation (An example shown for calculation)

S. No.	Cylinders Working	Dynamometer Reading, (T)kg	Engine Speed (rpm)	Brake Power, BP (KW)	IPofthecutoff cylinder,(KW)
1	1-2-3-4	8	2069	3.93	6.56
2	2-3-4	3	2004	$BP_{2,3,4}$=2.21	IP_1=1.72
3	1-3-4	3.2	2057	$BP_{1,3,4}$=2.42	IP_2=1.51
4	1-2-4	3.1	2018	$BP_{1,2,4}$=2.30	IP_3=1.63
5	1-2-3	3	2030	$BP_{1,2,3}$=2.23	IP_4= 1.7

10 Calculate Mechanica lEfficiency,ηmechanical=BPT/IPT =3.93/6.56

ηmechanical=59.9%

MODULE 14: Alternative Fuel System

EXERCISE 14.1: Identify the CNG Kit components and find out their location

Objectives

At the end of this exercise you shall be able to

- identify the CNG Kit Components in the vehicle and locate their place in vehicle
- trace the layout of CNG system.

Requirements

Tools/Instruments

- Mechanic Tool kit - 1 No.

Equipments/Machines

- A CNG vehicle Two post lift/four post lift
- Wheel chokes - as reqd.
- Steel Horses - as reqd.

Materials

- Cotton waste, waste cotton cloth - as reqd.

Procedure

1 Place a CNG vehicle on plain surface

2 Apply hand brake

3 Put wheel chokes on the wheels

4 Open the boot lid

5 Identify the CNG cylinder (1) its location and its position on boot space

6 Identify CNG cylinder locking clamps (2) and checkwhether it is securely locked

7 Identify the vapour bag (3) and cylinder shut off valve (4)

8 Part the vehicle on hoist/lift

9 Raise the vehicle on lift

10 Identify the fuel lock off valve (6) and manual shut off valve (7)

11 Trace the CNG fuel pipe line and check the clamps fitted with chassis frame

12 Down the lift

13 Open the engine hood

14 Identify the vibration loop on CNG fuel line (8)

15 Identify the quarter turn shut off valve if fitted (9)

16 Identify the pressure gauge (10)

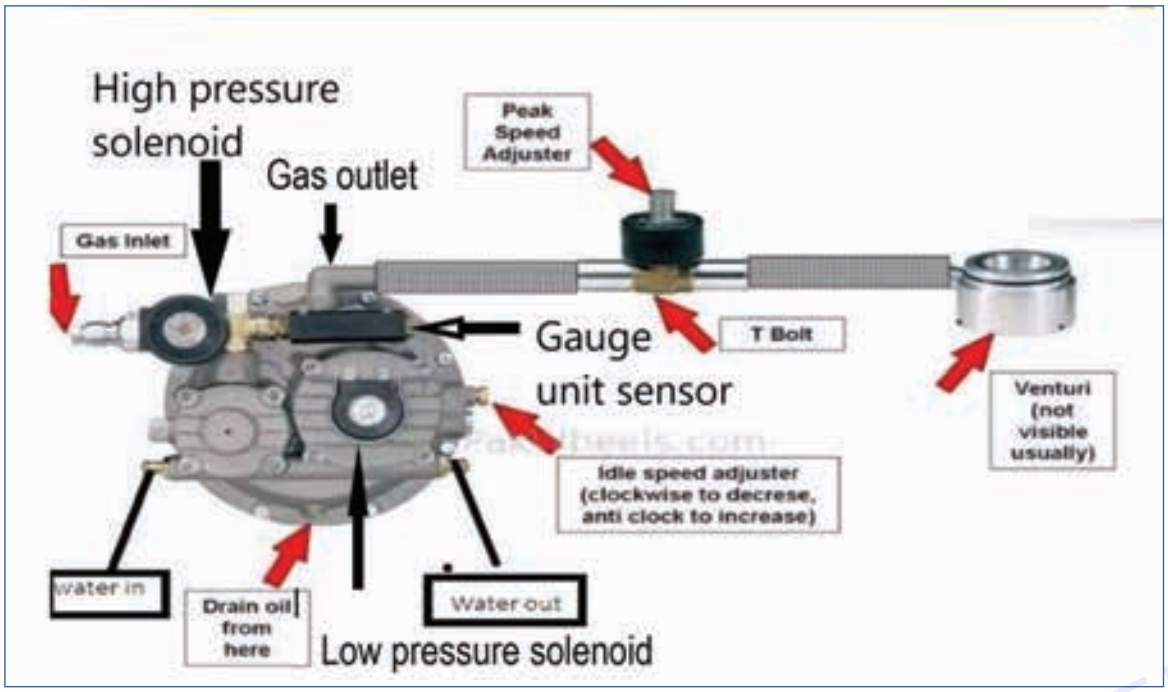
17 Identify the check valve (11) and its location

18 Identify the fuel fill receptacle (12) and its location

Note: In some vehicles fuel fill receptacle may come on vehicle back side conventional fuel filler location.

19 Identify the pressure regulator (13) and its location

20 Identify and locate the fuel filter (14) if fitted



21 Identify and locate the metering valve (15)

22 Identify and locate gas mixer (16) unit

23 Identify and locate the fuel shut off relay.

EXERCISE 14.2: Overhaul conventional type CNG Kit

Objectives

At the end of this exercise you shall be able to

- to the overhaul the conventional type CNG Kit Components
- adjust the idle speed and peak speed of engine while running on CNG.

Requirements

Tools/Instruments

- Mechanic tool kit, - 1 No.
- Gas exhaust analyser, - 1 No.
- CNG reducer overhauling kit - 1 No.

Equipment/Machines

- A light motor vehicle retrofitted CNG conventional kit - 1 No.
- 5 Gas Exhaust Analyzer - 1 No.

Materials

- Soap solution - as reqd.
- Cotton waste - as reqd.
- Waste cloth - as reqd.
- Kerosene - as reqd.
- Wire brushes - as reqd.

Procedure

1 Stop the vehicle in plain surface.

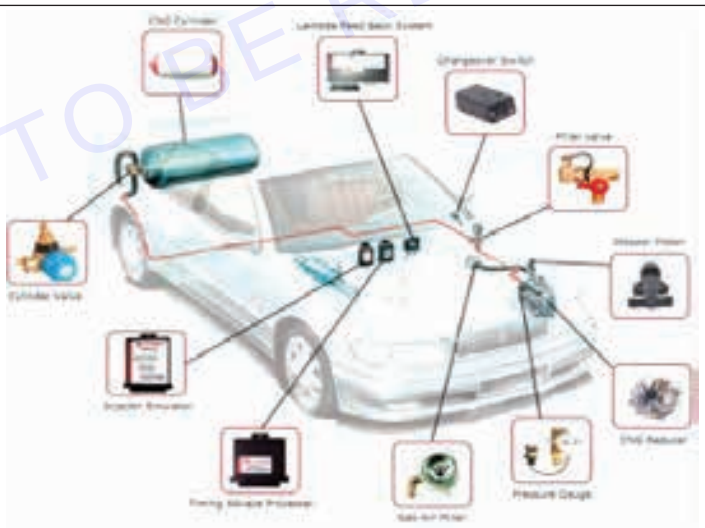
2 Apply hand brake.

3 Open the rear boot.

4 Check the manual shut off valve in open condition.

5 Open the engine head.

Fig 1



Visual inspection

6 Visually inspect for loose, damaged, disconnected or incorrectly routed wires.

Checking of Gas Leaks

7 Check the CNG Gas leak in the pipe line fittings and other CNG kit components fittings side using soap solution.

8 Check the Gas leak on filler valve side. If `O' ring damaged, replace with new one. If gas leaks on filler valve

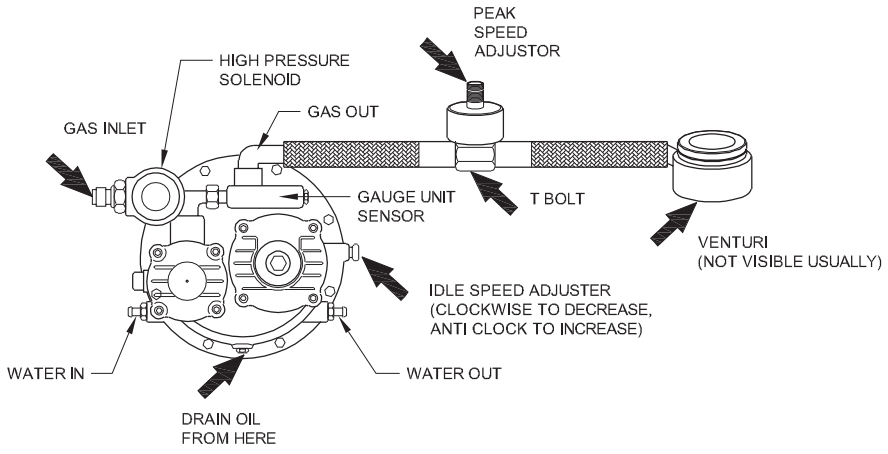
9 Purge the fuel lines which are leaking.

10 Replace the damaged pipe line fitting.

Servicing of CNG Reducer

Note: CNG reducer servicing is to be done when the vehicle fuel economy is poor, poor pickup and vehicle running is nor smooth.

Fig 2



CONVENTIONAL CNG KITS SETUP

11 Remove battery `-ve' cable

12 Shut off the fuel valve or cylinder

13 Disconnect the CNG reducer gas inlet pipe line connection and outlet pipe connection.

14 Remove the coolant hose connections from the CNG reducer

15 Remove the high pressure solenoid valve electrical connections

16 Remove the CNG reducer ground connection

17 Remove the reducer low pressure solenoid valve electrical connection

18 Remove the CNG reducer gauge unit positive (+ve) and negative (-ve) supply

19 Remove the complete CNG reducer unit from the vehicle chassis by removing supporting stud nuts and drain oil from reducer unit

20 Remove the gauge sensor unit holding nut, washer and detach the gauge unit with solenoid

21 Mark on the reducer casing (reference mark for dismantling and assembling

22 Remove the low pressure solenoid nut of CNG reducer kit.

23 Remove the low pressure solenoid and holding unit

24 Remove the low pressure side diaphragm casing bolts

25 Remove the low pressure diaphragm cover.

26 Remove the diaphragm spring, o ring, diaphragm nut and diaphragm

27 Remove the actuating unit of diaphragm

28 Remove the CNG reducer backside cover by removing bolts

29 Mark the reference mark on the casing

30 Remove the high pressure reducing diaphragm (Ist stage)

31 Remove the 1st stage diaphragm actuating lever unit and valve

32 Remove the 2nd stage diaphragm unit from CNG reducer unit

33 Remove the idle adjuster unit

34 Clean the casing and all the components removed from the CNG reducer unit

35 Inspect the diaphragm condition, valve actuation, diaphragm actuation. If found faulty replace with new components.

36 Reassemble all the removed components.

37 Refit the CNG reducer unit on vehicle.

38 Reconnect the electrical connections for solenoid and gauge sensor unit.

39 Reconnect the gas pipe lines and coolant lines.

40 Remove clean and reconnect venturiunit.

41 Open the gas valve in the cylinder.

42 Check for gas leaks.

43 Check the pressure gauge showing the gas pressure when cylinder shut off valve is open. If the pressure gauge found faulty replace with new one.

44 Check the gas level indicator display on change over switch.

45 Check the electrical connection of display switch and gauge sensor unit.

46 Replace the gauge sensor unit/switch if found faulty.

47 Check the emulator, timing advancer, stepper motor electrical connections. If necessary replace the components.

48 Start the engine and change into the CNG gas mode.

49 Adjust the idle speed by adjusting idle speed adjuster on the CNG reducer unit as per the manufactures recommendation.

50 Accelerate the engine and adjust the peak speed by peak speed adjuster.

51 Check the emission using 5.gas exhaust analyser.

52 Check the LAMDA system controlling the emissions.

EXERCISE 14.3: Overhaul Gas Injection type CNG Kit Components

Objectives

At the end of this exercise you shall be able to

- service and Test the sequential Gas Injection type CNG kit components - fuel temperature sensor, Fuel low pressure sensor, fuel gauge pressure sensor, High pressure Fuel shut off solenoid valve, Low pressure shut off valve, Fuel Injectors, CNG cylinder and hoses/pipe line.

Requirements

Tools/Instruments

- Mechanic tool kit, - 1 No.
- hand lamp - 1 No.
- Go-No-Go gauge - 1 No.
- Multimeter - 1 No
- Digital pressure gauge with adaptor - 1 No

Equipments/Machines

A light motor vehicle retrofitted CNG conventional kit

Materials

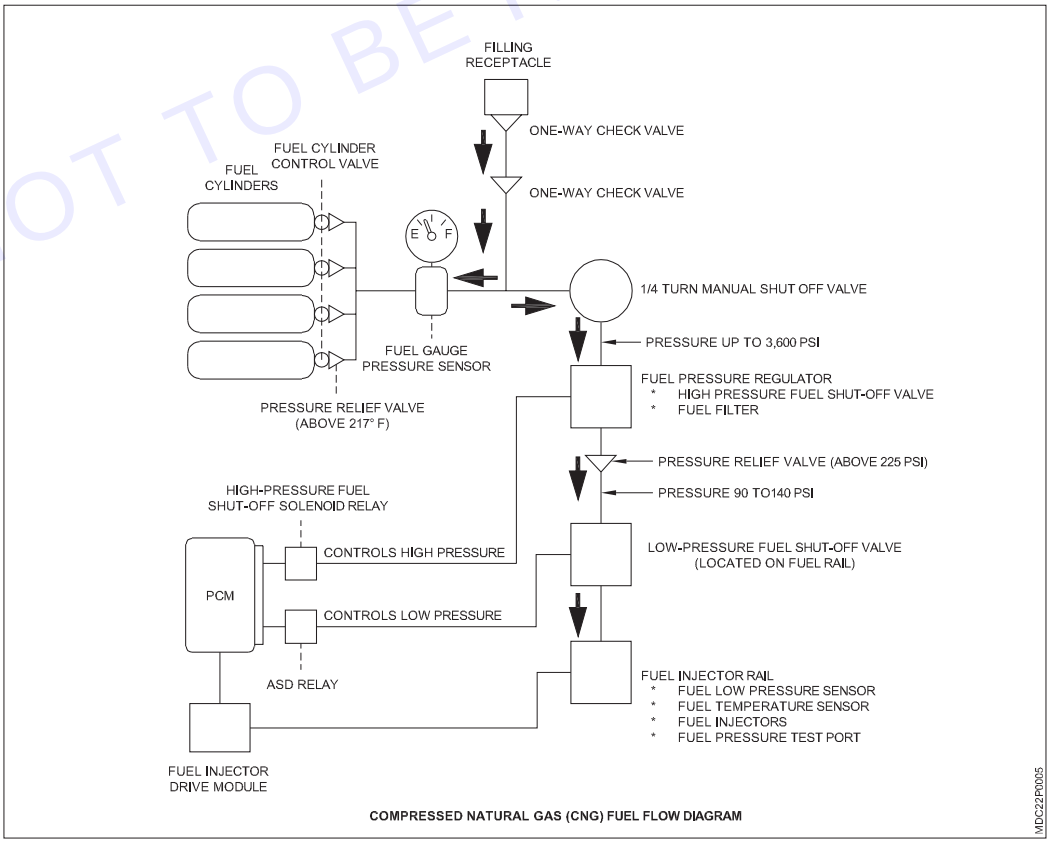
- Safety glasses - 1 No.
- Petrol - as reqd.
- Kerosene - as reqd.
- Thinner - as reqd.
- Emery Sheet - as reqd.
- Cleaning Brush - 1 No.
- Spare CNG Kit - 1 No.
- Diaphragm - 1 No.
- Set and overhauling kit - 1 No.
- Soap Solution - 1 No.
- Tafflon tape - 1 No.
- Gauge jumper wires - 1 Pair
- Gloves - 1 Pair

Procedure

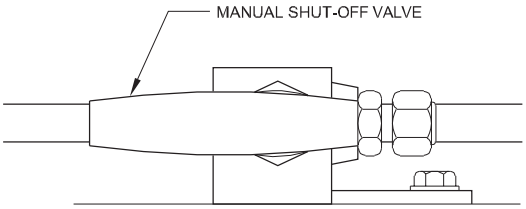
1 Stop Vehicle in plain surface and apply the brake

2 Open the Rear boot and check the manual shut-off valve

3 Open the Engine hood.

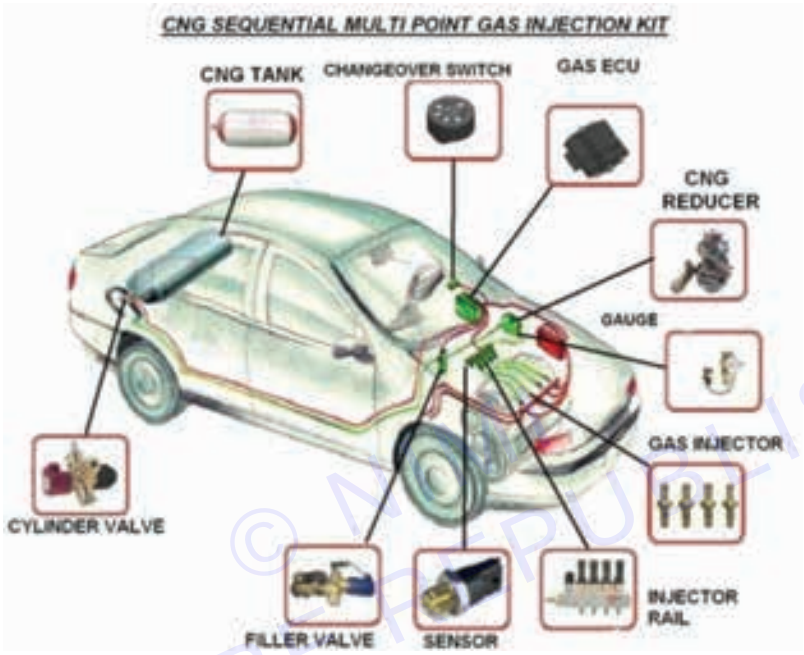


COMPRESSED NATURAL GAS (CNG) FUEL FLOW DIAGRAM



MANUAL SHUT-OFF VALVE

MDC22P0004



Visual Inspection

4 Visually inspect for loose, damaged, disconnected or incorrectly routed wires and fuel lines.

5 Check the electrical connections of the following

- i Battery cables.
- ii Pen connector.
- iii Low pressure fuel shut off solenoid.
- iv High pressure fuel shut off solenoid.
- v Fuel temp and Fuel pressure sensor.
- vi High pressure fuel shutoff solenoid relay.
- vii Injector driver module.

High Pressure fuel tube fitting replacement

6 Inspect the fuel tubes for damage or kinking.

7 Inspect all fuel tube connections for gas leaks. Apply soap solution to the joints and suspected area. If any bubbles appears, locate the leak area.

8 Purge the fuel system by following below mentioned procedure.

- i Close the fuel control valve.
- ii Verify the manual shutoff valve in open position.

iii Start and run engine until it runs outs of fuel.

iv Try three additional starts even after engine dies. Now fuel tubes completely purged

v Loosen the fitting which is leak and remove the fuel tube

vi Clean the high pressure fuel tube fitting and fuel tube

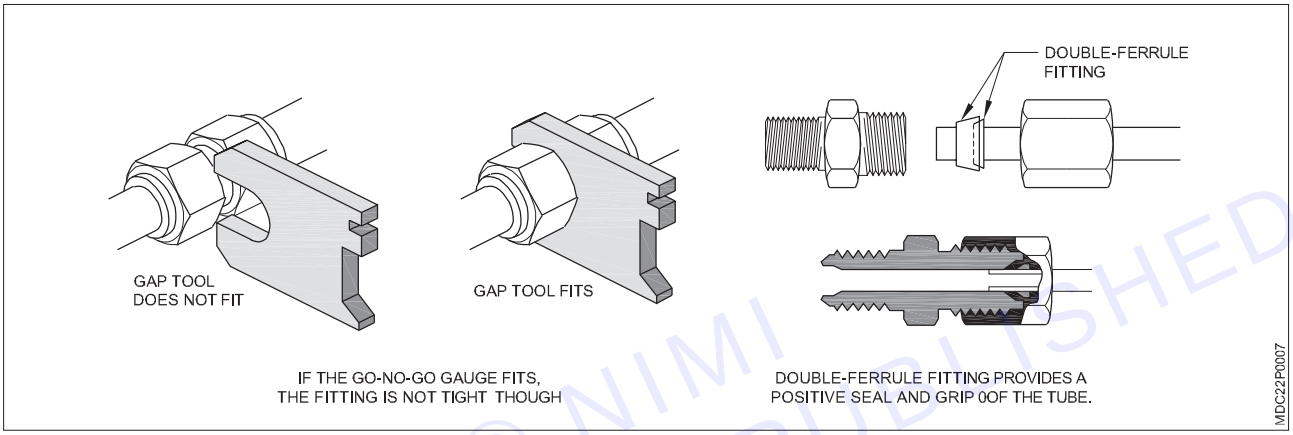
vii Insert fuel tube with pre-swaged, collapsed ferrules into the fitting body until the ferrules seats in the fitting body.

viii Tighten the fitting nut by hand, then attach a back up wrench in the fitting body and tighten the nut with another wrench

ix Check with Go-No-Go gauge

Note: Certain components required o rings lubricate the `O' rings with special o-ring tube.

x Open the fuel line and check the leak



Fuel System Pressure Testing

9 Remote the fuel pressure service port cap on fuel rail

10 Attach a pressure test gauge to the service port

11 Start the engine and bring it to operating temperature

12 Check the pressure reading and compare with specifications. If the fuel pressure is above specification replace fuel pressure regulator. If the fuel pressure is lower then specification

Check the following

i Verify the fuel cylinder control valves are open

ii Verify that manual shutoff valve are open

iii Verify fuel volume

iv Check for damaged fuel tubes

v Preform low pressure fuel shut off solenoid electrical test

vi Perform high pressure fuel shut off solenoid electrical test

vii Test the fuel injectors.

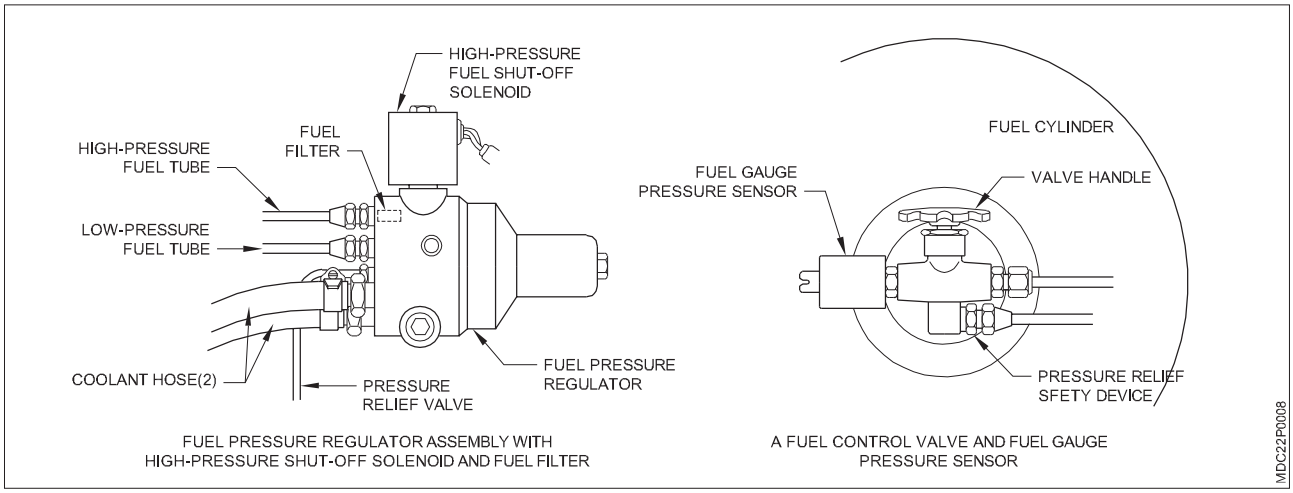
Note: Before checking fuel pressure, ensure that the cylinders are at least one - half full.

High Pressure fuel shut off solenoid Test (Fig 6)

13 Disconnect two way electrical connector for the solenoid

14 Use a set of 18 SWG jumper wires and momentarily apply 12v across the connector terminals of solenoid

15 Listen the solenoid click sound if it is not heard, replace the fuel pressure regulator assembly



FUEL PRESSURE REGULATOR ASSEMBLY WITH HIGH-PRESSURE SHUT-OFF SOLENOID AND FUEL FILTER

A FUEL CONTROL VALVE AND FUEL GAUGE PRESSURE SENSOR

Fuel Gauge Pressure Sensor unit Testing

16 Turn the ignition switch to the run position and disconnect the electrical connector at the fuel gauge pressure sensor.

17 Note the fuel gauge. It should move to empty if it is ok.

18 Check the signal circuit between connector and gauge if fuel gauge does not show empty.

19 Remove and replace the fuel gauge unit if the signal circuit is off.

20 Install a jumper wire between the fuel gauge pressure sensor signal circuit cavities in the body harness.

21 Note the fuel gauge needle. It should move to full if it is ok.

22 Turn the Ignition switch off and check the continuity between ground circuit cavity in the body harness and a grovel ground if the gauge does no show `FULL'.

23 Remove and replace the fuel gauge if the around circuit is ok.

24 Run the engine

25 Check the battery voltage at Ignition switch output

26 Remove and replace the fuel gauge pressure sensor unit if the battery circuit is ok

Fuel Low Pressure Sensor Testing

27 Identify the location of fuel pressure sensor.

28 Refer wiring diagram of appropriate service manual and findout pin location of three wire connector.

29 Run the engine and measure the voltage of sense circuit of low pressure sensor.

Note: Generally Voltage reading should be approximately 3 to 4.5 volts.

30 Compare with the service manual.

31 Disconnect the low pressure solenoid.

32 Measure the voltage of sense circuit after the runs out of fuel. The voltage reading should be approximately 0.5 volt. If `0' volts measured the sensor circuit is open.

Fuel Temperature Sensor Testing

33 Identify the location fuel temperature sensor.

34 Refer wiring diagram of appropriate service manual and find out pin location of two-wire connector.

35 Connect scan tool to the DLC and Start the engine.

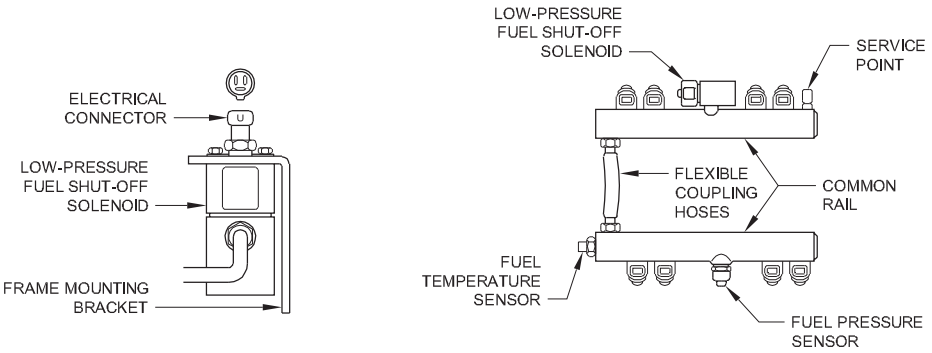
36 Warmup the engine upto normal operating temperature.

37 Go to the sensors menu in the scan tool and record ECT.

38 Disconnect wiring harness connector from the fuel temperature sensor

39 Measure the resistance of the fuel temperature sensor and record it.

40 Compare this reading with standard resistance valve given in the table below:



FUEL LOW-PRESSURE SENSOR USUALLY IS ATTACHED TO THE FUEL LINE OR ON THE TUBE TO THE FUEL

Fuel Temperature		Resistance (OHMS)	
C°	F°	Minimum	Maximum
- 40°	- 40°	291,490	381,710
- 20°	- 4°	85,850	108,380
- 10°	14°	49,250	61,430
0°	32°	29,330	35,990
10°	50°	17,990	21,810
20°	68°	11,370	13,610
25°	77°	9,120	10,880
30°	86°	7,370	8,750
40°	104°	4,900	5,750
50°	122°	3,330	3,880
60°	140°	2,310	2,670
70°	158°	1,630	1,870
80°	176°	1,170	1,340
90°	194°	860	970
100°	212°	640	720
110°	230°	480	540
120°	248°	370	410

Note: The Internal resistance of the sensor should be less than 4000 ohms with the engine at operating temperature.

41 Replace the sensor if the sensor resistance is out of range.

42 Test the resistance of the wire harness between the PCM connector and fuel Temperature sensor connector.

43 Repair the wire harness if necessary when resistance value is greater then 1 ohm.

44 Disconnect the scan tool from DLC and connect the wiring harness connector to the fuel temperature sensor.

Low Pressure Fuel Shut off Solenoid Test

45 Disconnect the low pressure fuel solenoid two way electrical connector

46 Use a set of 18 SWG jump wire momentarily apply 12V across the terminals of the solenoid

47 Listen the `click' noise of solenoid. If click noise is not heard then replace the solenoid

48 Reconnect the two way electrical connector

Fuel Injectors Test

49 Turn the ignition switch `OFF'

50 Disconnect the electrical connector at the low pressure fuel shut off solenoid

51 Disconnect the fuel injector electrical connector

52 Use a pair of 18SWG jumper wires, momentarily apply 12V across the fuel injector terminals.

53 Listen the injector click noise.If click noise is not heard, Replace the Injectors.

54 Use an ohmmeter to measure the resistance valve of the injector coil.

55 Compare the measured resistance valve with service manual specification if valve differs, replace the injector

56 Reconnect the electrical connector to the fuel injector

CNG Cylinder Checking

57 Check the cylinder outside visually for any damage.

58 Check the cylinder clamps are properly mounted or not.

59 Check the next testing due dater of the cylinder.

Note: Testing date generally stamped on the cylinder and name plate which is tagged near the cylinder.

60 Test the CNG cylinder at authorised CNG Cylinder Testing workshop

Note: Generally CNG Cylinder life is given for 10 years. Every three years once it has to be tested.

EXERCISE 14.4: Identify the LPG kit components and find out their location

Objectives

At the end of this exercise you shall be able to

- identify and locate the LPG kit Components in a vehicle
- trace the layout of LPG system.

Requirements

Tools/Instruments

- Mechanic tool kit, - 1 No.

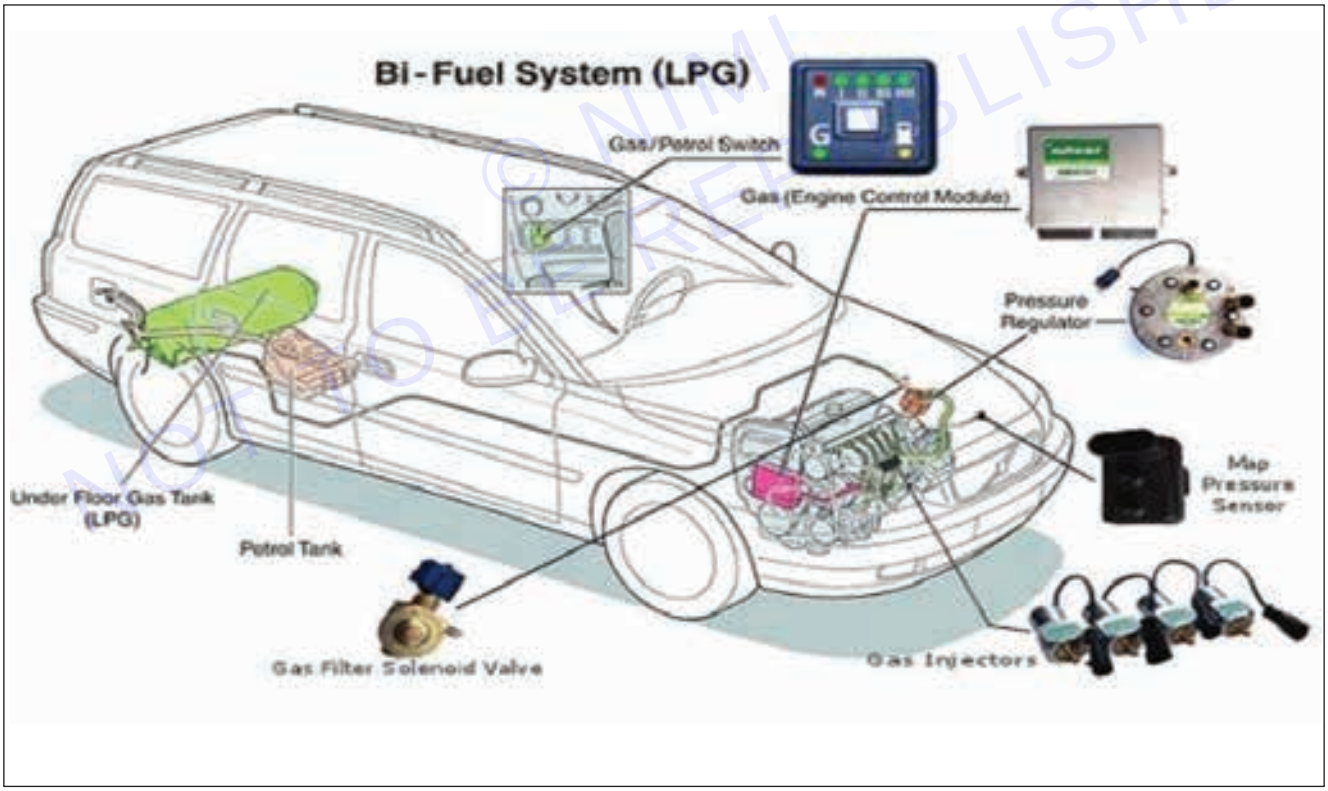
Equipments/Machines

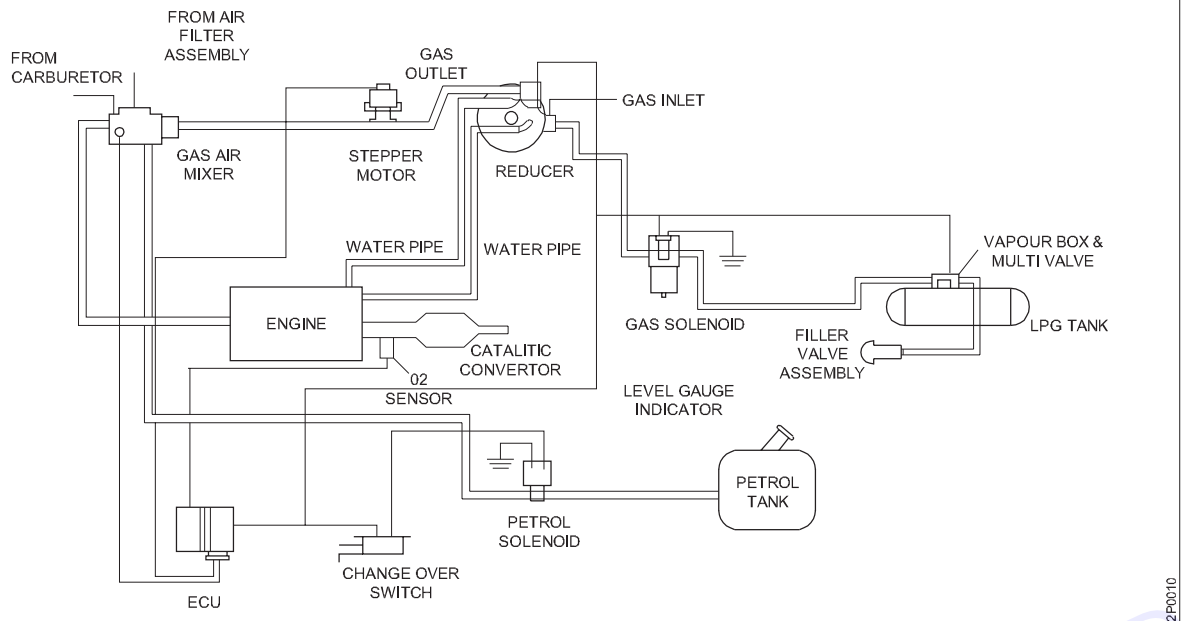
A light Motor vehicle Retrofitted with LPG Kit components

Materials

- Cotton waste
- Waste cloth

Procedure





SCHEMATIC DIAGRAM OF LPG KIT INSTALLTION ON THE VEHICLE

1 Place a LPG retrofitted vehicle on plain surface

2 Apply hand brake

3 Put wheel chokes on the wheels

4 Open boot

5 Identify the LPG Cylinder (1), its location and its position on the boot space.

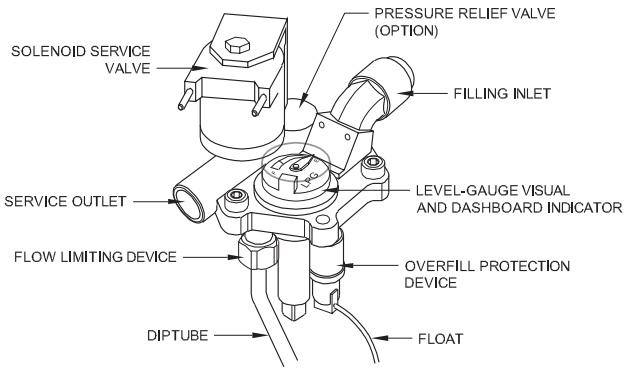
Note: In same vehicle models the LPG tank is fitted on the under hood side of the vehicle.

6 Secure mountings of LPG tank

7 Check and ensure that rubber paddings provided for inner side of the tank mounting pads

8 Check and confirm that clearance of minimum 5mm between tank and vehicle body

9 Identify the tank orientation as specified in type approval certificate for base model (i.e 0o/30o/90oetc)



LPG MULTI VALVE

10 Identify the multifunction valve (2) and its components of

- i Automatic fill limiter
- ii Service valve
- iii Excess flow check valve
- iv Pressure relief valve
- v Fusible plug
- vi Content Gauge
- vii Non return valve on fill connector

11 Identify locate the LPG filling valve (3)

12 Identify the selector switch (Gas/petrol switch) (4) inside the driver cabin

13 Open the Bonnet

14 Identify the gas solenoid valve (5)and its location

15 Identify and locate the vaporizer/pressure regulator unit(6)

16 Identify and locate the gas (Engine control module (8)

17 Identify and locate the map sensor unit (9)

18 Identify and locate the O2sensor (10)

19 Identify and locate the emulator

20 Identify and locate the stepper motor (11)

Note: In MPFI vehicle closed loop system gas injectors are provided. In non MPFI vehicles injector, gas air mixer is provided.

EXERCISE 14.5: Overhaul LPG kit Components

Objectives

At the end of this exercise you shall be able to

- inspect and service the LPG kit components.

Requirements

Tools/Instruments

- Mechanic tool kit - 1 No.

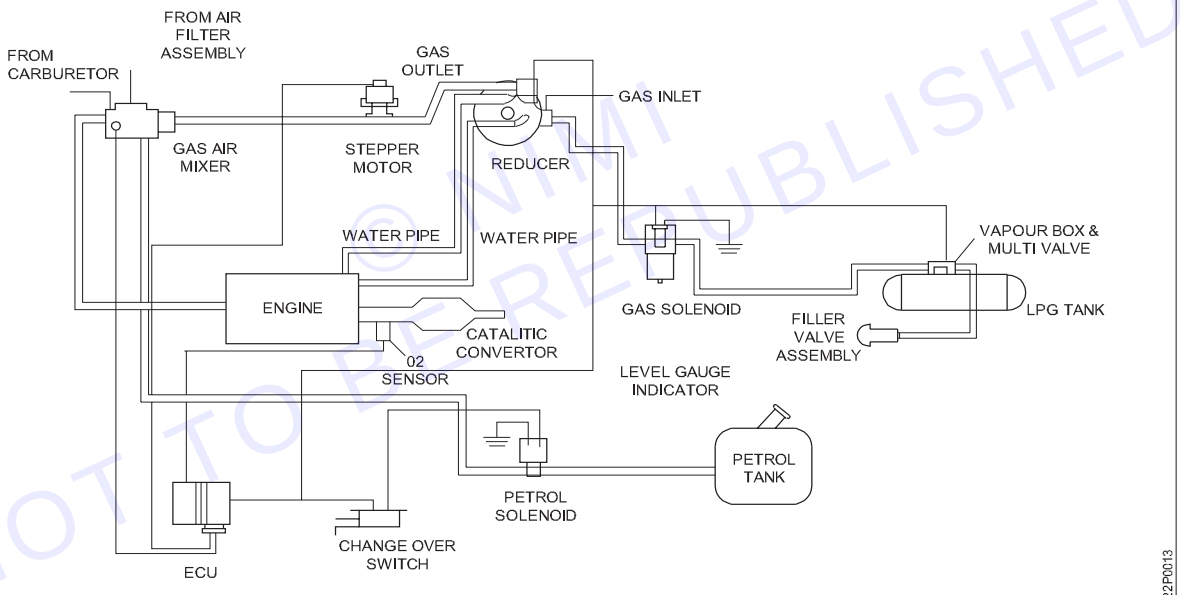
Equipment/Machines

A light motor vehicle retrofitted with LPG Kit

Materials

- Soap solution - as reqd.
- Cotton waste - as reqd.
- Cloth waste - as reqd.
- Multi valve overhauling kit - 1 No.
- Teflon tape - 1 No.
- Petrol/thinner compressed air - as reqd.

Procedure

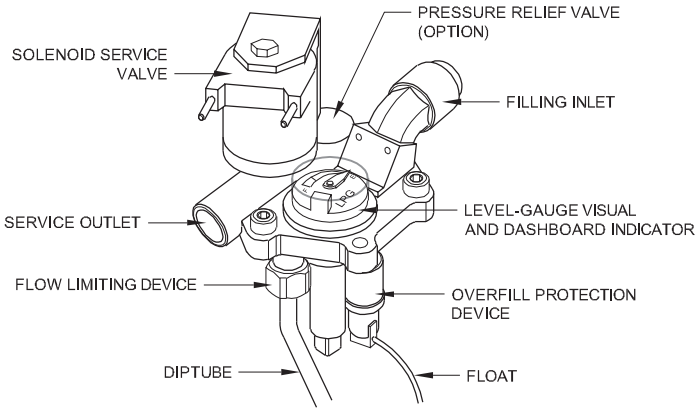


SCHEMATIC DIAGRAM OF LPG KIT INSTALLTION ON THE VEHICLE

Orientation of LPG tank and multifunction valve

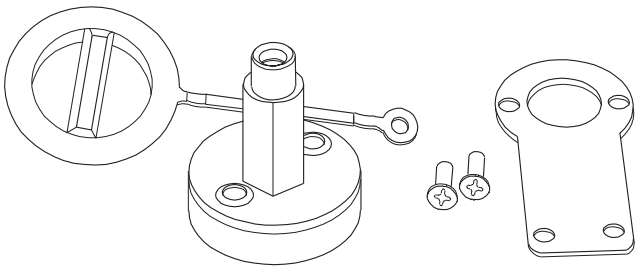
LPG tank 30° orientation

LPG tank 90° orientation



LPG MULTI VALVE

1 Stop the vehicle in plain surface
2 Apply parking brake
3 Open the rear boot
4 Check the pipe line and component fittings for gas leak by applying soap solution
5 Note down the location of leak if any found
6 Close the fuel shut off valve in cylinder
7 Run the engine till LPG Gas on the line Exhausted and engine stopped
8 Tighten or replace the pipe line/ fitting as per the necessity
9 Open the fuel lid



LPG filler valve

10 Test any leak on the filler mouth. If leak comes from filler mouth or Gas is not entering while filling the gas replace the filler valve

Servicing of Multifunction Valve

Note: The multifunction valve is to be serviced at following conditions

1 Gauge unit is not working.
2 Excess flow check valves not working.
3 Automatic fill limiter is not working.
4 Service valve and pressure relief valve is not working.

1 Remove the vapour bag cover.

2 Close the fuel shut off valve.

3 Disconnect the battery positive and negative terminals.

4 Remove the LPG gas inlet pipe line connections.

5 Remove the gauge meter by unscrewing the screws.

6 Remove the solenoid unit after disconnecting electrical connection.

7 Disconnect the LPG output line connection using double end spanner.

8 Open the fuel shut off valve and vent out the gas variable on the LPG tank.

Note: While venting out the LPG Gas the vehicle should be parked in an open ventilation space and no open flame or any hot objects should be present.

9 Remove the multivalve unit locking bolts

10 Take out the multivalve unit from LPG tank

11 Remove the service valve holding unit

12 Remove the shut off valve unit

13 Remove the LPG Gas input line lock

14 Remove the non return valve unit springs and check the o- rings. If `o' rings are damaged replace with new one

15 Remove the dip tube

16 Remove the flow limiting device jet and spring

17 Remove the gauge sensor magnet assembly post and remove the magnet from the rotor shaft

18 Inspect the magnet strength and condition. If magnet found weak or faulty replace the magnet

Note: If magnet is faulty gauge meter does not function properly.

23 Remove the float assembly

24 Remove the over fill valve unit and spring

25 Inspect the O rings

26 Clean the multi valve casing using petrol/thinner

27 Apply the compressed air on the casing and the holes of valve housing

28 Clean all the dismantled parts

29 Assembly the service valve unit in multivalve casing

30 Assembly the magnet assembly and float assembly in multivalve casing

31 Assembly the non return valve and spring in the input line

32 Put the input lock

33 Apply compressed air at inlet side

34 Check and confirm the air entering inside valve unit

35 Assemble the flow limit valve unit and spring

36 Fix the gauge meter unit

37 Lift the float and check the gauge meter needle movement

38 Check the solenoid valve function by supply of 12v.

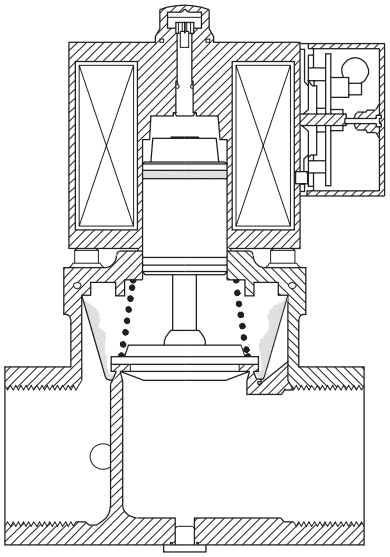
39 Refit the solenoid on service valve

40 Check and replace the O ring for multivalve flange

41 Refit the multi valve unit on tank

42 Reconnect inlet and out let pipe connections

43 Reconnect the solenoid electrical connections



LPG solenoid valve

EXERCISE 14.6: Depowering the High voltage system in Electric vehicle

Objectives

At the end of this exercise you shall be able to

- isolate the high voltage system in Electric and Hybrid vehicles before any service

Requirements

Tools/Instruments

- EV insulated hand tools kit - 1 Set
- Stanchion with retractable belt - as reqd.
- Multi meter - 1 No.

Equipment/Machines

- A light motor electric vehicle - 1 No.

Materials

- Waste cloth - as reqd.
- 1000 V“0 class” hand rubber gloves - 1 Set
- Lockout take off box (LOTO BOX) - 1 No.
- Glove powder - as reqd.

Procedure

1 Park the electric vehicle in plain surface and cover the vehicle parked area using stanchion to avoid the unwanted people entry.

2 Unlock doors, tail and bonnet

3 Turn off the ignition key

4 Put Ignition key in lockout take off box (LOTO box) and keep it 5 Metre away from the vehicle.

5 Remove the vehicle rear seat back to gain access to the high voltage battery module

6 Check the hand gloves for any cut or damage, ensure its standard, date of last inspection then wear it after applying the glove powder. Strap on the hand gloves

Note: Remove the Golden rings, bangles before wearing the gloves

7 Disconnect the 12V battery Negative cable and Low voltage fuse plug.

8 Remove the switch lid from the IPU cover on the battery module

9 Remove the locking cover and turn the battery module switch off and then reinstall the locking cover in its position to secure the switch is in off position

10 If no switch is provided, remove high voltage service plug and place it LOTO box

11 Wait for ten minutes to allow the ultra capacitors to discharge.

12 Locate the terminals for the junction board

13 Measure the voltage at terminals and verify the voltage is Zero or less than 30V. If the voltage is more than 30 V there is a problem, after rectifying the problem then only any service can be done

Note: The above general procedure for shutting off high voltage systems should only be used if instructions from the actual manufacturer are not available otherwise follow strictly the Manufacturers isolation procedure only. During the service insulated hand tools only must be used.

GLOVES

LOTO BOX

EV INSULATED TOOL KIT

EXERCISE 15.1: Maintenance and Over checking of FIP test bench

Objectives

At the end of this exercise you shall be able to

- ensure that the test bench is in good condition so that accurate and repeatable readings are obtained.
- do maintenance of FIP test bench
- rectify the FIP test bench problems.

Requirements

Tools/Instruments

- Trainee's toolkit - 1 No.

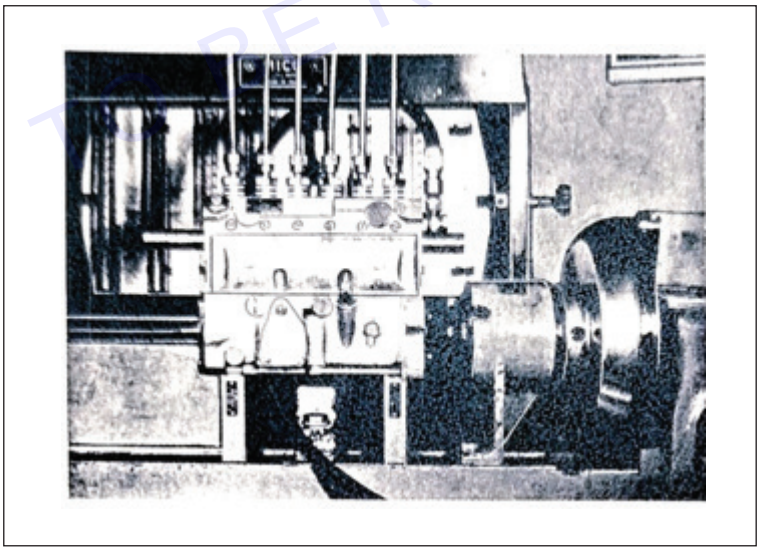
Equipments

- Fuel Injection pump test bench - 1 No.
- Master pump with adaptors - 1 No.
- Hand tachometer - 1 No.
- Reference manometer 0-6 kgf/cm² - 1 No
- Spare test nozzle - 6 Nos.
- Spare high pressure pipes - 6 Nos.
- Reference manometer 0-6kgf/ - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- SoapOil - as reqd.
- EngineOil - as reqd.
- Calibration oil - as reqd.

Procedure



Maintenance

Every week maintenance

- **Test injectors:** Test the injectors on an over checked nozzle tester for the various functional parameters viz. seat tightness, spray pattern, atomisation and opening pressure. If found unsatisfactory;

Clean nozzle, sieve/bar filter in the inlet connection.

Repeat functional tests

If still unsatisfactory, replace complete set of test nozzles .Reset opening pressure to:

175+5 kgf/cm² for testing inline pumps.

130*5 kgf/cm² for Nozzles used for testing distributors type pumps.

Caution: Test nozzles should not be reconditioned since it would affect delivery quantities.

- **Checking ofSpeed control shaft**

Lubricate the bearings at both ends of the shaft.

Every month maintenance

- **High pressure pipes**

Examine high pressure pipe nipples / sealing cones and bore. If deformed or pressed in, clean the bore with a 2 mm dia. drill. Flush thoroughly.

- **Test oil feed pump**

Clean the filter sieve. Examine rubber gasket for filter bowl, feed pump valves and springs.

Replace, if necessary.

- **Checking of 'V' belts**

Check the 'tension' and the condition of 'V' belts. Readjust the tension or replace if necessary.

- **Checking of hydraulic transmission of FIP Test bench**

Check oil level. If necessary top up with the recommended oil by the manufacturer. Clean the outside of the housing and ensure that the cooling pipes are clean and dry.

- **Checking of Intermediate gear box**

Check oil level. Top up with the recommended oil.

Overcheck the test bench with a master pump. Maintain a 'Record card' as per the specimen enclosed.

Maintenance of Every 2 months or after calibrating 200 pumps

Test the calibration oil

Replace with recommended test oil. Clean the test oil tank thoroughly while replacing the oil.

Observe oil contamination Indication

A dark yellow tinge but otherwise clean is Indicative of contamination with lubricating oil. This can influence delivery values.

A cloudy test oil with greyish tinge is indicative of direct contamination. This can damage pump and test injectors.

- Replace filter inserts at the time of changing the test oil or earlier if required.

Every year Maintenance

- Replace Hydraulic transmission oil

Every 2 years Maintenance

Get the bearings of electric motor greased by a competent electrical workshop.

Note: The bearings of electric motor need to be lubricated for the first time after 4-5 years service. Subsequently once in 2 years.

Overchecking procedure

Overchecking ofEvery month

Before overchecking the test bench ensure that the various maintenance checks have been carried out as recommended.

Overcheck of Test bench manometer

Connect the 'Reference Monometer' at the pump gallery with a suitable adapter.

Switch on the test bench motor.

Do not run the pump.

Compare the readings of test bench manometer with the reference manometer at different pressures. If there is any variation, replace or repair manometer or devise a correction table.

Caution: the comparison of manometer should be done only upto 3 kgf/cm² pressure. If the pressure control valve is screwed in further, the manometer on the test bench is isolated by the pressure shut off valve. However, in the pump gallery the pressure will build up to 45 kgf/cm² and damage the "Reference Manometer".

Overcheck of Tachometer

Overcheck the tachometer with a hand tachometer. The variation should be within + 1.5% of full scale reading. If more, devise / display a correction table or get the tachometer repaired.

OvercheckWith master pump

Check whether the seals on the master pump are intact.

Mount the master pump on test bench with a suitable coupling (maximum play permissible 0.5 mm).

- Connect high pressure pipes.

Maintain the test oil temperature at 40°C.

Vent out air from the master pump gallery. Run the pump for about 2 min, at 1000

min (rpm) maintaining the gallery pressure at 1 kgf/cm².

- Take 3 sets of readings at 1000 min¹ (rpm) and for 500 strokes. Record observations.

Note: Before taking each reading, ensure that the measuring glasses are wet and drained for 30 seconds.

If the average of the 3 readings is within the specified value the test bench is in order.

Specified value

25+ 0.5 cm³ for 500 strokes at 1000 min¹ (rpm)

Variation between cylinders should be within 0.5 cm³

If the average of 3 readings is not within the above specified values, the test bench needs rectification.

Example

Case	Observed delivery quantity	Remarks
I	24.0, 25.5, 23.0, 24.5, 26.0, 25.0	Erratic and not within specified value
II	24.5, 25.0, 25.5, 24.5, 25.5, 25.0	Within the specified value but variation between cylinders is more than 0.5 cm³

Rectification

Check the test injectors for various functional parameters. Rectify, replace test nozzle if necessary and repeat measurements.

If variation persists, change the high pressure pipes with new ones. Repeat measurements.

If variation still persists, Interchange high pressure pipes so that uniform values as close as possible are obtained.

If the observed delivery quantity is uniformly high or low:

Overcheck the tachometer.

Replace the test oil if it is suspected to be contaminated or too old.

Remove the high pressure pipes. Screw on adapters on master pump. Connect the other type of high pressure pipes which were being used.

Take 3 sets of delivery values and record observations.

If the specified delivery quantity (25 ± 0.5 cm³) is not obtained, replace high pressure pipes.

- With the new high pressure pipes, if the specified value is not obtained or if the variation between cylinders is more than 0.5 cm³ interchange high pressure pipes, without disturbing the test injectors.

In both the above cases the test bench needs rectification.

EXERCISE 15.2: Inline FIP Variable speed Governor setting

Objectives

At the end of this exercise you shall be able to

- perform phasing and basic setting
- adjust slider travel and setting of sliding bolt position
- adjustfull load delivery, maximum speed control and cutting in speed
- set idling speed, stop screw and starting travel of control rack
- set idle switching point.

Requirements

Tools/Equipments

- Trainee'stoolkit - 1 No.

Equipments

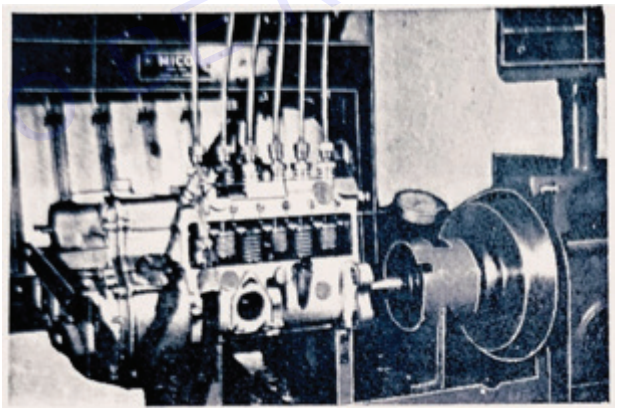
- Fuel Injection pump test bench - 1 No.
- Inline FIP with RQV governor - 1 No.
- Dial test indicator - 1 No
- Vernier caliper - 1 No.
- Governor setting deflection scale (special tool) - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Adjusting shims - as reqd.
- Soap Oil - as reqd.
- Engine oil - as reqd.
- Hydraulic transmission Oil - as reqd.
- Calibration oil - as reqd.

Procedure

Fig 1



1 Phasing Basic setting

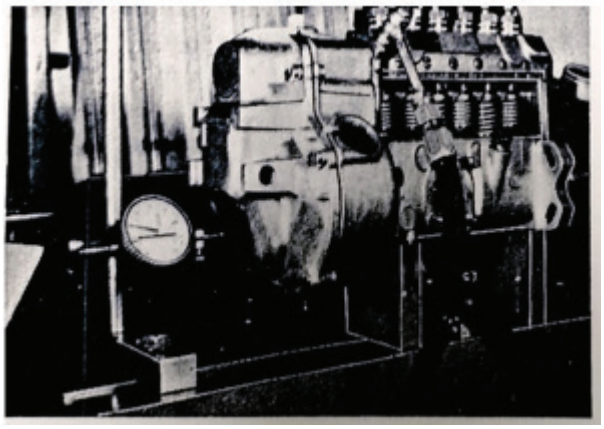
Carryout phasing and basic setting, as being done on other inline pumps.

2 Slider travel

Assemble the protective cover with a cutout for checking slider travel

Mount the stand with the dial indicator on test bench such that the magnetic tip of the dial indicator is in contact with the slider. Pre- stress the dial indicator by 20 mm and set it to '0'

Fig 2



Assembly of protective cover and dial indicator

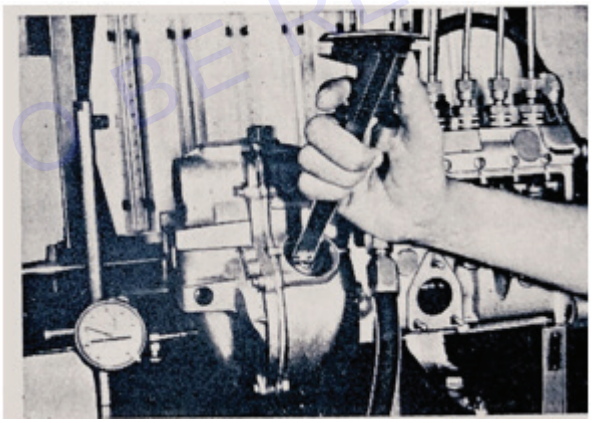
Set the control rack to 9 mm and fix it by control rack travel measuring device. Check the following readings

RPM	1400	400
Slider travel (mm)	71-75	15-18

If the readings are not obtained, adjust the maximum speed spring tension by adjusting nut (the threaded bolts should evenly be projected on each side of the flyweight and the projection should not be more than 2.5. mm or less than '0' from adjusting nut).

If the reading are still not obtained, replace spring seat/washer/max. speed springs.

Fig 3



Measuring the projection of bolt

3 Sliding bolt position.

Remove the protective cover and assemble the original cover. Fix control lever in reverse position. Control Lever in stop position, adjust control rack travel measuring device to '0'

Move control lever from stop position till the control rack just moves forward. At this point, set the scale on the control lever adjusting device to '0'.

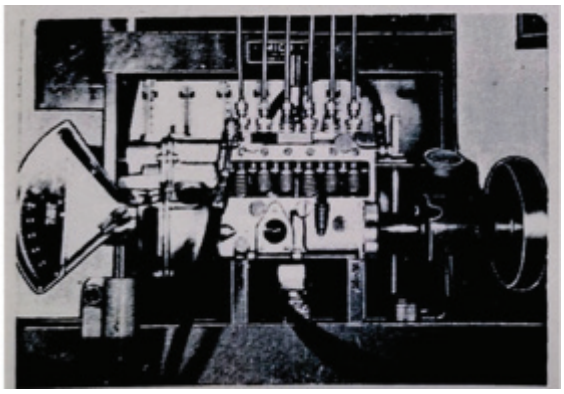
Control lever in maximum position, check the following readings

RPM	1400	1800
C Tr	min. 16 mm	0

If the readings are not obtained, adjust the length of the sliding bolt (1/2 turn of the bolt- approx 2.25 mm C.Tr.) or change the shim of the curve template (0.15 mm shim thickness = approx 1 mm C.Tr.).

Note: Shorter length of sliding bolt or lesser thickness of shim results in shorter C.Tr. and vice versa

Fig 4



Setting the control lever adjusting device to '0' position

4 Full load delivery

Assemble the full load stop assembly with torque control. Screw-in the threaded bush of torque control. Run the pump at 1400 rpm, move the control lever to maxmium position and adjust the hexagonal nuts of the full load stop till the C.Tr. is 9.1 mm. At this position, the delivery should be 24.224.8 cm^3/ 500 strokes. If not, readjust the hexagonal nuts.

Fig 5

Adjusting the full load control rack travel/ quantity

5 Maximum speed control

Control lever at 59 ± 4°, check the following readings:

RPM	1460-1470	1550-1585	1500-1630
C Tr	8.1	4.0	2.0

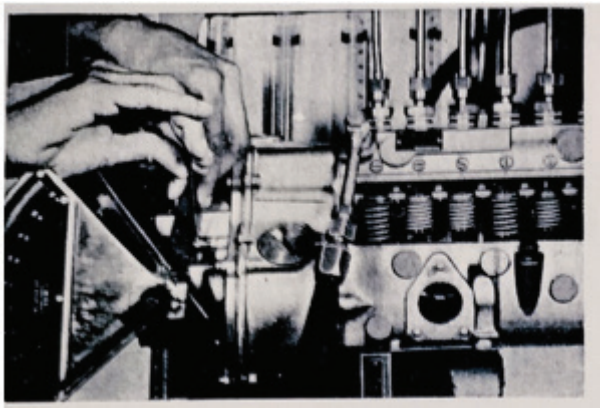
(If the C.Tr. at full load is other than 9.1 mm, take the difference from actual full load C. Tr.).

Note: With increasing/decreasing speeds. the control rack should move. continuously without jerking.

6 Cutting in speed

Fix control lever in the correct position. Control lever at maximum speed screw, adjust maximum speed screw till the control rack moves back by 1 mm from the full load position at 1460 1470 rpm.

Fig 6



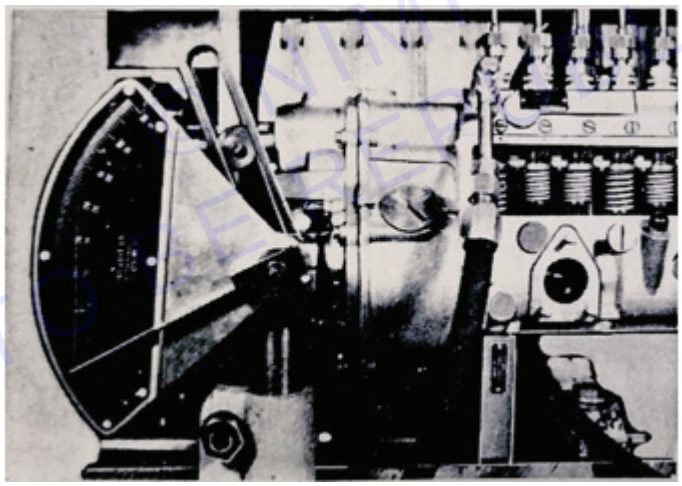
Adjusting the maximum speed stop screw

7 Idling speed control

Run the pump at 300 rpm and move the control lever till the control rack moves to 5.9-6.0 mm. The control lever position should be 14+4o.

If the readings are not obtained, replace idling springs.

Fig 7



Idling speed setting

RPM	1400	585-645
C Tr	min. 7.0	2.0

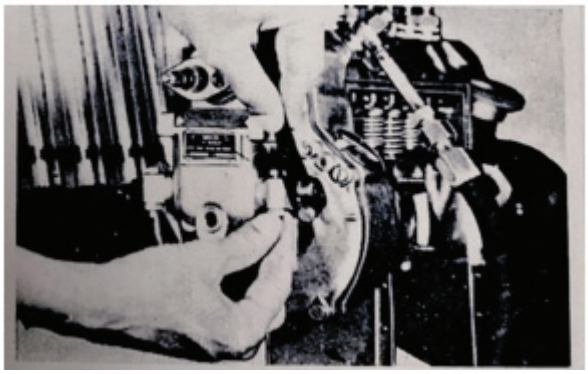
8 Torque control (torque control travel: 0.6±0.1 mm)

Run the pump at 600 rpm, keep the control lever at maximum speed screw and adjust the tension of torque control spring by adjusting the threaded bush till the control rack travel is 9.69.8 mm. Check the following readings:

RPM	600	900	1500-1630
C Tr	9.6-9.8	9.2-9.4	9.1

If the readings are not obtained, replace torque control spring sleeve with different collar thickness (if the C. Tr. at full load is other than 9.1 mm, take only the difference in C.Tr. from 600-1400 rpm).

Fig 8



Setting the stop screw

9 Course of delivery

With the control lever at maximum speed stop, check the following readings:

RPM	600	900
Cm3/500 stokes	21.3-22.3	22.3-23.8

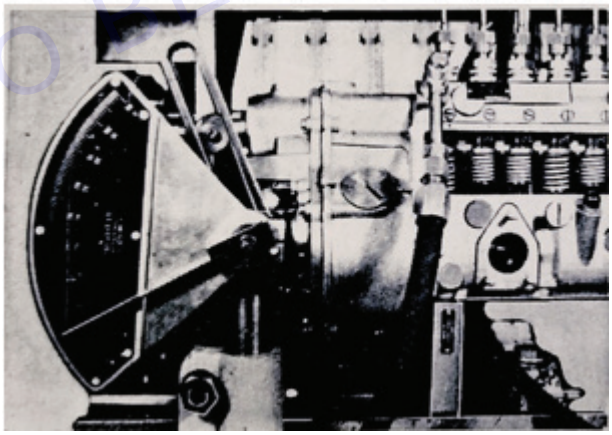
With the control lever in this position, check the following readings:

If the readings are not obtained, readjust the torque control travel by changing sleeve with different collar thickness.

10 Setting the stop screw

With the control lever in stop position, adjust the stop screw to 0.5 1.0 mm C.Tr.

Fig 9



Idling speed setting

11 Starting travel of control rack

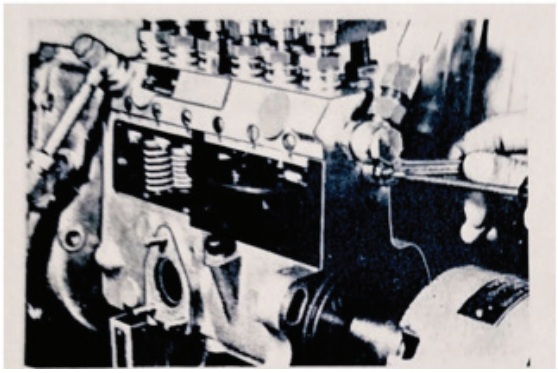
Run the pump at 100 rpm, move the control lever to maximum speed position and adjust the screw provided at the control rack end to 13.213.8 mm C.Tr.

12 Idle switching point

Pump at 100 rpm and the control lever at maximum speed position, the control rack should be at 'start' position.

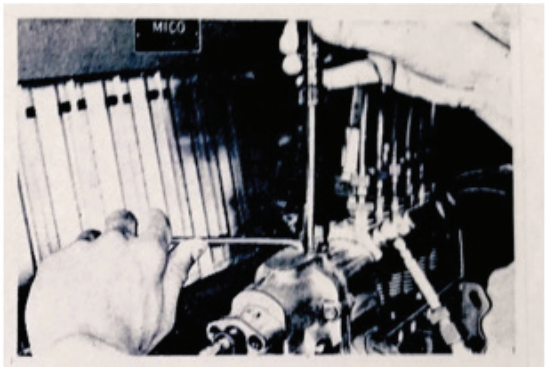
Bring the control lever to stop position. Increase the speed slowly from 100 RPM and move the control lever to maximum speed position. The control rack should return from starting to full load position between 180 and 250 rpm.

Fig 10



Setting the starting travel/quantity

Fig 11



Setting the idle switching point

Likewise, decrease the speed slowly from about 400 rpm and move the control lever from stop position to max. speed position. The control rack should move from full load to start position between 250 and 180 rpm..

If the idle switching point is not obtained, adjust the screw provided on the link fork.

EXERCISE 15.3: Servicing of Inline FIP Idle and Maximum speed Governor

Objectives

At the end of this exercise you shall be able to

- dismantle, Inspect and assemble the RSV Governor
- carryout mechanical testing of RSV governor
- check and Adjust full load delivery, maximum speed control and Adaption capsule
- set idling speed, Governor cutting in speed and starting travel of control rack.

Requirements

Tools/Equipments

- Trainee'stoolkit - 1 No.

Equipments

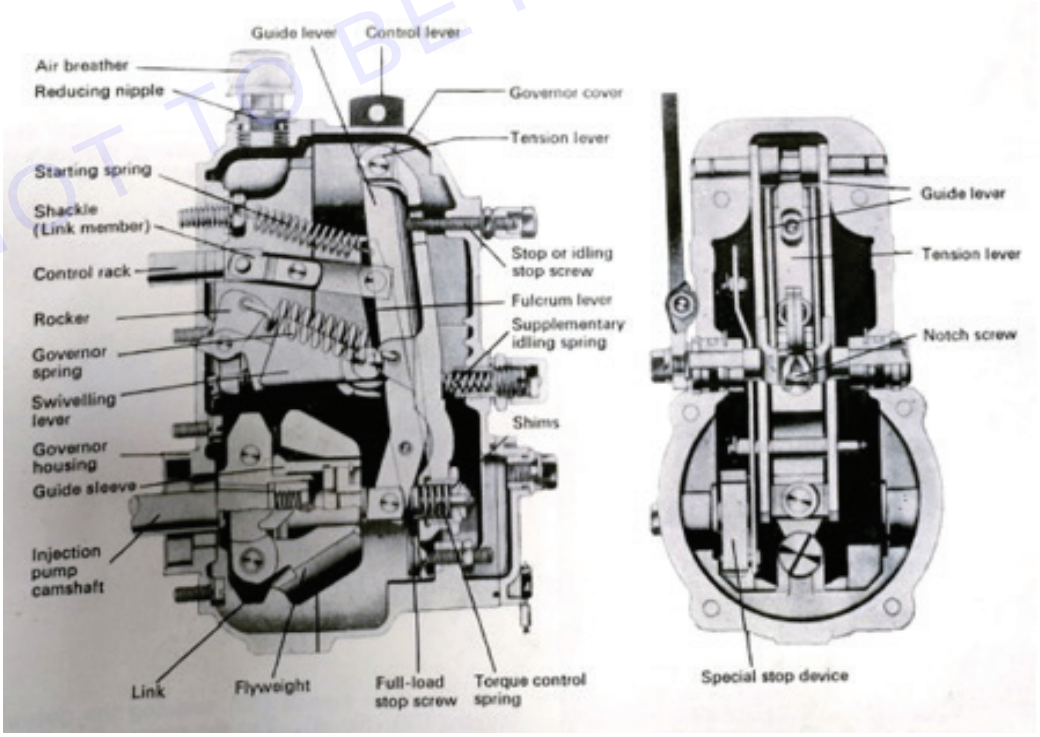
- Fuel Injection pump test bench - 1No.
- Inline FIP with RQV governor - 1No.
- Dial test indicator - 1 No
- Vernier caliper - 1 No.
- Governor setting deflection scale (special tool) - 1No.
- Circular control Rack measuring scale(special tool) - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Adjusting shims - as reqd.
- Soap Oil - as reqd.
- Engine oil - as reqd.
- Hydraulic transmission Oil - as reqd.
- Calibration oil - as reqd.

Procedure

Fig 1



1 Dismantling of RSV governor

Remove injection pump inspection cover, feed pump and dipstick (if provided).

Mount injection pump assembled with governor on swivelling vice 0 (Fig 2).

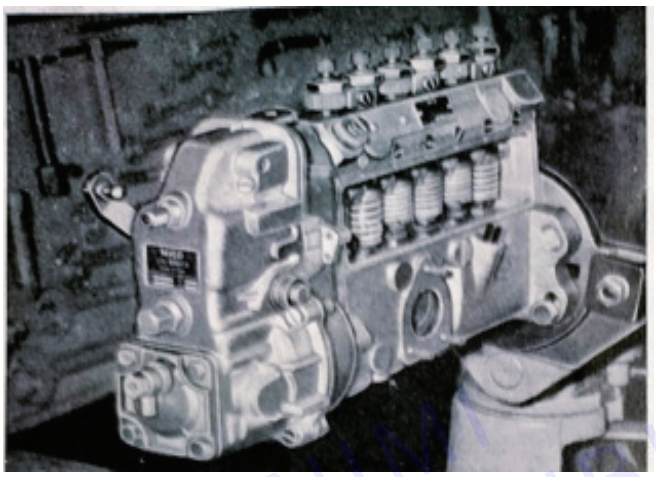
Unscrew stop or idling stop screw and supplementary idling spring.

Remove hexagonal bolts . Wherever tamper proof screws are provided, cut a slot with a hacksaw in the head of the tamper proof screw and remove the screw with a screw driver.

Remove end cover and rubber gasket

Collect lubricating oil which drains out of governor.

Fig 2

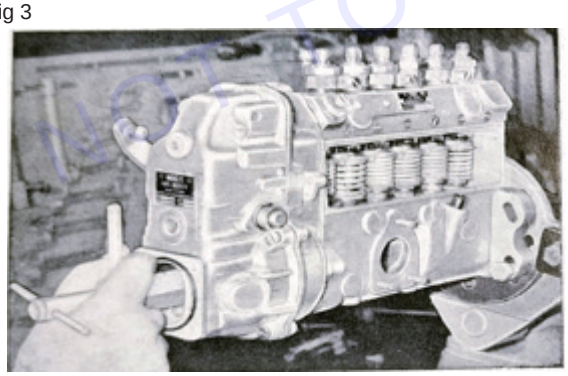


Pump and governor mounted on the swivelling vice 03-KDEP 2919

Unscrew adaption capsule from tension lever after removing the lock-nut with combination wrench (Fig 3).

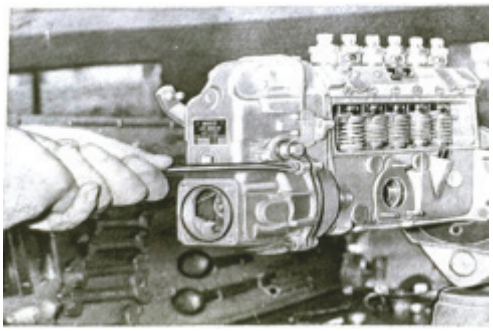
Remove screws securing the governor cover (Fig 4). Tap the cover lightly with a rubber mallet to loosen it from governor housing. Collect lubricating oil which drains out.

Fig 3



Unscrewing the lock-nut of torque control (adaption) capsule.

Fig 4

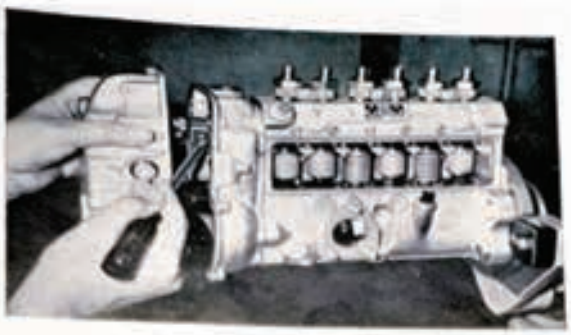


Unscrewing the governor cover screws

Disengage shackle from pump control rack by displacing the leaf spring from its normal position with a screw driver (Fig 5).

Unhook starting spring with thin nosed pliers (Fig 6). Do not overstretch the spring. Governor cover is now separated from housing. Guide sleeve assembly , remaining attached to guide lever , slides out of flyweight assembly.

Fig 5



Disengaging shackle (link member) from control rack

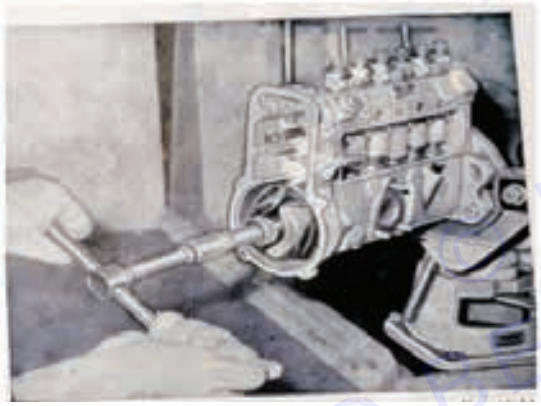
Fig 6

Unhooking the starting spring

Hold camshaft with slotted wrench by engaging to the coupling at drive end of camshaft. Unscrew round nut with pin wrench (Fig 7). Remove spring washer .

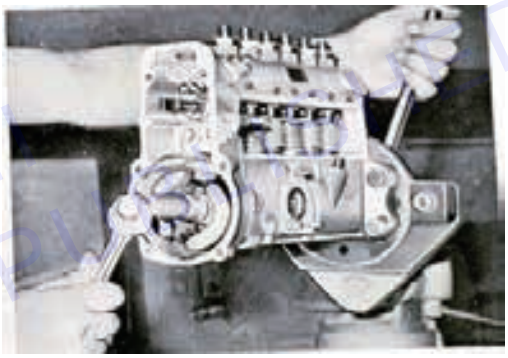
Remove flyweight assembly (Fig 8). Remove woodruff key from camshaft.

Fig 7



Unscrewing the round nut from the governor flyweight assembly

Fig 8

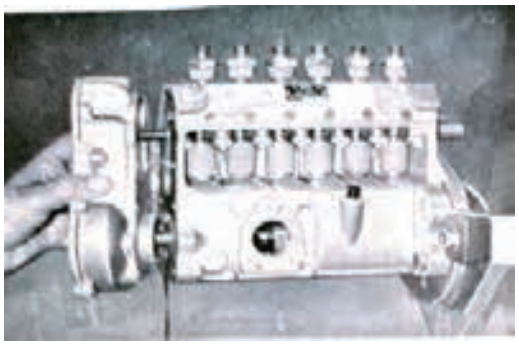


Extracting the governor flyweight assembly

If governor housing is to be removed, roller tappets of pump should be lifted off the camshaft with suitable tappet lifters. Unscrew the fixing screws . Tap the housing lightly with a rubber mallet and remove (Fig 9). Collect the oil in a container.

Push out lever shaft and sealing plugs by tapping lightly from one end (Fig 10)

Fig 9



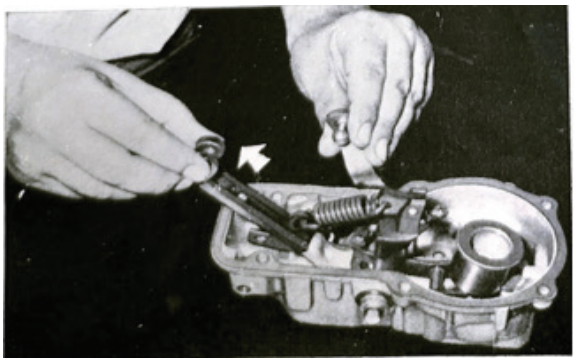
Removing the governor housing

Fig 10

Removing the lever shaft

Remove tension lever bymaneuvering it out upwards underneath the swiveling lever (Fig 11).

Fig 11



Removing the tensioning lever

Remove screw , washer and detach the control lever . Remove shim and sealing washer . In case governor is fitted with speed control device first remove control lever by loosening screw . Remove speed control device by loosening screws .

Unhook governor spring from tension lever and swiveling lever.

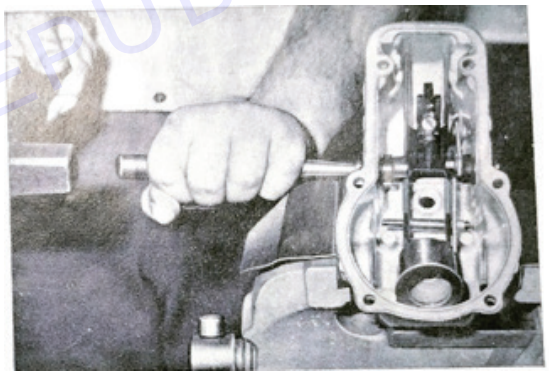
Remove retaining rings with screw driver using suitable protection pad on governor cover seating face to avoid damage (Fig 12).

Tap the swiveling lever to one side (with a brass drift) so that the bearing bush can slide out of governor cover (Fig 13).

Fig 12

Removing the swivelling lever retaining rings

Fig 13



Removing the bearing bushes

Remove bearing bush together with 'O' ring and closing cap . Move swiveling lever in opposite direction so as to facilitate removal of the second bearing bush. Swiveling lever can then be maneuvered out of the bearing bores. (Fig 14).

Fig 14

Removing the swivelling lever

Remove guide lever along with guide sleeve assembly and fulcrum lever as a complete unit. Unhook starting spring from fulcrum lever . If guide sleeve assembly requires replacement, remove with extractor and arbor press.

Dismantling of stop lever assembly (if provided).

Remove hexagonal screw , closing screw

(if provided) and stop lever . Remove spring cap and spring . Before removing supporting lever with shaft , remove full load stop screw and if necessary bearing bush.

Inspection of parts

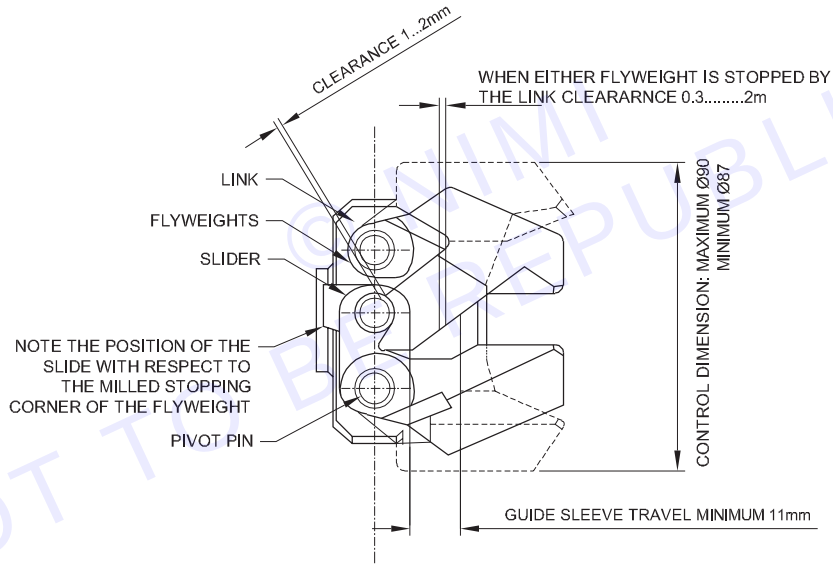
Wash all the dismantled components thoroughly in clean fuel oil. The linkages/components should be carefully examined and parts showing excessive wear must be replaced.

Note: Perfect movement of linkages/components is extremely important because stickiness or excessive clearance will result in control rack reacting sluggishly to governor movement which in turn will unfavorably influence the engine performance.

Flyweight assembly Inspection

If sliders, pivot pins, keyway and threads on link and flyweights are worn out or damaged, the complete flyweight assembly must be replaced. Check whether flyweights move freely and can take up position shown in Fig 15.

Fig 15



STANDARD DIMENSIONS FOR FLYWEIGHT ASSEMBLY

Check the condition of woodruff key, replace if necessary.

Examine guide sleeve assembly to ascertain the condition of bearing surface for flyweight sliders. The surface should not bepitted or worn out. Replace guide sleeve assembly, if found damaged.

Check ‘stop’ face of tension lever for damage/wear.

Check full load stop screw for wear/ pitting marks. Replace if necessary.

Check whether fulcrum lever is in good condition. The bottom pin, the bearing for guide lever pin and shackle must not be worn out. There should not be excessive play between slider and link fork

The shafts of swiveling lever mustnot have excessive play in bearing bushes . If groove for retaining ring on bearing bush is damaged replace the bearing bush.

The rocker on the swiveling lever should properly clamp the notch screw i.e. notch screw should not rotate freely. Otherwise replace the swiveling lever.

The taper bore in the control lever must not be worn out. It should mate perfectly with the taper at the end of the swiveling lever shaft.

The stop lever should not be excessively worn out and the corresponding bearing surface of governor cover should be in good condition.

The drive tendons of shaft must fit without any appreciable play in the corresponding recess of stop lever.

Air breather should be washed in petrol and 'blown dry with compressed air.

The link fork or the stop pin should not be loose in the assembly. If necessary replace governor cover and link fork

Assembly

Thoroughly wash the repaired and the new parts in clean fuel oil. 'Moving parts should be smeared with engine oil SAE 30, prior to assembly.

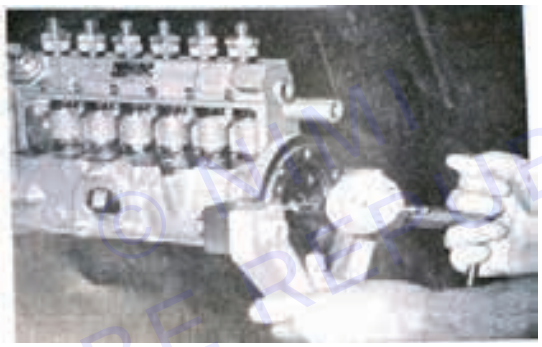
Governor housing

If governor housing is removed (or replaced) it should be fitted with new gasket and tightened securely with screws.

Measure camshaft projection on drive end with measuring bar . This dimension should be 9.8±0.5 mm. If necessary, correct the projection by inserting shims.

Fix the end play measuring attachment together with dial gauge (0-10 mm- Least count 0.01 mm) to camshaft. During this measurement, the roller tappets should be lifted off the camshaft with suitable tappet lifters. Exert a steady axial pull on the attachment (Fig. 16) and set dial indicator to '0. Then exert a steady axial pressure on the attachment and note down the reading.

Fig 16



Measuring camshaft and play

The camshaft end play values should be:

Ball bearings	Taper roller bearings	Corresponding ambient temperature
0.03to0.13mm 0.07to0.17mm	0.02to0.06mm 0.06 to 0.10 mm	Around 20o C Around 40°C

If 'excessive end play' or 'no play' exists, the cam- shaft should be removed and shims totalling at least 0.2 mm thickness removed, as it is easier to measure accurately when some play exists.

Refit camshaft (avoid using grease since it influences the measurement).

Measure end play and if required add shims between spacer ring and bearing. Always compensate camshaft end play on governor side so that the specified end play is obtained without affecting the camshaft projection.

Flyweight assembly

Before fitting the flyweight assembly the conical surface of the camshaft should be cleaned with kerosene/ turpentine and blown dry with compressed air.

Insert woodruff key into camshaft keyway and fix flyweight assembly with round nut

Tighten round nut to 50...60 N.m. (5...6 kgf.m) torque, using pin wrench .

Guide sleeve assembly

Proceed as follows to maintain a distance of 19+0.2 mm between the inner shoulder of actuating T of the guide lever and the governor housing face with flyweights in closed position (Fig. 17-A).

Push guide sleeve assembly without guide lever into the flyweight assembly and measure with a depth gauge the distance between the front face of the thrust bearing of guide sleeve to the face of governor housing (Fig. 17).

Fig 17

Removing the swivelling lever

Select compensating washer of the required thickness which, when added to the dimension measured above, would give 19±0.2 mm. Press guide sleeve assembly with the 'selected compensating washers on to the actuating 'T' of guide lever.

Screw the adaption capsule into tension lever until the adaption capsule protrudes out 1 mm beyond the inner face of lever. Secure the capsule with hexagonal nut .

Fig 17 A

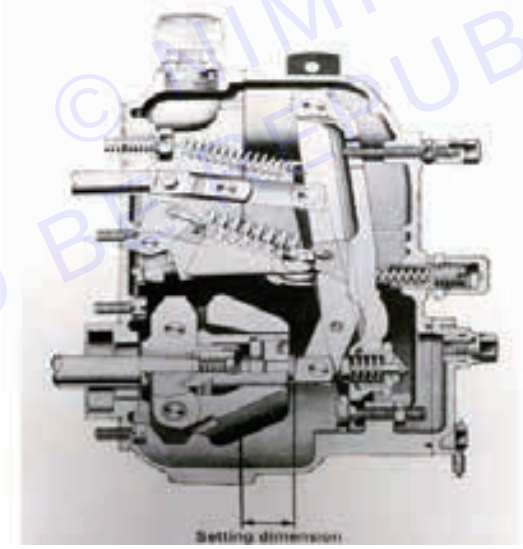


Fig 17-A Setting dimension distance from contact face of actuating "T to contact surface of governor housing

Stop lever assembly

- Assemble shaft , spring capsule , springs and fixing bracket on to supporting lever . Thoroughly grease the shaft Insert supporting lever assembly into bearing bush.
- Place the rubber ring into the groove of bearing bush
- Position the spring inside the closing cap such that the straight end (parallel to spring axis) of spring projects through the hole in closing cap In this position assemble the closing cap to governor cover The bent end of spring should rest on the corresponding lug of governor cover.
- Insert straight end of spring (projecting above the closing cap into the corresponding hole (indicated by arrows in a top lever.
- Rotate stop lever till the slot engages with lugs of shaft and assemble screw along with spring washer .

Full load stop screw

Screw in full load stop screw into governor cover temporarily until it engages lock-nut (Fig 18)

Guide lever

Insert guide lever with fulcrum lever guide sleeve assembly and shackle

Insert lever shaft into governor cover partially to that it engages with one leg of guide lever.

Fig 18

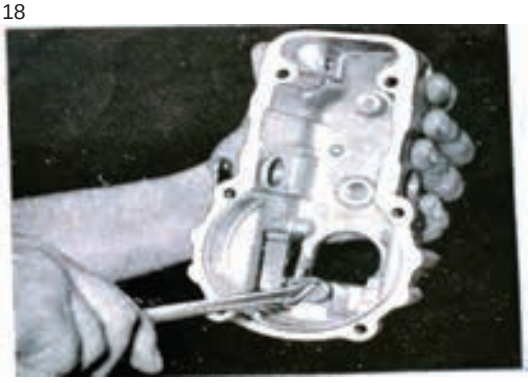


Fig 19

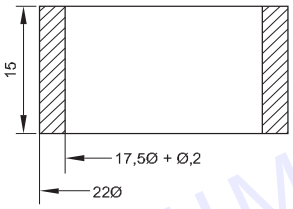


Fig 19 Assembly aid bush for pressing bearing bushes into governor cover

Swivelling lever

Insert swiveling lever shafts into governor cover bearing bores. Insert bearing bushes with rubber rings from outside into governor cover. Using two assembly aid bushes (Fig 19) firmly press bearing bushes into position so that the grooves for retaining rings become accessible. (Fig 20). At this stage, insert retaining rings into position (Fig 21).

Fig 20

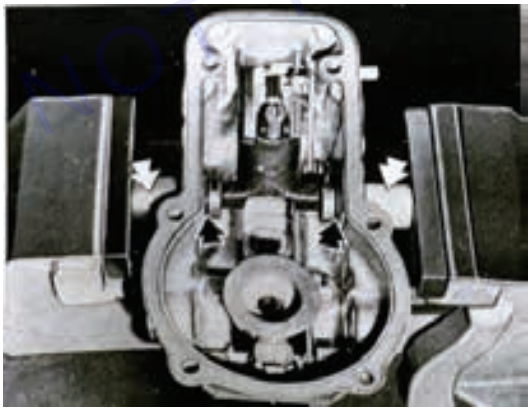


Fig 21

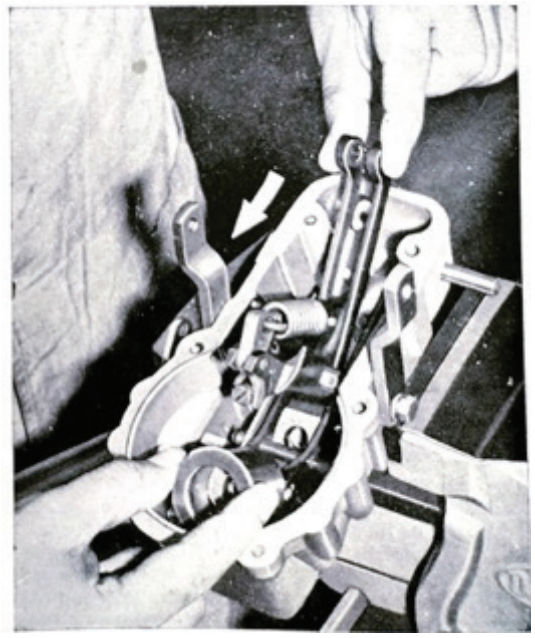
Install rubber ring and select washer such that the rubber ring is not loose or subjected to undue pressure or the bearing area of control lever on swiveling lever shaft flat is not reduced. Fix control lever with screw washer and spring washer . Check the axial clearance and free movement of swivelling lever by moving the control lever.

The axial play of the swivelling lever can be adjusted by selecting suitable thickness of washer

Tension lever

Hook the governor spring to swivelling lever and to tension lever. Install tension lever from upper side of governor cover, pushing it underneath the swiveling lever (Fig 22).

Fig 22



Insert lever shaft through the holes in guide lever and tension lever and secure with new sealing plugs .

To 'pre-tension the governor spring, screw in notch screw fully into swiveling lever and then screw out six full turns (24 clicks).

Note: The notch screw works with ratchet effect one click after every one-fourth turn of the screw.

Governor cover

Apply a thin coating of rubber sealing compound to governor cover face and place the gasket in position. Proceed as follows:

- Hook starting spring into fastening plate
- Push guide sleeve assembly into flyweightassembly.
- Connect the shackle (link member) to control rack and secure it with leaf spring.

Place governor cover on governor housing, loosely securing with fixing screws . Control rack should now be checked for free movement, Push control rack to stop and release; control rackmust automatically return to 'full load position. Repeat this test several times. Finally tighten the screws to 5...7 N.m (0.5...0.7 kgf.m) torque.

Fix end cover . Fix supplementary idling spring , adjusting screw , washer , hexagonal nut and secure with capnut.

Provisionally screw in stop or idling screw (9/14). Fix lock-nut (9/15) with washers (9/13) and capnut.

Screw the closing plug into governor housing. If air breather is provided, screw it into its reducing nipple. Fix the speed control device wherever provided, with screws. If maximum speed stop screw was unscrewed, fit in provisionally and secure with lock-nut . Remove tappet holders from the pump. Pour fresh engine oil into pump camboxupto the mark. The governor is now ready for testing.

Testing of RSV governor

Setting of fuel injection pump without governor action

Mount pump assembled with governor, on fuelinjection pump test bench using suitable mounting brackets/clamps

Remove governor cover assembly

- Setting the pre-stroke (port closing)

Adjustment "A size pumps by adjusting the roller tappet adjusting screws or by varying the thickness of shims

'P' size pumps-by varying the thickness of shims under the element-delivery valve assembly flange.

- Cam sequence

Commencement of delivery of other elements should be adjusted according to the cam sequence starting from cylinder No. 1. Tolerance of +0.5 is permissible on the cam displacement angles.

Example:

For 4 cylinder: 90±0.5° For 6 cylinder: 60 +0.5”

The tappet clearance in each cylinder should be checked immediately after setting (on ‘A’ size pumps minimum 0.2 mm).

Basic setting

The basic setting of fuel delivery is considered as pre-setting, uniform setting of elements, in order to check the condition of ‘element-delivery” valve combination.(Fig 23)

“Maximum spread in delivery quantity means the difference between the individual cylinders in one pump

Adjustment

‘A’ size pumps-by adjusting control sleeve Psize pumps by turning the element delivery valve assembly flange.

After calibration of pump is over, fix the governor cover assembly with screws and proceed as per the recommended sequence of operations

1 Mechanical testing

Unscrew the stop/idling stop screw and supplementary idling spring. Unscrew adaption capsule using combination wrench 03-EFEP 202. (Fig 24 & 25)

Note: Test specification chart columns 1to 10

Control lever at stop position, adjust control rack measuring scale to ‘0’ and screw in the stop/ idling stop screw so that the control rack moves 0.3-1 mm from the STOP position.

Fig 23

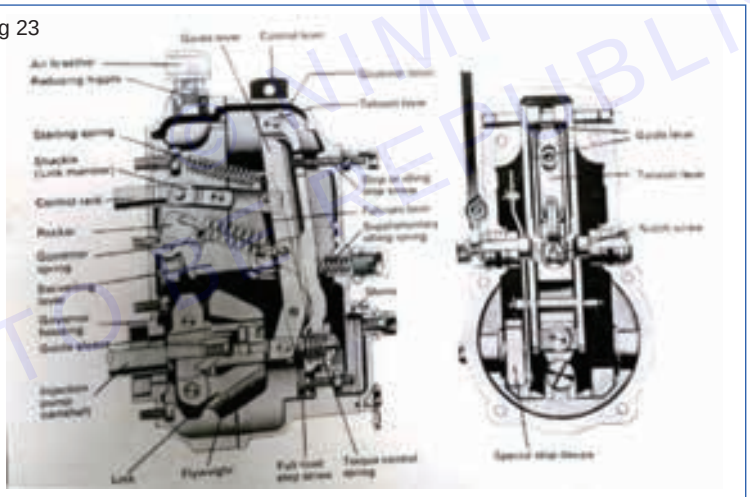


Fig 24

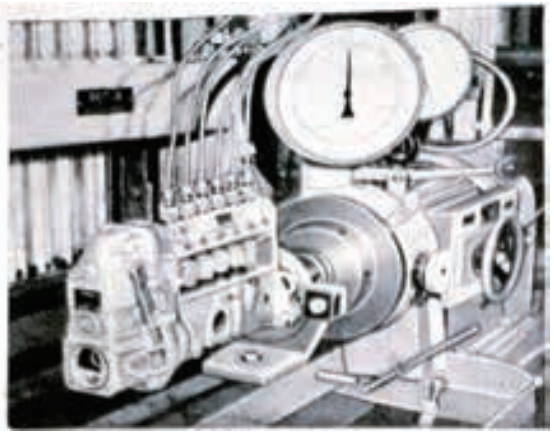
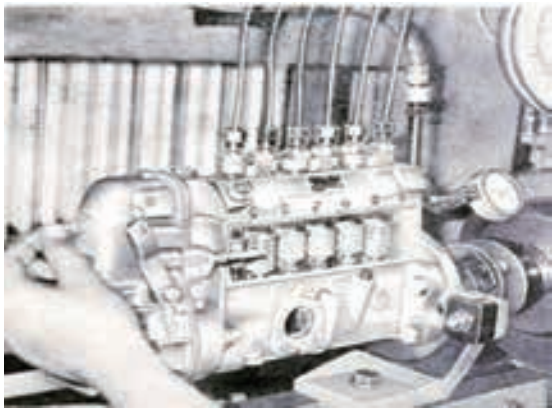


Fig 25

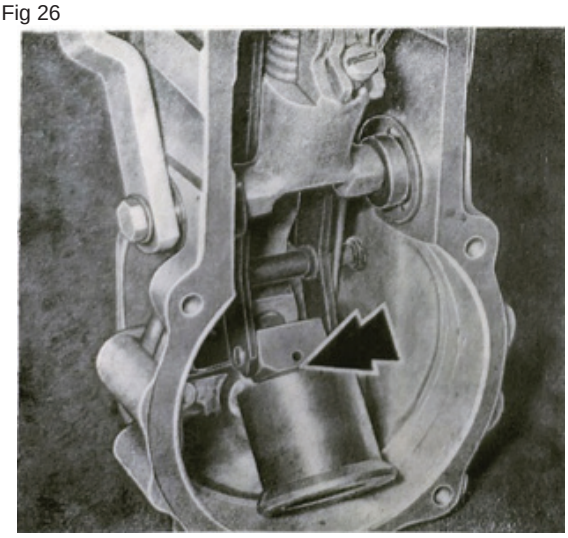


Bring the control lever to the maximum position and run the pump at 20 rpm below the maximum rate speed the governor should not cut-in. If it cuts-in, tighten the notch screw of swivelling lever.

In the above control lever position and the speed, adjust the full load stop screw until 1-2 mm more control rack travel (C.Tr.) is obtained.(Fig 26)

Increase the speed until governor cuts off completely. Check whether the control rack has gone back to 0.3-1 mm. If not the thickness of compensating washer (71) between the guide sleeve assembly and the actuating 'T' of guide lever has to be changed.

Fig 26



Note: The distance of 19+ 0.2 mm between the inner shoulder of the actuating 'T' of the guide lever and the governor housing face with the fly- weights in their closed position should be maintained. Refer point 4.4 of repair instructions.

0.5 mm shim = 1 mm C.Tr. (approximately).

Bring the control lever to vertical position and set the scale of the control lever adjusting device to 40°. Then bring the control lever to the maximum position indicated in the Test chart column 1, bearing in mind that the angle given is intended only as a guide. Check whether the control rack travel is 20-21 mm. Screw-in the maximum speed stop screw until it touches the control lever and secure provisionally with lock-nut.(Fig 27&28)

Fig 27

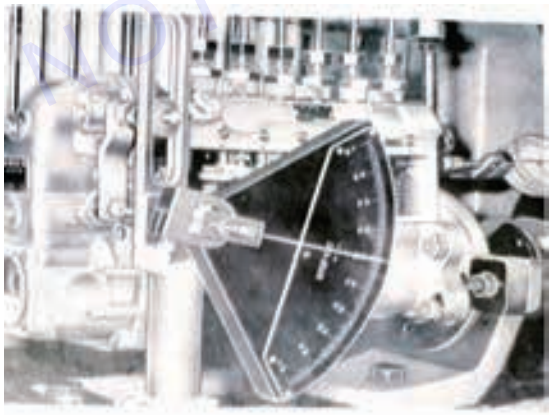
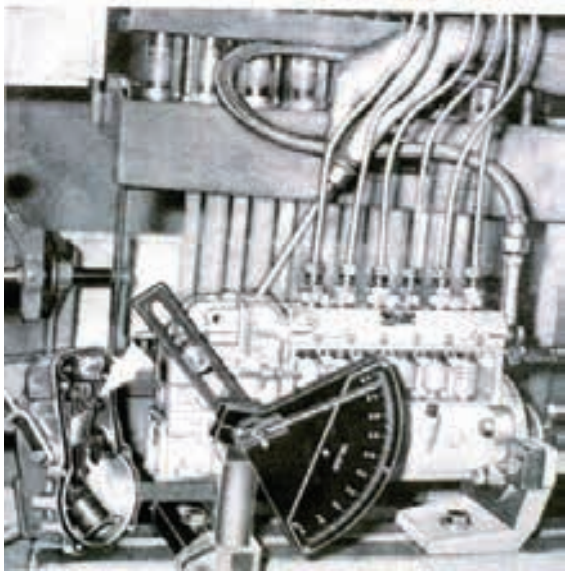


Fig 28

Setting and testing the maximum speed control(without supplementary idling spring)

Run the pump at the specified maximum rated speed and set the control lever to the maximum speed stop screw. Adjust the notch screw to get the specified control rack travel (without tolerance). When making the notch screw adjustments, stop the pump and bring the control lever to 'STOP' position. (Fig 29)

Fig 29



Caution

Calibration of pump/governor should be done in accordance with the respective Test specifications chart.

Check control rack travel again. If the value is still not obtained, adjust slightly the maximum speed stop screw

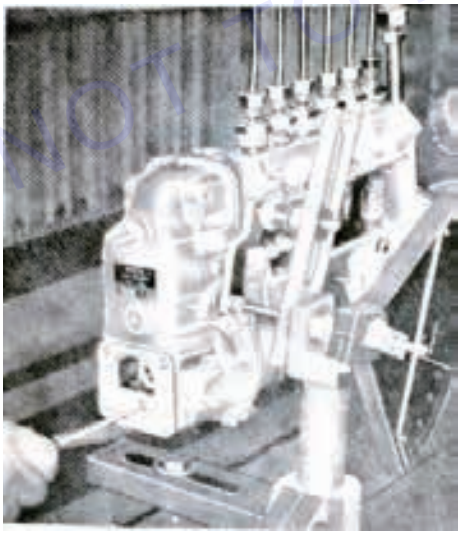
Testing

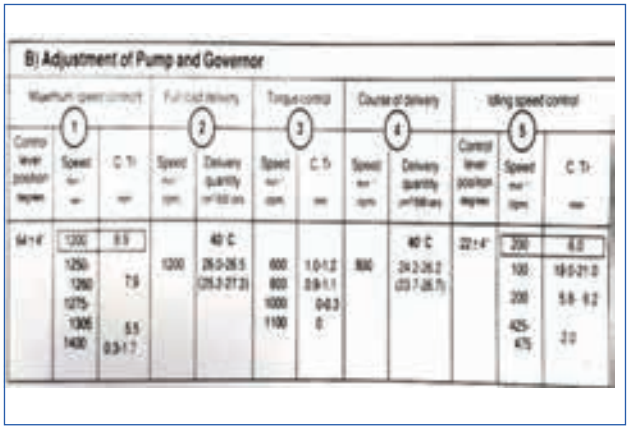
With the control lever resting against the maximum speed stop, check the readings. If specified readings are not obtained, readjust both the maximum speed stop screw (fine adjustment) and the notch screw (rough adjustment)

Adjusting the full load delivery (maximum output) Test chart column 2

Run the pump at the specified speed, set the control lever to the maximum speed stop and adjust the full load stop screw to obtain the specified delivery quantity (Fig 30)

Fig 30

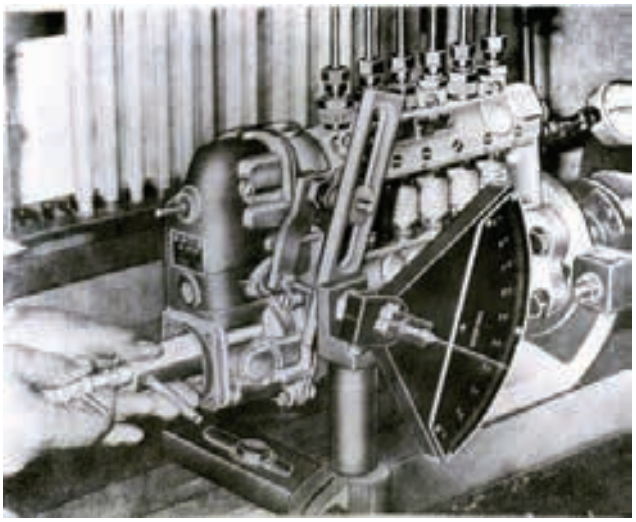




Adjusting the torque control (Adaption capsule)(Test chart column 3)

Run the pump at the specified minimum speed of the governor, set the control lever to maximum speed stop and note down the control rack travel. Screw the adaption capsule with combination wrench into the tension lever (Fig 31) until the control rack moves further by the specified value given against the above minimum speed. Check the other readings.

Fig 31

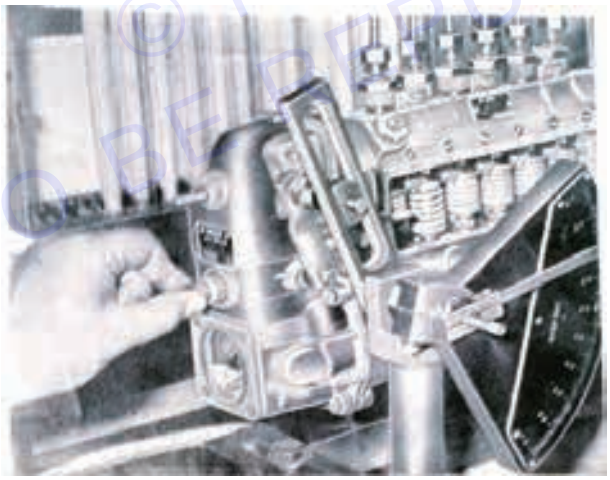


Note: These readings do not indicate the actual control rack travel but only the difference in control rack travel between maximum and minimum specified speeds. If the readings are not obtained, replace the adaption capsule or the shims. After adjustment, tighten the lock-nut of the adaption capsule.

Testing the course of delivery at the torque control range(only if specified) Test chart column 4

Run the pump at the specified speeds, keeping the control lever at the maximum speed stop and check the values. If the values are not obtained readjust the adaption capsule and tighten the lock-nut.

Fig 32



Adjusting and testing the idling speed control(governing at lower range) Test chart column 5.

Setting the supplementary idling spring:

Run the pump at the rated Idling speed (framed value). Move the control lever close to the specified angle, until the control rack moves to 0.5-1.0 mm loss than the specified (framed) control rack travel. Then screw in the supplementary idling spring (Fig 32) until the control rack moves to the specified framed value in the Test chart. Tighten the lock-nut slightly and check the readings. If the specified values are not obtainable, re-adjust the control lever and supplementary idling spring.

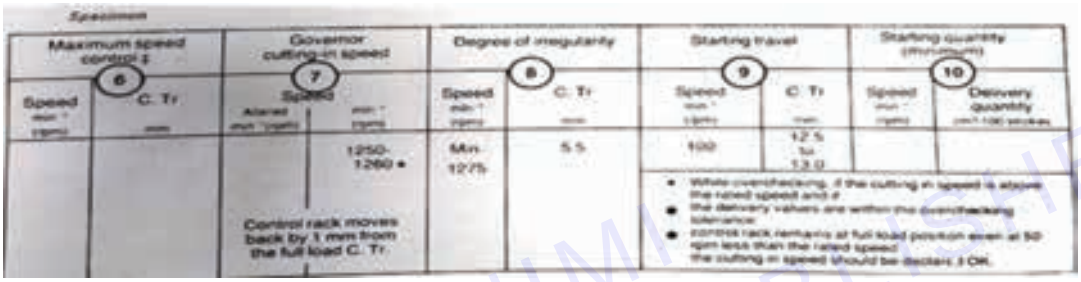
Setting the idling stop screw(in the case of governors with stop lever).

With the control lever in the above idling position screw-in the idling top screw till it touches the swivelling lever. Tighten the lock-nut.

Testing the maximum speed control at upper range(with supplementary idling spring) Test chart column 6.

Set the control lever to the maximum speed stop and check the specified readings.

Course of delivery (4)		Idling speed control (5)		
Speed min⁻¹ (rpm)	Delivery quantity cm³/500 strs	Control lever position degrees	Speed min⁻¹ (rpm)	C. Tr mm
800	40° C 24.2-26.2 (23.7-26.7)	22 ± 4	200	6.0
			100	19.0-21.0
			200	5.8- 6.2
			425-475	2.0



Setting the cutting-in speedTest chart column 7

Cutting-in speed is the speed at which the governor starts governing i.e. the control rack starts moving back towards STOP.

Run the pump and set the control lever to the maximum speed stop. At the specified cutting in speed the control rack should move back by 1 mm from the full load position. If not obtained, adjust the maximum speed stop screw only.

Adjustment of degree of irregularity (only if specified) Test chart column 8.

With the control lever at the maximum speed stop, increase the speed further until the control rack returns to the specified control rack position. The speed should be as specified. If not adjust both the notch screw and the maximum speed stop screw so that the specified readings, given in columns 7 (cutting-in) and 8 (degree of irregularity) are obtained.

Setting the starting travel of the control rack (only if specified) Test chart column 9.

Remove the control rack travel measuring scale. Fix circular control rack measuring scale H-S/EFEP 38. Run the pump at the specified speed and set the control lever to the maximum speed stop. Set the control rack travel to the specified value by adjusting the stop screw provided at the control rack end (Fig. 11). Secure with the lock-nut and screw-in the closing cap for the control rack end

Testing the starting quantity (only if specified) Test chart column 10.

Run the pump at the specified speed and set the control lever to the maximum speed stop and

check the delivery quantity.

Securing and sealing the stops

On all the stops, which are intended for limiting the settings on pumps and governors the lock-nuts of the stop screws should be tightened firmly before sealing.

The sealing wire should be fixed in such a way that it becomes impossible to adjust the stop without damaging the wire or the seal

If tamper proof screws were provided for fixing end cover use new tamper proof screws and tighten till the hexagonal head breaks off.

EXERCISE 15.4: Servicing of In line pump Pneumatic Governor

Objectives

At the end of this exercise you shall be able to

- dismantle, Inspect and assemble the Pneumatic Governor
- check control rack travel, Tightness test and governor spring
- set full load stop screw and Idling spring stopper
- check and Adjust full load delivery.

Requirements

Tools/Equipments

- Trainee'stoolkit - 1 No.

Equipments

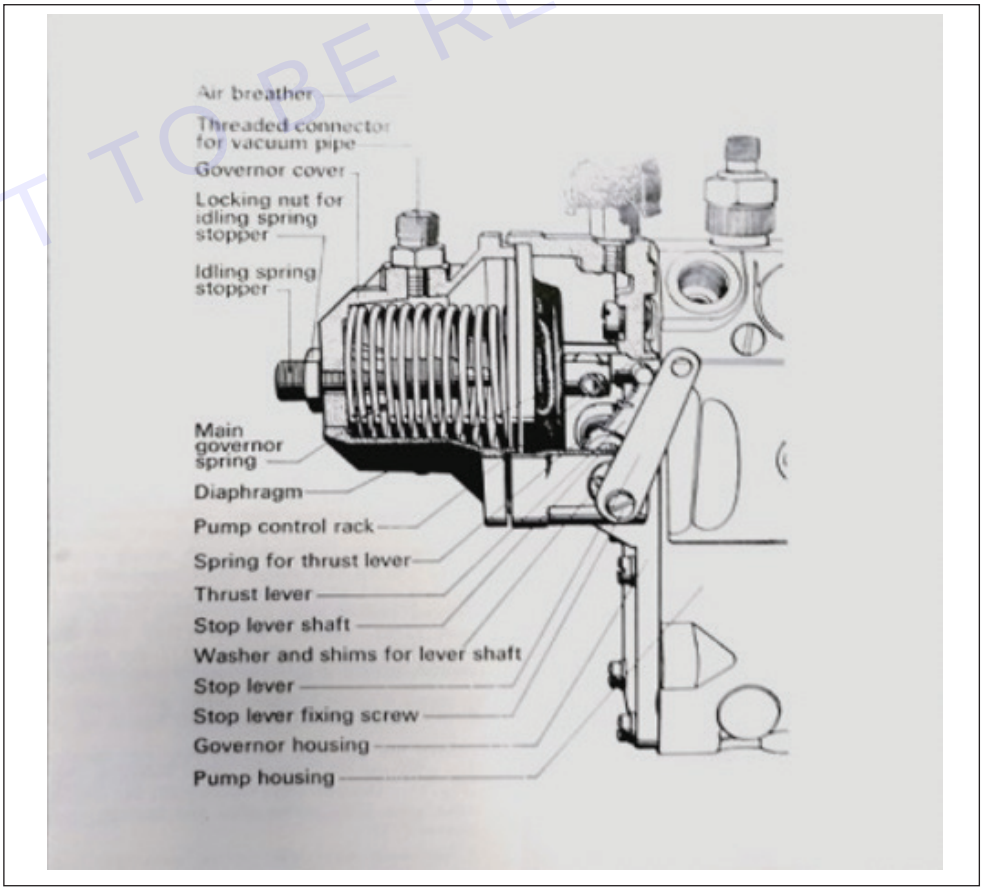
- Fuel Injection pump test bench - 1No.
- Inline FIP with RQV governor - 1No.
- Dial test indicator - 1 No
- Vernier caliper - 1 No.
- Governor setting deflection scale (special tool) - 1No.
- Circular control Rack measuring scale(special tool) - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Adjusting shims - as reqd.
- Soap Oil - as reqd.
- Engine oil - as reqd.
- Hydraulic transmission Oil - as reqd.
- Calibration oil - as reqd.

Procedure

Dismantling

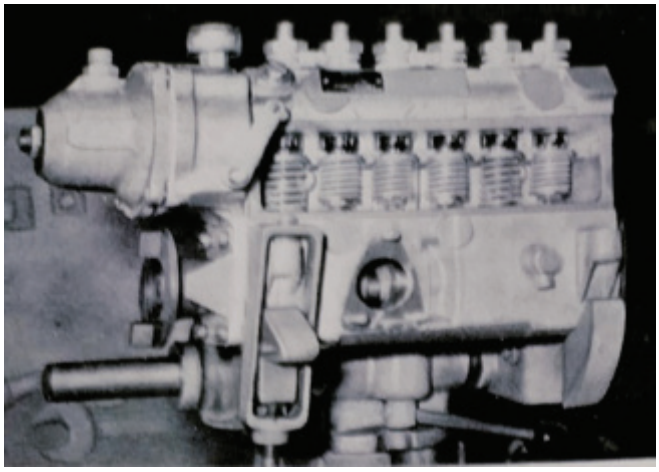


Mount injection pump assembled with governor on swiveling vice (Fig 2) with suitable mounting flange and adapter ring.

Auxiliary idling spring/damping valve

- MZ type earlier design

Fig 2



Remove screws and take out cap together with guide bush adjusting screw and other components (. Pressure spring and stop pin from the governor cover. Where necessary, remove guide bush screw and other components

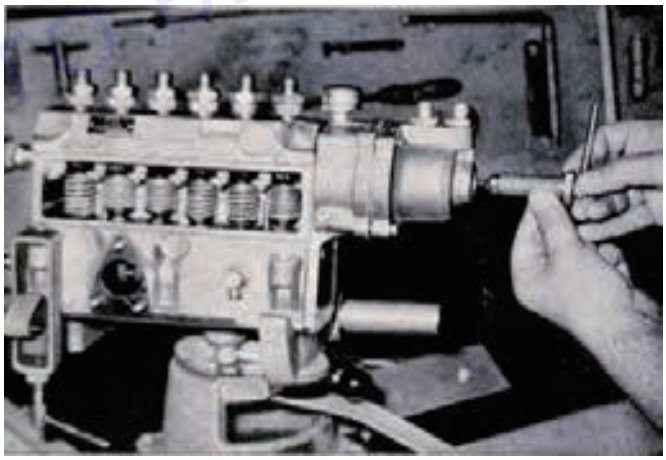
- MZ type simplified design

Loosen the hexagonal nut and screw out the spring stopper assembly

- MZ type modified design (with cam operated spring stopper).

Remove the two screws along with washers . In the earlier design where countersunk screws are used, carefully remove the aluminium washers with a sharp tool taking care not to damage the countersunk surface. Remove end cover and gasket . Pull out the sliding spring stopper .

Fig 3



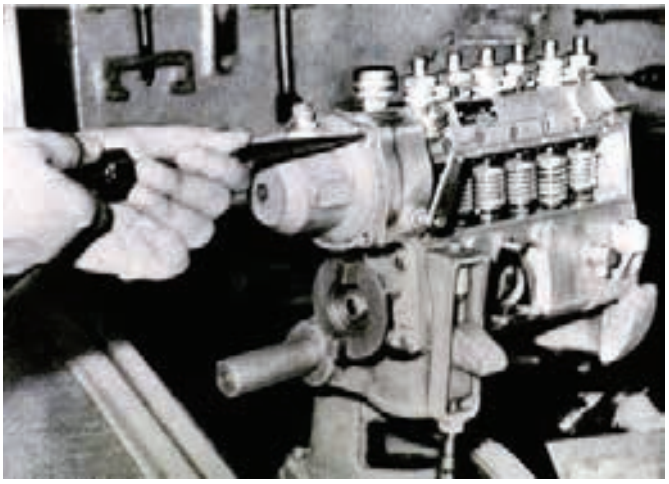
Remove screw along with spring washer . In the new design where hexagonal head screw is used, an additional plain washer is used. Remove control lever , spring and bush . Remove washer from this side. Take out the split pin and remove washers . Remove 'O' rings .

- MV type with damping valve

Loosen the nut with an open end spanner and unscrew the damping valve assembly (Fig 3). Unscrew valve retainer and remove valve cone , spring and compensating washer .

Remove governor cover by unscrewing Screws (Fig 4). Remove governor spring .

Fig 4



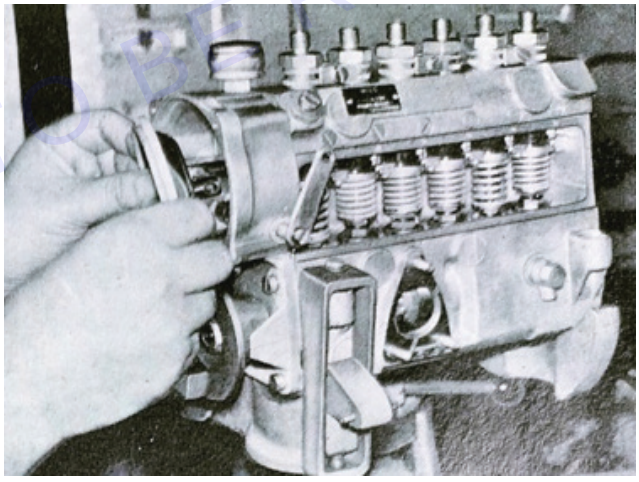
Remove diaphragm (Fig 5). Unscrew nut and remove guide piece (where provided) and pivot pin from pump control rack.

Lever shaft assembly

Un-hook spring from thrust lever .Remove screw (Fig 6). Loosen hexagonal screw remove stop lever and woodruff key .

On new type of MZ governors the stop lever can be removed by taking out the cheese head screw and spring washer. Remove split pins from both sides of the lever shaft Take out the lever shaft along with washers and shims. Remove thrust lever and spring from governor housing. If necessary remove governor housing by unscrewing the screws and after having lifted the roller tappets off the camshaft with tappet lifters.

Fig 5



Control rack stop cum excess fuel device

Unscrew the locknuts and remove excess fuel device from pump housing. Remove threaded bush and engaging bolt from control rack. Remove pin fromhousing by tapping with a punch. Remove push button and spring from housing.

Inspection of Governorparts

Wash all the dismantled components (except the diaphragm) thoroughly in clean fuel oil. Diaphragm should not be washed in kerosene, diesel or trichloroethylene as it will remove the impregnating oil which keeps diaphragm supple. Examine parts carefully and replace the parts showing excessive wear/damage.

Diaphragm Check for cuts/puncture. Replace, if necessary.

Replace governor spring if corroded/surface coating damaged or cracked/nicked.

Replace idling spring stopper if spring is suspected to be broken or if stopper pin is sticky.

Replace leaky or damaged cover/housing/cap.

Inspection of Damping valve MV type governor

Replace valve cone and valve retainer if found to be worn out.

Fig 6

Remove air breather from governor housing and wash it with patrol and blow dry with compressed air.

Inspection of Modified MZ type (with cam operated spring stopper)

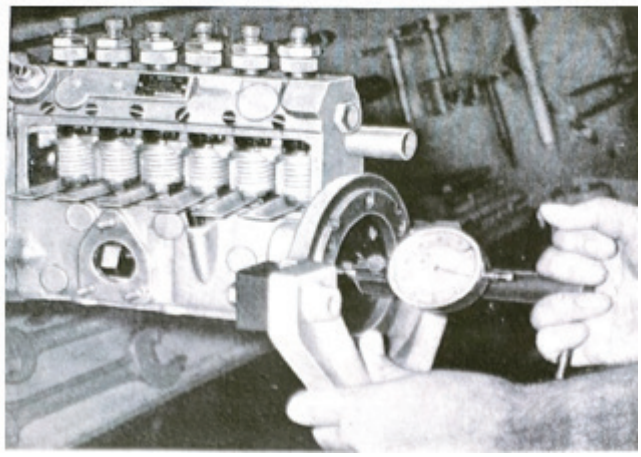
- If tenons, threads of lever shaft are worn out or damaged or if cam surface shows excessive wear, replace the end cover.

If the bearing bores for lever shaft show excessive wear, replace the end cover assembly.

- Replace '0' rings .

Replace washers .

Fig 7



Assembly of governor parts

If governor housing is removed (or replaced) fit it with new gasket and tighten securely with screws and Measure camshaft projection on drive end with measuring bar and calipers. This dimension should be 9.8-0.5 mm. If necessary, correct the projection by inserting shims. This operation is also necessary when camshaft, bearings or the bearing cover require replacement.

Fix the end play measuring attachment with dial gauge to cam- shaft (drive end). During this measurement, the roller tappets should be lifted off the camshaft with suitable tappet lifters. Exert a steady axial pull on the attachment (Fig 7) and set dial indicator to '0'. Then exert a steady axial pressure on the attachment and note down the reading.

The camshaft end play showing in the Tabular Colum:

Ball bearings	Taper roller bearings	Corresponding ambient temperature
0.03 to 0.13 mm 0.07 to 0.17 mm	0.02 to 0.06 mm 0.06 to 0.10 mm	Around 20° C Around 40° C

If 'excessive end play or no play' exists, the camshaft should be removed. At this stage it is advisable to remove shims totalling at least 0.2 mm thickness as it is easier to measure accurately when some play exists. Refit camshaft (avoid using grease since it influences the measurement). Measure end play and if required add shims between spacer ring and bearing.

Keep thrust lever and spring inside the governor housing and insert lever shaft

Secure thrust lever on lever shaft with screw .

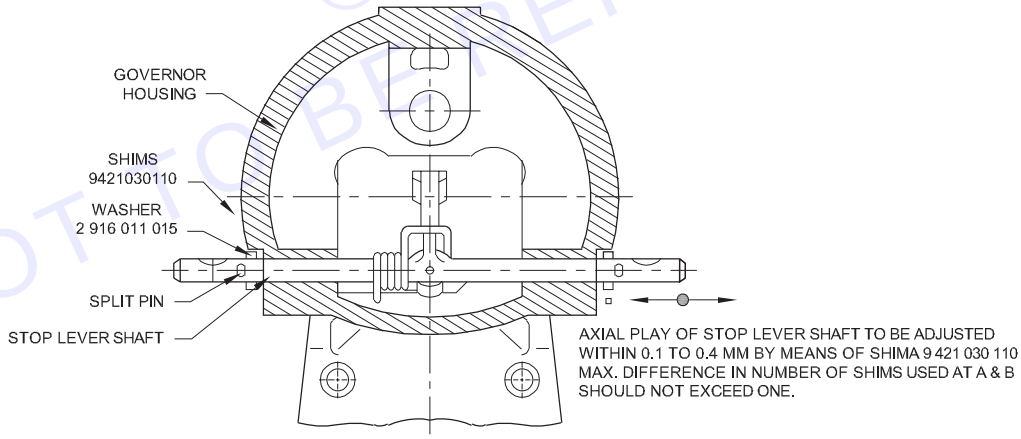
Hook the spring to thrust lever. Add equal number of shims , washer on both sides and assemble split pins .

Check the axial play of lever shaft The axial play should be between 0.1 to 0.4mm (Fig 8). If not, add or remove shims difference between the number of shims on either side should not be more than one.

Assemble stop lever with woodruff key spring washer and secure with screw .

Assemble pivot pin and guide piece , where provided, to pump control rack with nut and washer . To keep diaphragm supple, smear it liberally with recommended oil (one part technical grade fish oil with two parts of motor oil grade SAE 30). Assemble diaphragm.

Fig 8



ADJUSTMENT OF AXIAL PLAY OF STOP LEVER SHAFT

Hold the governor spring against the diaphragm and assemble governor cover with screws . Tighten the screws evenly to ensure proper tightness,

Caution: Before compressing the governor spring ensure that governor cover holes are in alignment with the threaded holes in governor housing to avoid diaphragm being unnecessarily torsioned during assembly. Torsioned diaphragm may cause control rack stickiness and fail prematurely.

Assembly of end cover

Smear mutton tallow on '0' rings and assemble '0' rings into the corresponding counterbores of end cover

Assemble equal number of washers .

Assemble washer and split pin on the opposite side of control lever. Assemble bush , spring . The spring should be assembled such that the straight end (parallel to spring axis) is engaged in the corresponding groove on end cover and U bent end is hooked on to control lever.

Engage the tenons of lever shaft to the corresponding hole of control lever and fix screw along with spring washer . In the case of new design where hexagonal head screw is provided, assemble plain washer, spring washer and fix the screw .

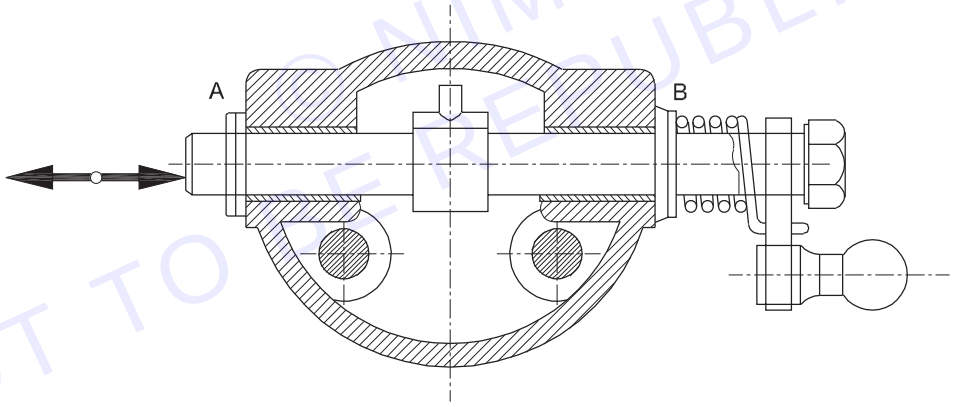
Tighten the screw (to 6 N.m (0.6 kgf. m) torque.

Check the axial play of lever shaft. The axial play should be between 0.1 and 0.4 mm (Fig 9). If not, add or remove washer . The difference between the number of washers on either side should not be more than one. Check for free movement of lever shaft. Smear good quality grease on the cam and the lever shaft near the bearing bushes.

- Check the overall length (L) of the spring stopper (Fig 10). The overall length should be as specified in column '3b' of calibration chart. If specified length is not maintained, this can be adjusted by means of
- Screw and nut arrangement in the case of earlier design.
- Shims between the end of spring stopper and hexagonal head screw in the case of new design.

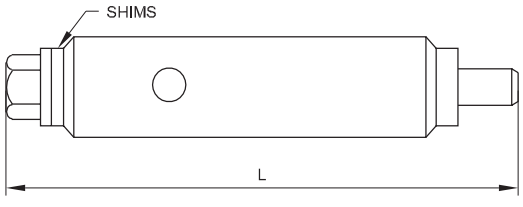
For adjusting the length hold the spring stopper by inserting a pin in the cross hole provided in the stopper body and loosen locknut or hexagonal head screw. Adjust the length of screw or vary the thickness of shims. After adjustment, tighten the locknut or hexagonal head screw.

Fig 9



CHECKING THE AXIAL PLAY OF CONTROL SHAFT FOR SPRING STOPPER CAM

Fig 10

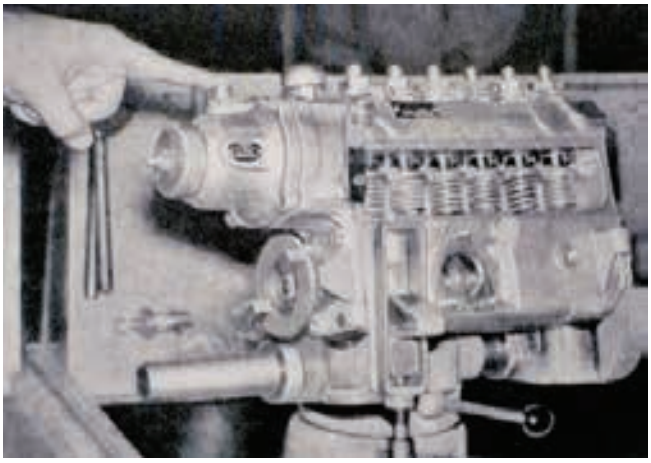


OVERALL LENGTH OF SLIDING SPRING STOPPER

Smear good quality grease on the body of spring stopper and insert into governor cover . Ensure that the spring stopper slides. freely in the governor cover and no stickiness is experienced.

- Fix gasket on to governor cover
- Assemble end cover to governor cover and fix screws along with washers temporarily.

Fig 11



Assembling of Excess fuel device

Screw in engaging bolt to the control rack, threaded guide bush to the pump housing.

Insert spring and push button into the housing and fix with pin . Caulk the pin at both ends and screw in this assembly to the threaded guide bush , which is already assembled to the pump housing, with locknuts .

Tightness test

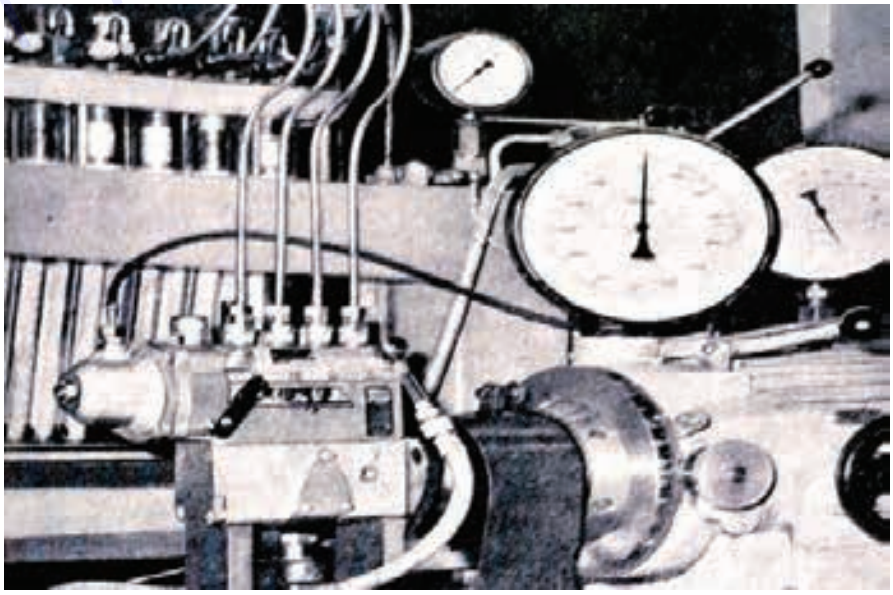
With stop lever, move the control rack to stop position, close the vacuum pipe connection with a finger and release the stop lever (Fig 11). The control rack would move slightly and stop. If the governor is airtight, the control rack would not move further towards full-load position unless finger is removed from the vacuum pipe connector.

Testing of pneumatic governor

Mount fuel injection pump, assembled with governor on test bench using suitable mounting brackets/ clamps (Fig 12). Carry out all tests in the prescribed direction of rotation as seen from the drive end Maintain sufficient quantity of lubricating oil in pump Prior to adjusting/testing the governor. fuel injection pump should be calibrated without governing action .

- Setting the pre-stroke (port closing) . Port closure is reached when the oil flow from swan neck pipe fitted to test injector cuts off.

Fig 12



Adjustment

A size pumps by adjusting the roller tappet adjusting screws or by varying the thickness of shims in the case of 3000 series pumps.

'P' size pumps by varying the thickness of shims under the element delivery valve assembly flange.

- **Cam sequence**

Commencement of delivery of other elements should be adjusted according to the cam sequence starting from cylinder No. 1. Tolerance of 0.5 is permissible on the cam displacement angles.

Example:

For 4 cylinder: 90° 0.5°

For 6 cylinder: 60°+ 0.5

The tappet clearance in each cylinder should be checked immediately after setting (on 'A' size pumps minimum 0.2 mm).

- **Basic setting**

The basic setting of fuel delivery is considered as pre-setting uniform setting of elements- in order to check the condition of element- delivery valve' combination.

The fuel delivery given under 'delivery quantity column is the average value for all cylinders and should be as close as possible within the specified.range.

'Maximum spread in delivery quantity' means the difference between the individual cylinders in one pump.

Adjustment

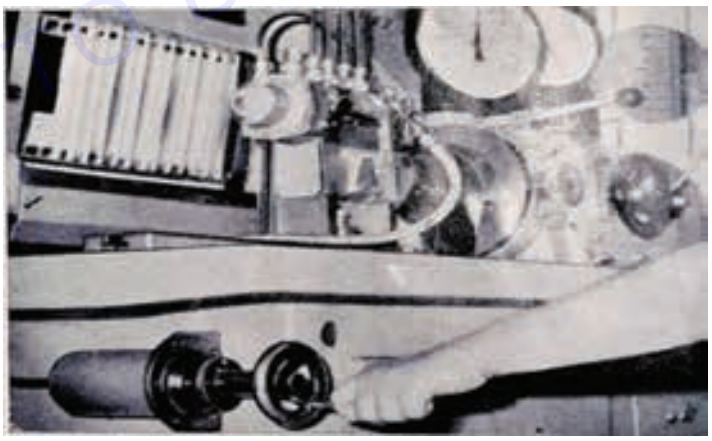
'A' size pumps by adjusting control sleeve

'P' size pumps by turning the element-delivery valve assembly flange

After basic setting of the pump is over, assemble governor cover assembly and proceed as per the recommended sequence of operations given below.(Fig 13)

Note: Figures in brackets indicate the corresponding test specifications column number.

Fig 13



1 Control rack travel (1)

Check control rack for free movement, release full load stop completely by removing the cap (50/51). Fix circular control rack travel measuring scale (H-S/EFEP 38) on pump inspection window and fix the pointer. Push control rack to stop position and set circular control rack travel measuring scale to '0' Release the control rack; it shouldmove to the position as specified (Column 1).

2 Tightness test (2)

Connect vacuum pump (03-EFAW 16), U-tubemanometer (H-S/EFEP 3) connections to thegovernor. By operating the vacuum pump buildup the specified vacuum (Fig. 2). Note the timefor the specified drop in vacuum. The time shouldbe as specified. If leakage is observed rectify.

B) Adjustment of Governor

Control rack travel (1)	Tightness test (2)		Limiting the control rack for governor spring setting/check up							
				Full load stop (3a)		Idling stop/ Damping valve (3b)		Checking (3c)	
mm	Vacuum drop mm WC	Test time minimum Sec	Speed min⁻¹ (rpm)	Vacuum mm WC	C.Tr. mm	Vacuum mm WC	C.Tr. mm	Vacuum mm WC	C.Tr. mm
21	500-480	10	500	500	9.8	350 min⁻¹ (rpm) 600-630 mm WC spring stopper length ≥ 70 mm	7.5	500 600-630	9.8 7.0-7.5

Specimen

Caution!

Excerpts of calibration chart [as shown above] are given only for illustration.

Calibration of pump/governor should be done in accordance with the respective Test specifications chart.

Fig 14

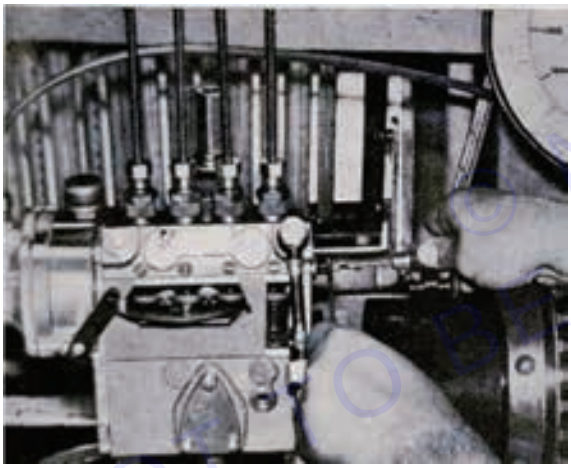
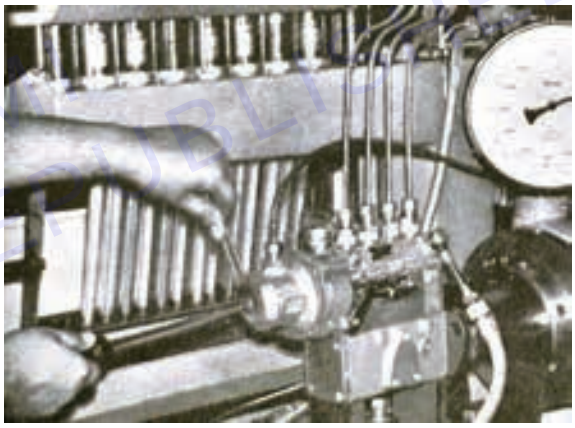


Fig 15



3 Governing (3a, 3b and 3c)

Run pump at the specified speed.

3.1. Setting full load stop screw

Set the specified vacuum and adjust full load stop to the specified control rack position (Fig 14) The cap should be assembled while checking the control rack travel after adjustment In the case of excess fuel device, set the full load stop by screwing in/out the threaded sleeve of housing . While carrying out this adjustment push button should be in 'released' position.

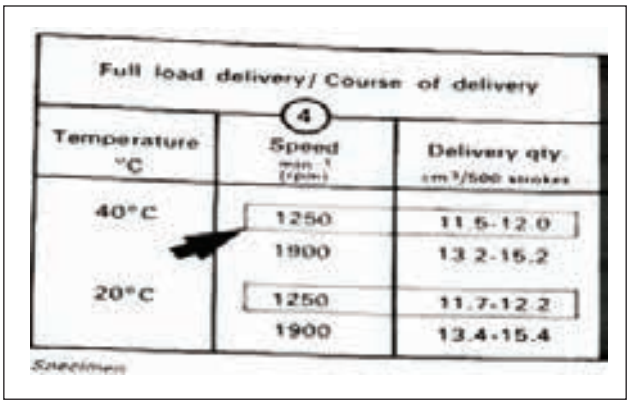
3.2. Setting idling stop/damping valve (3b)

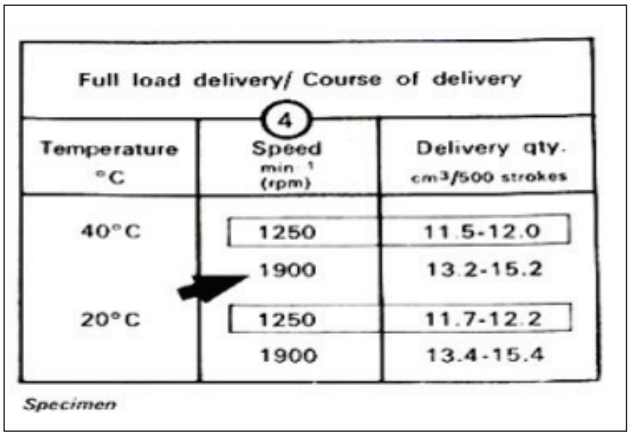
Set the specified vacuum and adjust idling screw or damping valve to the specified control rack position (Fig 15)

3.3. Checking (3c)

Check control rack travel with respect to the vacuum. The values should be as specified.

If the specified values are not obtained, re-adjust idling stop/damping valve or replace the governor spring .





Specimen

4 Setting the full load delivery

(Test chart column 4 framed)

Disconnect vacuum connections.

Run pump at the specified speed and adjust full load stop to obtain the specified delivery quantity (Fig 16)

4.1. Checking course of delivery (Column 4 unframed)

Run pump at the specified speed and check the delivery values.

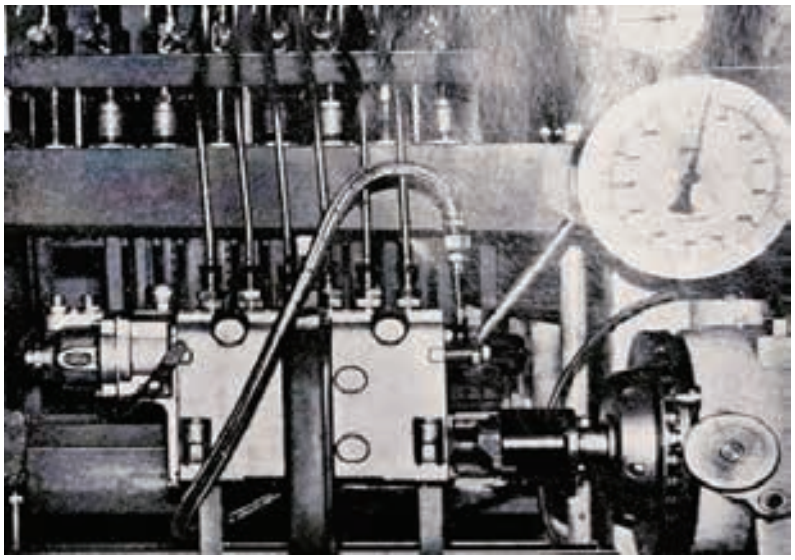
5 Excess fuel device, if provided (5)

Again connect vacuum connection to the governor. Run pump at the specified speed and press excess fuel device button; control rack should move beyond full load position. Set vacuum as specified, excess fuel device button should snap back.

6 Testing the starting delivery, specified (6) if

Run pump at the specified speed; press the excess fuel device button, where provided and check the specified delivery.

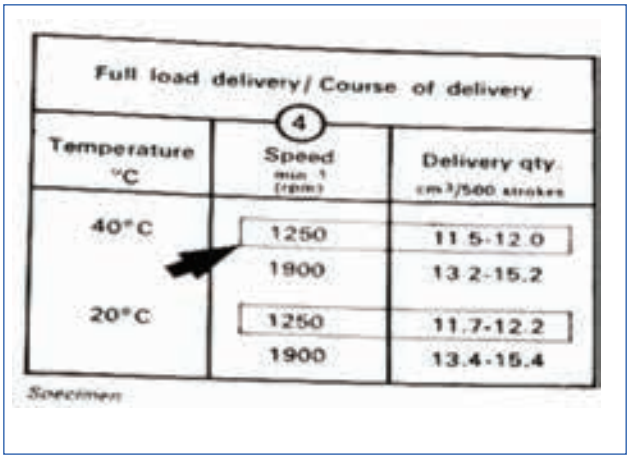
Fig 16

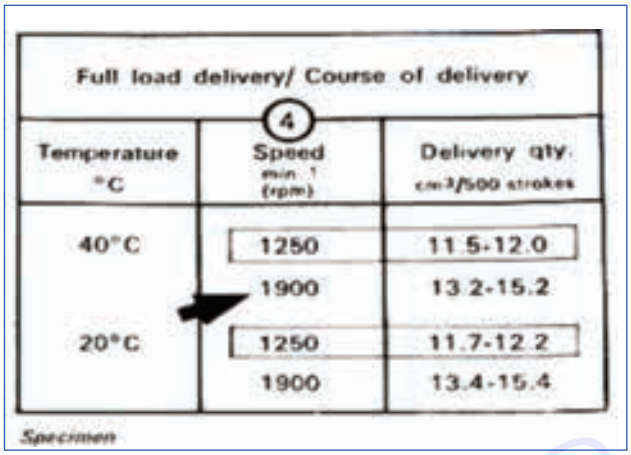


Starting delivery. (minimum)

7 Governor cutting-in vacuum Connect vacuum pipe.

Run pump at 500 rpm. Operate the vacuum pump till the control rack just starts to move back and note the vacuum on “U” be manometer. The vacuum should be as specified





Mounting of pump with pneumatic governor on engine

Though pneumatic governor pumps are calibrated on fuel injection test bench by simulating engine manifold vacuum conditions with the help of a vacuum pump, finer adjustments of governor, in conjunction with engine venturi settings are essential so as to obtain the desired idling, full load and flyup (maximum no load) speeds.

By exercising due care at the time of mounting the pneumatic governor pumps on the engine.customer complaints viz. engine hunting, surging. erratic running etc which are normally associated with governor and venturi adjustments can be minimised.

Normally idling position and maximum speed setting screws of the venturi unit are sealed/set by the engine manufacturer after adjusting idling. full load and no load maximum speed on the dynamometer. While mounting the pump, the original setting of maximum speed stop screw. should not be tampered with. We are giving. hereunder the recommended procedure for the various adjustments necessary.

- Mount fuel injection pump on engine and warm up the engine.

Adjust spring stopper (on governor cover) till engine idles 50-100 rpm below the specified idling speed (recommended by the engine manufacturers). In this condition, the engine would hunt.

Screw-in the spring stopper (on governor cover) gradually till stable idling speed is obtained. Do not screw-in the idling stop screw too much as it would increase the no load maximumspeed (fly-up speed).

If the stable idling speed obtained is not as specified by the engine manufacturer adjuststop screw to get specified idling speed.

- Check maximum no load (fly-up) speed. If the speed is more than that specified, adjust idling stop screw on the governor cover and re-check the idling speed as well as fly-up speed to obtain both the values within limits. This is applicable where maximum speed stop screw of venturi, has not been tampered with and engine manufacturers’ seal is intact.

In case the maximum speed stop screw of venturi is found to have been tampered with, proceed as follows:

- Adjust idling speed as detailed above with the help of governor spring stopper and venturi.
- Check maximum no load speed. If necessary, adjust the venturi maximum speed stop screw to obtain the specified no load speed. How- ever, this is not an accurate method because full load speed is not assured.

Note: As long as stable idling speed and no load speed, as specified are obtainable, it is not necessary to check the stability of engine rpm at no load speeds in the intermediate speed ranges.It is mainly because such conditions are normally not encountered during actual operation of engine.

EXERCISE 15.5: Servicing of Distributor type fuel Injection pump

Objectives

At the end of this exercise you shall be able to

- dismantle Distributor pump on FIP test bench
- check Distributor type FIP
- assemble Distributor type FIP.

Requirements

Tools/Instruments

- Trainees tool kit - 1 Set.

Equipments/Machines

- Distributor type FIP - 1 No.
- Distributor FIP holding vice - 1 No.

Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Adjusting shims - as reqd.
- Engine oil - as reqd.

Procedure

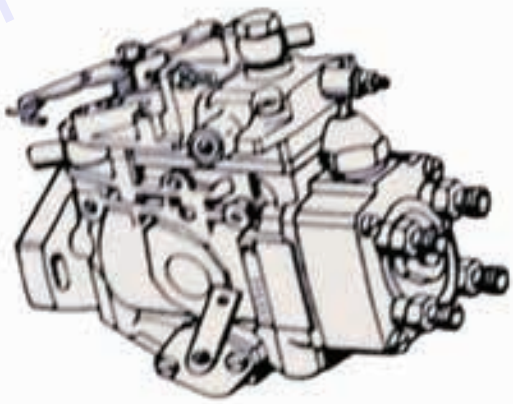
Preparation

Identify the type of Rotor type FIP which is to be serviced. An Example is given below:

Injection Pump Type Number Explanation

V	-	Rotary Distributor
E	-	Type of Pump
4	-	Number of outlets
12	-	Plunger diameter in mm
F	-	Mechanical Governor
1500	-	Max. Adjusted full-load speed
R	-	Direction of rotation clockwise
12	-	Design number

Fig 1



Dismounting of the Injection pump

Connect the injection pump to the plate of the adjustable bracket of Holding vice

Remove return spring out of plate

Mark the position of the reference between shaft and lever

Remove nut and pull off lever along with plate and control lever from the shaft

Detach Spring plate, Spring and spring plate, unscrew the fastening screws and remove the cover

Take out full load stop screw from cover

Disconnect the cover and the driving shaft

Remove the cover seal

Detach the spring out of the pin to which the spring plate and the idling spring are fixed to remove the driving shaft and the governor lever.

Remove the pressure control valve

Remove locking nut and plain washer, unlock the governor shaft

Remove speed governor unit and keep collar disc and adjustment plate

1 Speed governor

2 Governor weights

3 collar disk

4 Governor collar

Remove solenoid and valve with inner spring.

Remove screw of plunger of the hydraulic head by means of wrench (!) Unscrew the four feed pipe connections

Dismantle the feed pipe connection parts

1 Pipe connection

2 spring support

3 Adjustment disks

4 Spring

5 Valve seat

6 Ball

7 Spring support with calibrate bore

8 Spring

9 Valve housing

UnScrew fastening screws of the hydraulic head by socket wrench.

Remove hydraulic head the guide pins and the pressure springs of the governor disk.

Pull out the spring plate of the pump element return springs, the distance washers the guide pins the pressure spring and the seal ring out of the lower parts of the hydraulic head.

Remove the distributor piston together with the return springs, the slider, the spring plate and the condensing washers.

Unscrew and remove the fastening screws of the governor disk by means of socket wrench

Remove the cam disk along with adjustment screw for feed start .

Remove Oldham coupling

Remove locking clamp and locking pin of the connection

Remove timer stop pin and take out retaining pin

Remove roller ring assembly and timing device piston.

Push sliding pin towards the centre of roller ring assembly so that the claw of the drive shaft to it.

Take out coil supporting ring without fitting it

Note : Do not mix up the rollers

Remove fastening screws by means of wrench and remove both covers of the injection adjuster.
Remove the injection adjuster.
Remove nut for fastening of coupling at the pump driving shaft. Avoid rotation of coupling by holding socket wrench
Remove coupling from pump driving shaft using pulling - off device
Remove driving shaft, unscrew fastening screw of plate for booster pump.

Mount driving shaft, turn injection pump and pull out the booster pump parts together with the driving shaft Take off the toothed wheel for driving of the speed controller and buffer for the driving shaft

Checks

Clean pump housing and the different dismounted benzene parts carefully with petroleum.

Check if the parts are worn or cracked; check carefully if working surface have score grooves. Test if springs are deformed or broken.

Replace damaged parts.

Pump Assembly procedure

Arrange pump housing on plate.

Mount seals on pump housing by means of standard driving mandrel

Mount eccentric ring and corresponding booster pump with blades into pump housing.

Align the suction of diesel is through hole Hole away from inner diameter of Eccentric rign Hole should face RH side when viewed from governor side. Hole should face governor side

Mount the following parts provisionally driving shaft toothed wheel, controller drive buffer,compensating disk,Fastening disk,Vane cell booster pump and eccentric ring

Take out driving shaft and fix fastening disc by means of the corresponding screws.

Mount key to driving shaft and insert this assembly into the pump housing in such a way that the key locks into it seat in the impeller.

Mount operating pin of the injection adjustor in its seat in the coil supporting ring Ensure that the curved washers are fitted on the out side of the rollers.The conical side must point to the outer ring.

Mount coil supporting ring, in pump housing.

Mount connection pin into piston and insert it into its seat

The spring part of the piston must correspond to the anti pump bore in the pump housing.

Press operating pin into the connection pin of the governor piston.

Ensure that the claw of the drive shaft is positioned towards transversely to it.

Insert locking pin and corresponding locking clamp into connection pin

Mount sealing ring and flat cover Arrange adjustment washer of 1 mm in spring seat and mount spring place adjustment washer in the cover hollow and mount cover.

Maintain ‘SVS’DIMENSION

Exact adjustment washer quantity is determined on the test bench.

Mount Oldham coupling in its seat.

Place cam disc , on cam rollers

Stop for pump element must point at notch in the driving shaft.

Mount the washer for adjustment of feed start

ADJUSTMENT OF PRETENSIONING OF THE DISTRIBUTOR PISTON RETURN SPRINGS (DIMENSION “KF”)

Place indicating caliper in tool and adjust to zero on surface plate with a pretension of * mm

Mount spring journal, adjustment washers, spring plate and spring, in hydraulic head.

Mount distributor piston together with spring plate and with collar disk in hydraulic head.

Place tool according to figure check.

Test without squeezing of spring if dimensions KF is mm otherwise replace adjustment washers. Place slider in distributor piston. Lubricating bore hole must be aligned to piston foot.

Only one single adjustment washer must be mounted to the guide journals.

The Controller washer with negative adjustment increases the feed for increase engine speed.

Mount distributor piston housing in such a way that the milling at the piston foot lock at the driving pin of the cam disk.

Mount controller disc place operating pin into the fit in the slider.

After mounting of springs in the spring plate and the pressure spring In their seats, fit the hydraulic head in the pump element and insert into the pump housing fix the hydraulic head by means of our fastening screws which have to the tightened by mm of tightening torque of 11/13 Nm

ADJUSTMENT OF DISTRIBUTOR PISTON POSITION (DIMENSION 'K') Mount the indicating calliper in special tool and adjust it to zero on the surface plate with a pretension of mm.

Place the tool with indicating caliper at the hydraulic head

Check dimension "K" which must be mm

The dimension K is the distance between the sealing surface of the head and the surface of the distributer piston

If dimension "K" deviates from the specification the adjustment washer below the foot of the distributor piston must be replaced.

Mount plug with vent screw and tighten up to a torque of 60/80 Nm. Mount feet valves and pressure pipe connections and tighten torque of 35/45 Nm. Mount solenoid valve.

Mount locking clamp at plug and insert it into the adjusting bushing

Parts of the controller group

1 Fastening hub nut of the governor shaft
2 Plain washer
3 Governor shaft
4 Adjusting plate
5 Compensation washer
6 Housing governor group
7 Weights
8 Distance washer
9 Adjusting bushing

Place in housing of the controller group the weights the plain washers (5 and 8) and the adjusting bushing

Mount the shim and the controller group in the pump housing. Screw in the shaft .

The adequate adjustment is carried out subsequently on the test bench.

Adjustment of the Governor shaft

Control with feeler gauge that the shaft end piece of the controller is placed at a distance of 3 mm from the pump housing flange.

Adjustment Governor shaft

A_3 the exact adjustment is carried out subsequently at the test bench.

Adjustment of the Starting Dimension "MS"

Place tool between housing and governor lever place the feeler gauge between the control lever and pin. This distance is Ms Dimension. If not is range adjust the controller group.

For different valve dismount controller group once again out of the pump housing remove plug from the adjustment bushing and replace by a different one with an adequate size. Remount the controller group into the pump housing

Check pressure increasing control value

Pull out the locking clamp by means of tool pull out piston and spring out of valve housing.

Pressure control value

1 Elastic locking ring
2 Piston 0
3 Spring
4 Sealing ring
5 Valve housing
6 Sealing ring

Check that the controller valve parts are not worn. otherwise they must be replaced.

Place adjusting piston at the height of the valve housing by means of a centre punch. Remount housing pressure increasing control valve and screw it down in to the pump.

Mounting guide pin the idling spring and the spring plate into the adjustment dise hook in the tension spring in the driving shaft together with the sealing ring and the compensation washer.

Place seal in the cover.

Mount cover. The min and max speed adjustment screw and the full load gap screws.

Mount the lower Spring plate, the spring and the upper spring plate at the shaft.

Mount lever together with plate and operating lever in such a way that the reference notch covers then one applied to the shaft during dismounting and fix the lever by means of nut.

Mount the key the driving clutch and the plain washer and tighten the nut to a tightening torque of 49 Nm by means of the torque wrench.

Pace the engine block on stand fix it with a clamps.

Lubricate the tappets and mount them tappet bore of crank case.

Refer the data for oversize tappet details

Mount rear camshaft cover in the front of engine.

Mount idler spindle Lubricate camshaft bushes and inset camshaft into the crank case.

Tighten fastening screw of camshaft though bores In camshaft gear Mount injection pump drive gear and accessory drive dear with bracket.

EXERCISE 15.6: Testing of Distributor type fuel Injection pump

Objectives

At the end of this exercise you shall be able to

- mount distributor pump on FIP test bench
- set Timing device travel, Van pump pressure and Full load delivery
- set idling speed, maximum speed and starting quantity
- testing of Timer travel, Vane Pump and Overflow quantity
- checking of fuel deliveries at end stop and Idle stop
- checking of pump solenoid

Requirements

Tools/Equipments

- Trainee's tool kit - 1 No.

Machines

- Fuel Injection pump test bench - 1No.
- Distributor type FIP - 1No
- 12V DC Battery - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Adjusting shims - as reqd.
- SoapOil - as reqd.
- Engine oil - as reqd.
- Hydraulic transmission Oil - as reqd.
- Calibration oil - as reqd.

Procedure

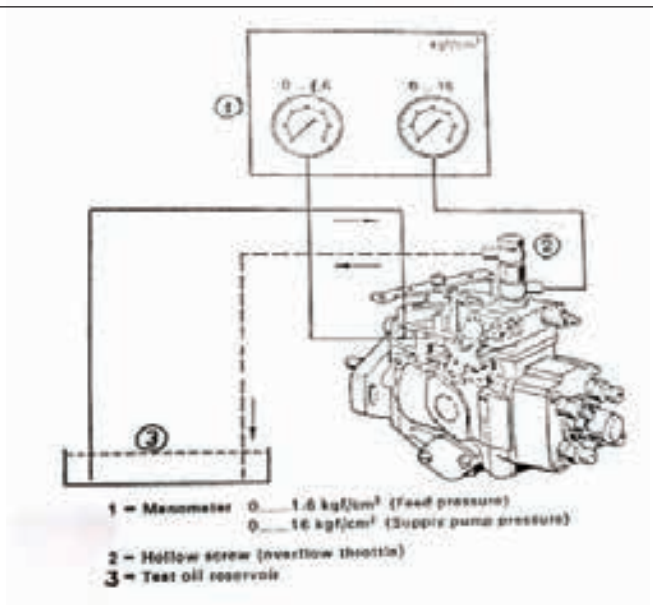
Preparation

Mount the pump on the test bench and connect the inlet, overflow and pressure gauge lines as shown in Fig 1.

In order to bring test conditions as close as possible to the operating conditions of the engine, the test equipment has been altered as illustrated in Fig 2.

Fig 1: Inlet, Overflow and Pressure gauge connections.

Fig 1



When using the 450 mm long high pressure pipe (6) the test injectors cannot be placed in the measuring panel. Hence, test injectors are held in a platform (7) which is mounted on the test bench bed (Fig 2)

Fig 2

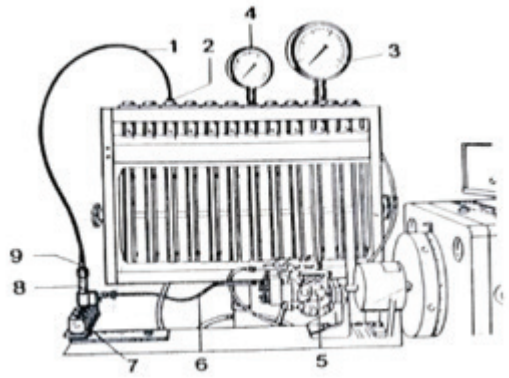
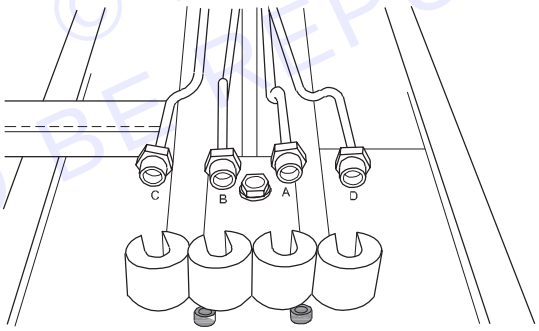


Figure 2 : Arrangement of Test Equipment for VE Pump testing

1. Connecting pipe
2. Adapter with spray damper cap
3. Pressure gauge : 0..16 kgf/cm²
4. Pressure gauge : 0..1.6 kgf/cm²
5. Distributor type (VE) FIP.
6. High Pressure pipe
7. Mounting platform
8. Test injector
9. Adapter of connecting pipe

Fig 3: Mounting Platform

Fig 3



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Unscrew spray damper caps from test injectors,

Mount test injectors onto mounting platform (7) in an inverted position (Fig 2).

Screw adapter (9) of the connecting pipe with copper washer to the test injectors (8) in place of spray damper.

Mount the removed spray damper caps on adapter (2) of connecting pipe and insert into the nylon bush.

Bend high pressure pipes as shown in figure 2 and 4. Mark the union nuts of high pressure pipes in accordance with the outlets of the VE pump. Mount the high pressure pipes on the pump and test injectors.

Setting

Timing Device Travel

Run the pump at 1250 rpm and check the travel of the timer piston. If the travel is not correct, adjust the supply pump (vane pump) pressure within specified limits or ascertain thickness of timing device shims .

Vane Pump Pressure

Run the pump at 1250 rpm and check the vane pump pressure. It should be 3.9 to 4.5 kgf/cm². If it is less than the specification, use 03-KDEP 1092 to press the plunger down. If the pressure is more, use 03-KDEP 1083 to remove the pressure control valve from the pump. Dismantle the pressure control valve using KDEP 1027 and press the vent plug outward. Then assemble the pressure control valve and press the bracing sleeve using KDEP 1093.

Full Load Delivery

Run the pump at 1250 rpm and adjust the full load screw to get a delivery quantity of 14.8 to 15.3 cc for 500 strokes.

Idle Speed Regulation

Run the pump at 375 rpm and place the control lever against the idle speed adjusting screw. Set the delivery quantity to 5.3 to 6.3 cc for 500 strokes by adjusting the idle speed adjusting screw.

Maximum Speed Regulation

Run the pump at 2350 rpm and place the control lever against the speed adjusting screw. Set the delivery quantity to 15.3 to 18.3 cc for 500 strokes by adjusting the maximum speed adjusting screw.

Starting Quantity Checking

Run the pump at 100 rpm. The delivery quantity should be 22.5 to 42.5 cc for 500 strokes. If not, readjust the 'MS' dimension.

Testing

Timer Travel

Run the pump at 800 rpm. The Timer travel should be 0.8 to 1.6 mm. Run the pump again at 2000 rpm. The timer travel now should be 6.3 to 7.1 mm. If not, replace the timer spring and check the timer piston for wear, or the supply pump pressure.

Vane Pump

At 800 rpm of the pump, the vane pump pressure should be 2.6 to 3.2 Kgf/cm² and at 2000 rpm it should be 5.9 to 6.5 Kgf/cm². If not, check for wear/correct assembly of vane pump or check for wear on the pressure control valve spring.

Overflow Quantity

Run the pump at 500 rpm and measure the overflow quantity for 10 seconds. It should be 42 to 84 cc. At 2250 rpm it should be 55-138 cc/. If not, check/replace the throttle banjo.

Fuel Deliveries

End Stop

Keep the control lever against the maximum speed adjusting screw and run the pump at different rpm as specified in the test specification chart and check the fuel delivery quantities for 500 strokes. If there is a variation between cylinders, change the delivery valve. If there is a variation in the quantities at different rpm, adjust the full load screw and maximum speed adjusting screw.

Idle Stop

Keep the control lever against the idle adjusting screw and check the delivery quantities at the rpm specified in the test specification chart. If they are not correct, adjust the idle adjusting screw.

Solenoid

Use a battery/D.C. supply of 10 to 12 volts and check for the correct functioning of the solenoid. If it does not perform satisfactorily replace the solenoid.

EXERCISE 15.7: Servicing Unit Injector

Objectives

At the end of this exercise you shall be able to

- to dismantle the unit injector
- to clean and injection parts
- to Reassemble the unit injection
- to test the spray pattern & opening pressure.

Requirements

Tools/Equipments

- Trainee's tool kit - 1 No.

Machines

- Unit Injector - 1 No.
- Injector holding fixture - 1 No.
- Injector test bench - 1 No.
- Air compressor - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.

Procedure

Dismantling

1 Mount it in a holding fixture and remove the filter caps from the inlet side.

2 Remove the filterfrom inlet side andcheck up the filter seating

3 To remove the stop pin, push the follower slightly down without hand and with plier in the other hand.

4 Turn the stop pin 90° and with draw it.

5 On the fuel pinchar unit injector, push the follower down.

6 Rotate clock wise to align the relief lot with roll pin and with draw the follower.

7 Turn the injector fixing vise about 145° to 15° to with draw the follower, & follower spring and plunger,

8 Again to tilt the injector vise about 180 and using a deep socket spanner to loose the injector nut and take it out.

9 Keep the spray tip separately with needle valve.

Note: Keep spring cage, spring seat, spring check valve cage and check valve in the separate container with oil.

10 Remove the bush and insert the plunger

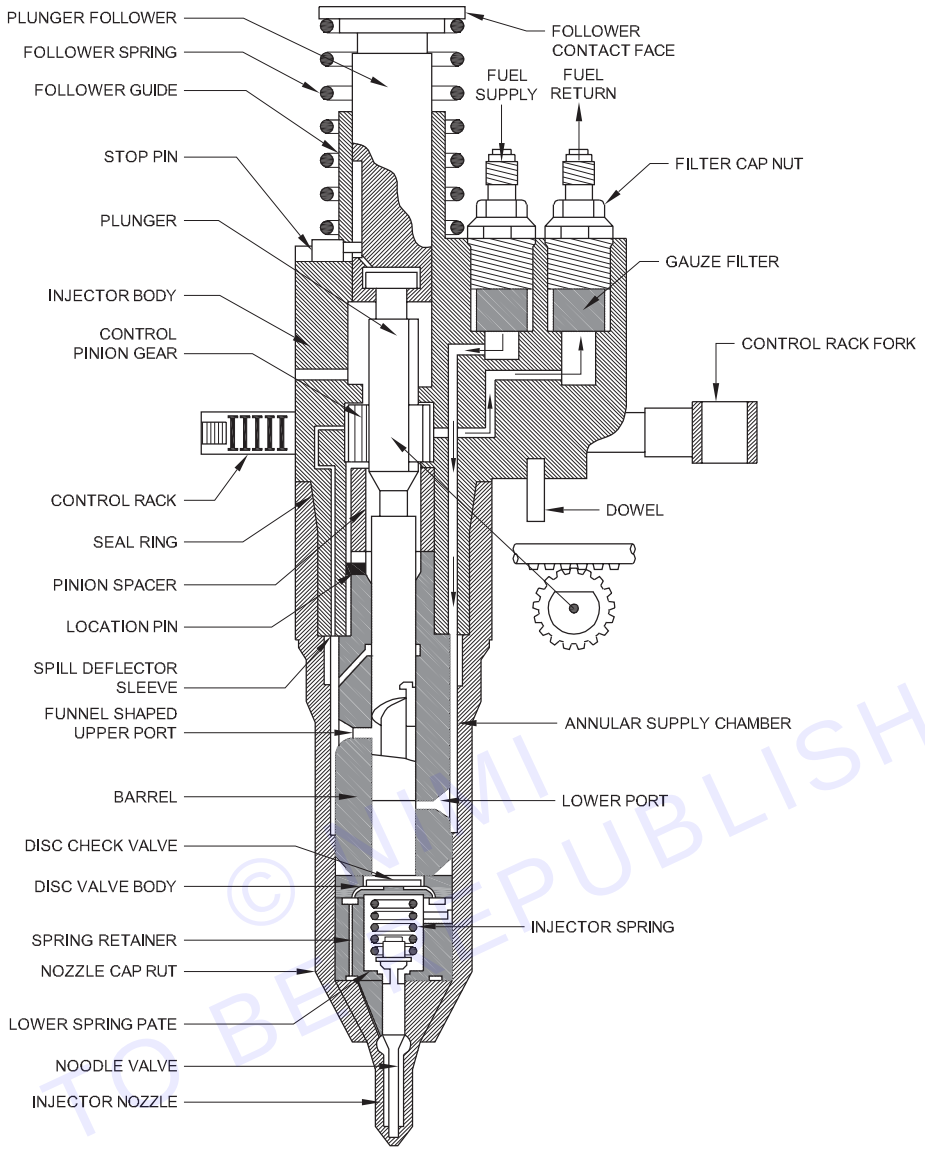
11 Remove the gear container and remove the control rock.

Cleaning & inspection: Clean all individual parts separately using solvent fuel etc.

Inspection

Inspect the body, threads of the fuel filter cap and the nut. Check the dowel pin. Resurface the ring face with a reamer by using a straight flute reamer any nicks and burrs from the bore turn the reamer only in a clock wise direction to prevent damage the flutes. Check to contact surface of the bush, other part must be check up& inspect

Fig 1



Reassembling unit injector

Before reassemble the unit injector all the components must be thoroughly cleaned, serviced tested and measured, keep you particular attention to the following points during reassembly.

1 Use compressed air to remove fuel from the filter opening

2 Install the filter with the slotted end upward

3 Use new gasket and tighten the filter cap to the specific torque.

4 Slide the control rack in place so that the drill mark are visible, place the gear in the injector body with its drill mark aligned between the two marks on the control rack.

5 Place the gear retainer on top of the gear

6 Position the bushing dowel pin over the slot and position the bushing to the injector body.

7 Assemble the value and spray tip on the bushing in the following order spill deflector seal ring check valve cage, valve spring, spring seat spring cage, and spray - tip assembly

8 Carefully guide the nut over the stacked assembly and hand tight the nut while turning the spary tip, use a torque wrench for tightening with 85 lbs/ft (115 nm).

9 Position the stop pin so that the tighter wound end of the follower spring and keep the injector body flat the stop pin.

10 On fuel pincher unit injector, place the clamp on to the body and the spring to the clampit.

11 Hook the plunger head in to the follower Align the follower slot with the stop pin and align the flat side of the plunger with the gear.

12 Guide but do not force, the plunger through the gear and into the bushing.

13 With the plunger in position push the follower down ward and at the same time force the stop pin in place.

14 On the fuel pincher align the roll (spring) pin in the followers with the release slot in the body. Then press down ward on the follower rotate it clock wise until the pin contact the guide slot, and then release the force from the follower.

15 Remove the injector from the vise, bring the control rack to the full- fuel position and check the rock to plunger timing the visible marks must be from flat side of the injector.

16 Next place the unit injector in the concentricity gauge, Adjust the dial gauge to zero slow turn the injector 360° and observe the dial movement if total spray tip run out is more than 0.008 inch (0.2 mm) loosen the injector nut.

17 Reposition the spray ti-re-torque the nut and recheck the spray - tip concentricity.

18 If spray - tip is more than inch 0.008 (0.2 mm) out of the concentricity if could cause the needle valve to stick and or allow combustion gases to pass by the injector or cause reduced injector cooling.

Test carried out on unit Injectors

1 Fill the injectors with clean diesel fuel place the galary pumps. Under the tip and depress the follower. Sharply observe the spary pattern No have should be blocked and the radial lines. Should be this and continues and then should not be any drop have at the tip.

2 Mount the injector on the test bench and opreate the lever several times and see that there is drop let at the spary tip. Depress the follower to bring down the tight of the follower from the body surface to 33.5 mm Move the control rack fully into the body use the test pump and bring up the pressure to 50 kg cm² and hold it. Observe the pressure drop, it should not drop below 19 Kg/cm² in 55 seconds. If it leaks the plunger and barrel are worn out.

3 Place the plunger in upper most position more than control rack fillingout of the body build up of the pressure to 25 kg/cm² and slowly increase the pressure in stop at 2 kg/cm and observe the fall of pressure detecting the check valve opening. It should be between 33- 52 kg/cm². If required change the valve and spring.

4 Move the control rack fully in to the body operate the pump to bring the pressure to 100 kg/cm² and maintain this pressure for 1.5-2 mints and observe the leak at on the joints.

MODULE 16: Engine Management System

EXERCISE 16.1: Perform onboard diagnosis on engine and emission control system

Objectives

At the end of this exercise you shall be able to

- detect the engine malfunction by mil lamp and svs light
- carry out step by step diagnostic procedure on engine and emission control system.

Requirements

Tools/Equipments

- Trainee's toolkit - 1 No.

Equipments/Machines

- Scan tool - 1 No.
- A light motor vehicle with CRDI engine - 1 No.

Materials

- Diesel - as reqd.
- Coolant - as reqd.
- Engine oil - as reqd.
- Cotton cloth - as reqd.

Procedure

TASK 1: **Detect the engine malfunction by MIL lamp and SVS light**

Check operation of malfunction Indication Lamp (MIL)

1 Turn ON the vehicle Ignition key into Ignition ON position and engine OFF condition.

2 Observe the engine cluster for MIL lamp ON. If MIL lamp does not turn ON, Check the MIL lamp and its circuits.

3 Start Engine and observe the engine cluster for MIL lamp turns OFF, If MIL continuously ON it indicates some troubles in Engine control system which affects vehicle emission and Diagnostic trouble code is stored in ECM memory.

Check operation of Service Vehicle Soon light (SVS)

1 Turn ON the vehicle Ignition key into Ignition ON position and engine OFF condition

2 Observe the engine cluster for SVS lamp Turns ON for 4 seconds then it Turns OFF If SVS lamp does not turn ON, Check the SVS lamp and its circuits. If SVS Light flashes there is some troubles in Immobilizer control. If SVS light continuously ON it indicates some troubles in engine control system but it does not affect vehicle emissions.

— — — — —

TASK 2: **Step by Step diagnostic procedure on engine and emission control system**

Step 1: Customer complaint Analysis

Collect the details of vehicle problems, how it is occurred, when it is started ,Vehicle condition and kind of symptoms and record it.

Step 2: DTC record and clearance

Connect scan tool to DLC , read DTC and Freeze frame data.

Take a print out and Clear DTC. If DTC is not cleared problem persists on engine continue the next step.

Step 3: Visual Inspection

Check visually the following components and systems if any fault noticed , repair and replace the parts and go to the final confirmation test otherwise go to the next step

1 Engine oil level and any oil leakage

2 Engine coolant level and any leakage of coolant

3 Air filter for dirt or clogged

4 Battery electrolyte level and corrosion of battery terminals

5 Water pump belt tension and its wear

6 Vacuum leakage of air intake system,

7 Blown Fuses, Tightness of wiring connectors and any other parts deformation

8 Check MIL lamp, SVS Light, Charging Indicator light, oil pressure light, Engine temperature high warning light and fuel level meter operation after engine starting

9 Check exhaust leakage after engine start

Step 4: Trouble symptom confirmation

Confirm the DTC by start the engine and warm up upto normal operating temperature stop the engine and check DTC

Or

Confirm the DTC by drive the vehicle at 60 kmph for 5 minutes and then 100 kmph for 5 minutes, stop the vehicle and read DTC. Identify the trouble symptom if any during this test go to the next step.

Step 5: Rechecking and Record of DTC

Recheck whether the same DTC appears again as shown in the step 2 then go to the Troubleshooting for DTC step or no DTC record it and go to the next step of engine basic inspection engine symptom diagnosis.

Step 6: Engine basic inspection and engine symptom diagnosis

Perform basic engine inspection and engine symptom diagnosis as listed below and go to the step of final confirmaton.

1 Check Engine and emission control

2 Check Battery voltage

3 Check engine start condition

4 Check Immobilizer system

5 Check Low fuel pressure circuit and High fuel pressure circuit

6 Check Engine hard starting

7 Check engine smooth running

8 Check engine performance and engine hesitation while accelerator depressed

9 Check engine Idling, Knocking, excessive smoke,excessive oil and Fuel consumption.

Step 7 : Troubleshooting for DTC

Check and repair according to the DTC shown.

Step 8: Intermittent problem check

Check the parts where the intermittent problem may occur easily like wiring hareness, connectors etc,,. and related circuits of DTC.

Step 9: Final confirmation Test

Confirm that the problem symptoms are removed and engine is free from the trouble. Clear the DTC and freeze frame data.

Perform the DTC confirmation as per step4 and ensure that no DTC is shown.

— — — — —

EXERCISE 16.2: Identify engine trouble by using scan tool

Objectives

At the end of this exercise you shall be able to

- identify the data link connector location and connect engine scanner
- read the diagnostic trouble code.

Requirements

Tools/Equipments

- Trainee's toolkit - 1 No.
- Engine scan tool - 1 No.
- OBD-II connector - 1 No.

Machines

- A running condition of CRDI light motor vehicle - 1 No.

Materials

- Cotton waste - 1 No.

Procedure

1 Keep ready the scan tool related service manual for the vehicle.

2 Attach the proper test connector cable to the scan tool.

3 Ensure that the ignition switch is in the 'OFF' position.

4 Locate the correct location of diagnostic Data Link connector. (Fig 1)

5 Attach the scan tool test connector (OBD_II)to the diagnostic Data Link connector(DLC). (Fig 2)

Fig 1

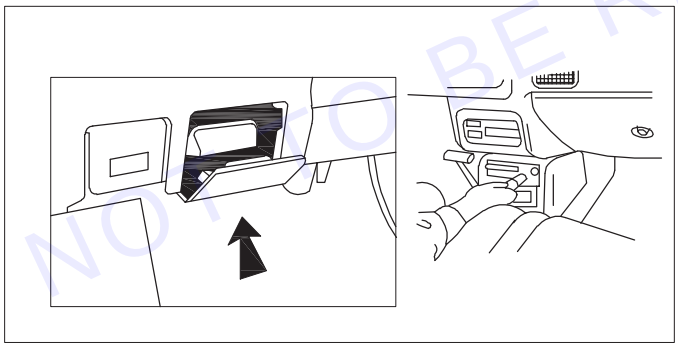
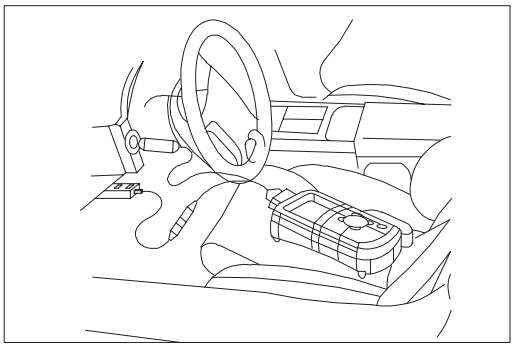


Fig 2



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OBD II scan tools are powered from terminal 16 of the diagnostic connector, and no other power connection are needed.

6 Observe the scan tools screen to ensure that the scan tool is working properly.

7 Enter vehicle information's needed as required by the scan tool.

- Most OBD II scan tools automatically read the vehicle identification number (VIN). When the ignition switch is turned to the 'ON' position. This gives the scan tool the information needed to check for codes and perform other operation.
- Older scan tools are programmed with the proper vehicle information by entering the vehicle year, engine type and other information. This information is usually contained in certain numbers and letters in the VIN.

8 Turn the ignition key to the 'ON' position.

9 Select DTC option on scan tool

10 Observe the scan tool to determine whether any trouble codes are present.

11 List out all trouble codes as indicates in scan tool. Note down the Freeze frame data

12 Use the scan tool literature (or) service manual to determine the meaning of the codes.

13 Rectify the fault of stored DTC code related circuit. Erase the trouble codes shown in the scan tool and clear the freeze frame data.

14 Switch 'OFF' the 'ignition and switch on again.

15 Check the engine Malfunction indicator is ON. Start the engine and check Malfunction Indication lamp goes off

16 When the test is completed turn the ignition switch to the 'OFF' position.

17 Remove the scan tool test connection cable from the diagnostic connector.

EXERCISE 16.3: Perform testing of sensors

Objectives

At the end of this exercise you shall be able to

- test the temperature sensor
- test the pressure sensor
- test the potentiometer
- crankshaft position sensor
- test the camshaft sensor.

Requirements

Tools/Equipments

- Trainee's toolkit - 1 No.
- Multi Meter - 1 No.
- Thermometer 0-100◦C - 1 No.
- Air drier portable - 1 No.

Materials

- Tray - 1 No.
- Banian cloth - 1 No.
- 12 V Lead acid battery - 1 No.
- 1.5V batteries - 3 Nos

Machines

- A light motor vehicle with CRDI engine - 1 No.

Procedure

TASK 1: **Checking of engine coolant Temperature sensor (Fig 1)**

Fig 1

FIUKE MODEL 80TK TEMPERATURE SENSOR WITH AN 80PK-6A PIERCING-TYPE PROBE

MDC22P0153

1 First open the bonnet by removing the lock.

2 Locate the temperature sensor, mostly it is located in the thermostat valve region.

3 Set the multi meter in the resistance measuring mode.

4 Ground the black terminal, connect the red terminal to the temperature sensor, measure the resistance.

5 Turn the engine on, run for two to three minutes to warm up the engine.

6 Now measure the resistance with the same procedure.

7 If the difference in resistance is more than 200 ohms the sensor is in good condition.

8 If the difference is not more than 200 ohms. Replace the temperature sensor.

TASK 2: **Checking of pressure sensor (Fig 1)**

Note: Air intake pressure, atmospheric pressure,vapor pressure in the fuel tank and fuel injection pressure sensors are used in the vehicle. But the testing procedure of the sensors used in the vehicle is same for all the sensors.

1 Identify the location of the sensor.

2 Use the multi meter, set in AC mV range.

3 Start the engine, keep it in running.

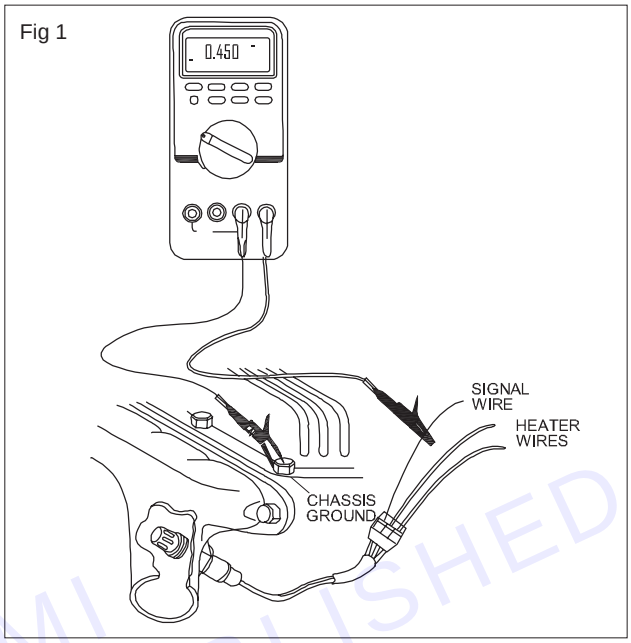
4 Ground the black terminal

5 Touch the red terminal

6 If any voltage say at about 200 to 400mV then the sensor is functioning correctly.

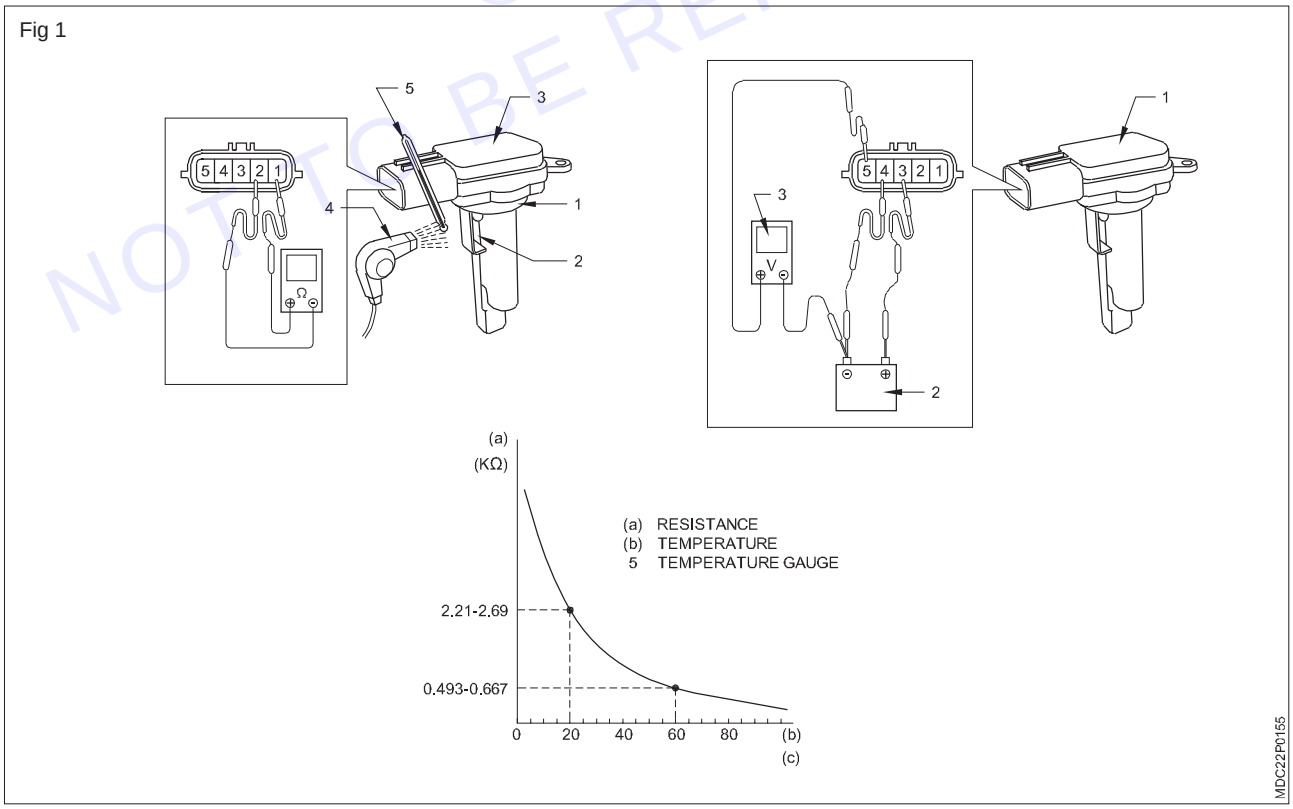
7 If not develops any voltage then replace the sensor.

Fig 1



TASK 3: **Checking of Mass air flow sensor & IAT Sensor (Fig 1)**

Fig 1



1 Disconnect battery negative cable.

2 Remove MAF and IAT sensor wiring connector.

3 Remove MAF and IAT sensor from air cleaner casing.

a IAT sensor inspection

- Set the multimeter in K resistance mode.
- Measure the resistance between sensor terminals while blowing hot air to temperature sensing part.

The resistance value at 20° C 2.21 – 2.609 K Ω

The resistance value at 60°C 0.49 – 0.667 K Ω

Note: The resistance value is shown as example. It may very as per manufactures model.

b MAF sensor Inspection

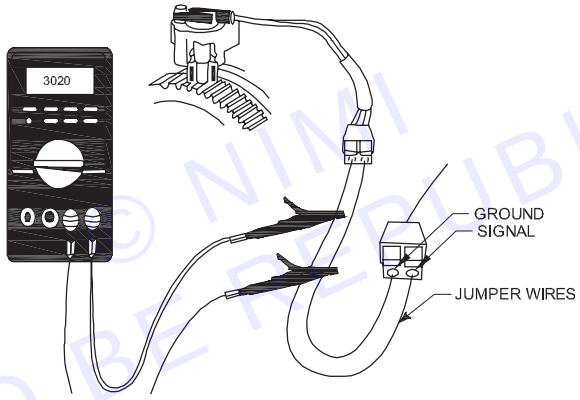
1 Connect a 12 V Battery and volt meter To MAF& IAT sensor as shown in fig.

2 Check the voltage variation depending upon amount of blown air it should increase. If it is not increased,Replace MAF &IAT sensor.

— — — — —

TASK 4: **Checking of crank shaft position sensor (CKP) (Fig 1)**

Fig 1



Note: These sensors are called by so many different names like: Hall effect sensor, CKP sensor, MP sensor, pickup coil, Magnetic pulse generator, variable reflector and the list goes on with a few more names. There are two types Three pin type and two pin type. If the car engine fails to start properly, there may a defect in crank shaft position sensor and cam shaft position sensor. This sensor measures the crank shaft position and speed. Both the sensor have the control injection and ignition timing.

1 Locate the sensor. Normally it is located either end of the crank shaft.

2 Run the engine and set the multi meter in the AC mille volt range.

3 Measure the voltage using the probes.

4 Normal range would be 200mV. Also refer the manufacturer's manual for the exact readings. It may vary manufacturer to manufacturer.

5 If not develops any voltage sensor may be opened. Replace it.

While testing the following condition to be satisfied.

6 Ambient temperature should not exceed 50°C.

7 Accelerator pedal should be in idle position. i.e fully closed condition.

— — — — —

TASK 5: **Cam shaft position sensor CMP**

1 It is also of very simple procedure like CKP.

2 Locate the sensor. Normally it is located either end of the head assembly.

3 Run the engine and set the multi meter in the AC millivolt range.

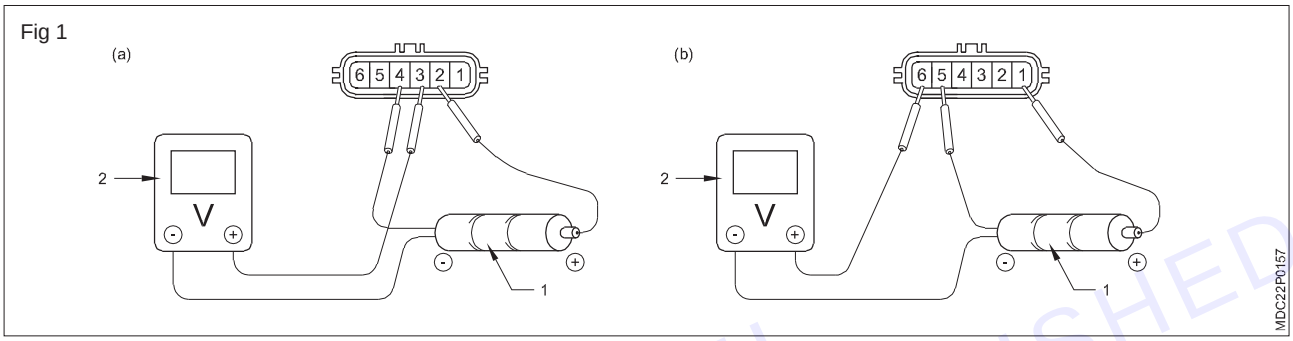
4 Measure the voltage using the probes.

5 Normal range would be 200 mV. Also ~~refer~~ ~~the~~ ~~manufacturer's~~ manual for the exact readings. It mayvary manufacturer to manufacturer.

6 If not develops any voltage sensor may be opened. Replace it.

TASK 6: **Checking of Accelerator pedal position sensor (Fig 1)**

Fig 1



1 Remove APP sensor assembly.

2 Connect three 1.5 V batteries in series as shown in figure and check that total voltage is 4.5-5.0V.

3 Connect volt meter and batteries to APP sensor as shown in figure.

4 Check the APP sensor voltage variation depending upon accelerator fully depressed and released condition.If the voltage is not varied replace the APP sensor.

EXERCISE 17.1: Servicing of CRDI low pressure fuel supply circuit

Objectives

At the end of this exercise you shall be able to

- servicing of fuel tank
- servicing of low pressure fuel pump
- servicing of fuel filter
- checking of fuel level sensor and fuel water sensor
- checking of fuel leakage.

Requirements

Tools/Instruments

• Trainee's toolkit	- 1 No.
• Multi meter	- 1 No.

Equipments

• A LMV with CRDI engine	- 1 No.
• Two post lift	- 1 No.
• Hand operated pump	- 1 No.
• Telescopic jack stand	- 1 No.

Materials

• Tray	- as reqd.
• Cottoncloth	- as reqd.
• Kerosene	- as reqd.
• Fuel pipe line and Hoses	- as reqd.
• Diesel	- as reqd.
• Fuel filter	- 1 No.

Procedure

TASK 1: **Servicing of fuel tank**

1 Disconnect the battery negative cable

2 Remove fuel filler cap

3 Connect a hand operated pump hose on fuel filler hose and drain fuel level till just above the fuel tank filler inlet valve

4 Lift the vehicle. Remove clamp, fuel filler hose and breather hose from fuel tank

5 Remove the exhaust pipe

6 Drain the fuel by opening the drain plug. If drain plug is not provided, drain the fuel by using hand operated pump through fuel tank filler.

7 Disconnect the hoses connected to fuel tank.

8 Remove the mounting bolts of fuel tank after proper support is provided.

9 Lower down the fuel tank to provide sufficient space for disconnecting the fuel pipe lines.

10 Loosen the hose clamp and Disconnect the fuel pipe hose connected to the fuel tank return line.

11 Loosen the hose clamp and Disconnect the fuel pipe line connected to the fuel rail at Fuel pressure regulator end.

12 Disconnect the fuel pipe line quick joint connected to the fuel filter inlet by pushing the lock button.

13 Disconnect the fuel pipe line quick joint connected to the fuel filter inlet by pushing the lock button.

14 Disconnect the fuel pump and fuel level float wiring harness connector.

15 Remove fuel tank from vehicle.

16 Remove all hoses, pipes and Fuel pump assembly.

17 Drain the fuel remains on the tank.

18 Fill tank with warm water and rinse it . Repeat it till the tank is clean.

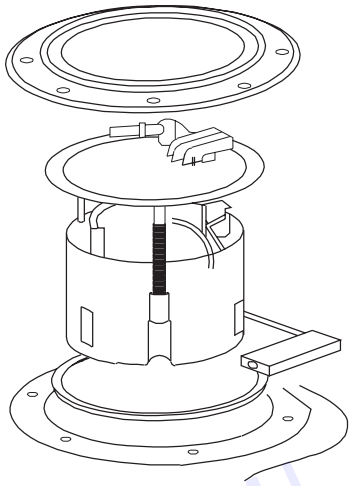
19 Flush out water and make it dry by keeping on sun light.

20 Check the hoses, pipes and fuel tank for any leak. If necessary replace it.

21 Refix the fuel tank.

— — — — —

TASK 2 : **Servicing of LP fuel pump**



Fuel pump

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1 Remove Fuel pump cover plate from fuel tank.

2 Remove fuel pump assembly from fuel tank.

3 Check fuel pump assembly for damage. If necessary replace it.

4 Check fuel pump suction filter for blockage of dirt or any contamination. Clean and If necessary replace it.

5 Check the resistance between terminals of fuel level sensor for different float position. Compare the values with service manual. If the values are out of specification, change the fuel pump.

6 Clean mating surface of fuel pump assembly and fuel tank.

7 Change the gasket.

8 Place the fuel pump inside the fuel tank.

9 Refix the fuel pump cover plate with new bolts.

10 Reconnect the Fuel supply line and return line.

— — — — —

TASK 3: **Servicing of Fuel filter**

1 Disconnect the battery negative cable of vehicle.

2 Remove ECM coupler.

3 Loosen the fuel filter hose clips and disconnect the fuel filter inlet and outlet hoses.

4 Loosen the bleed screw and drain water and fuel.

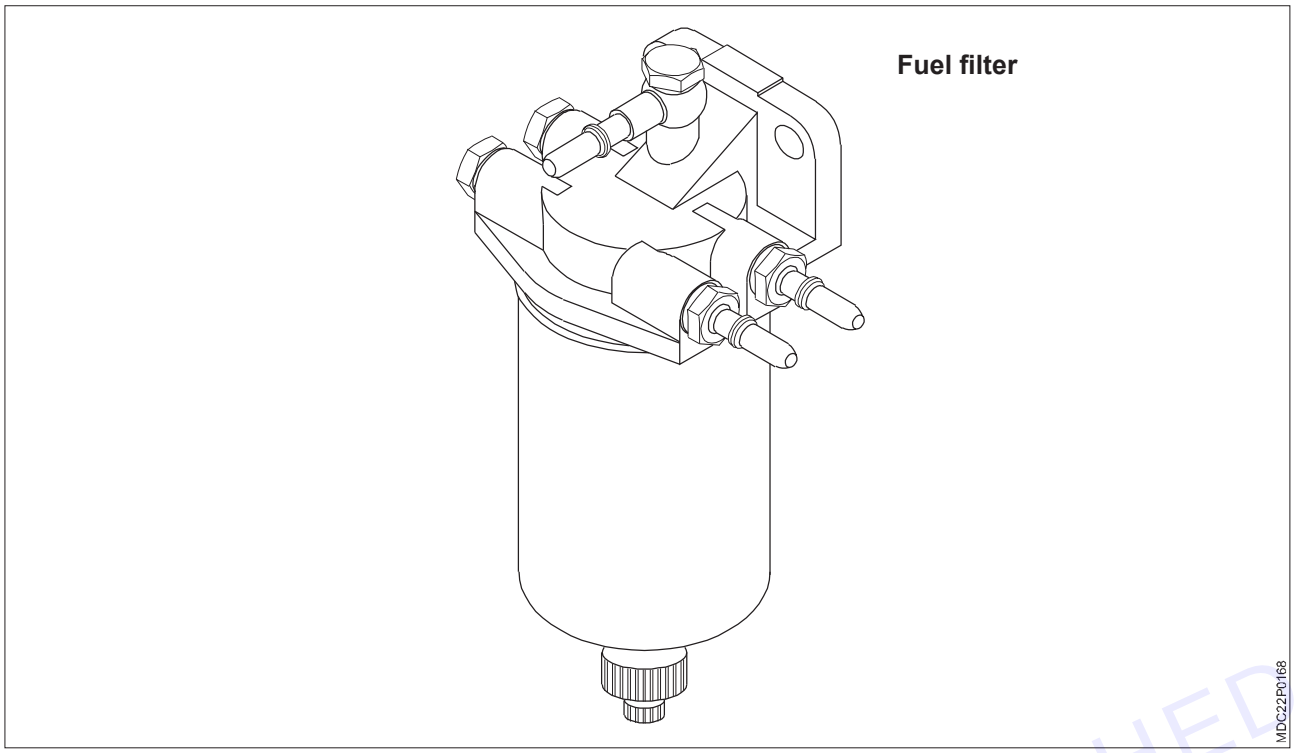
5 Remove water level sensor and fuel temperature sensor wiring connector.

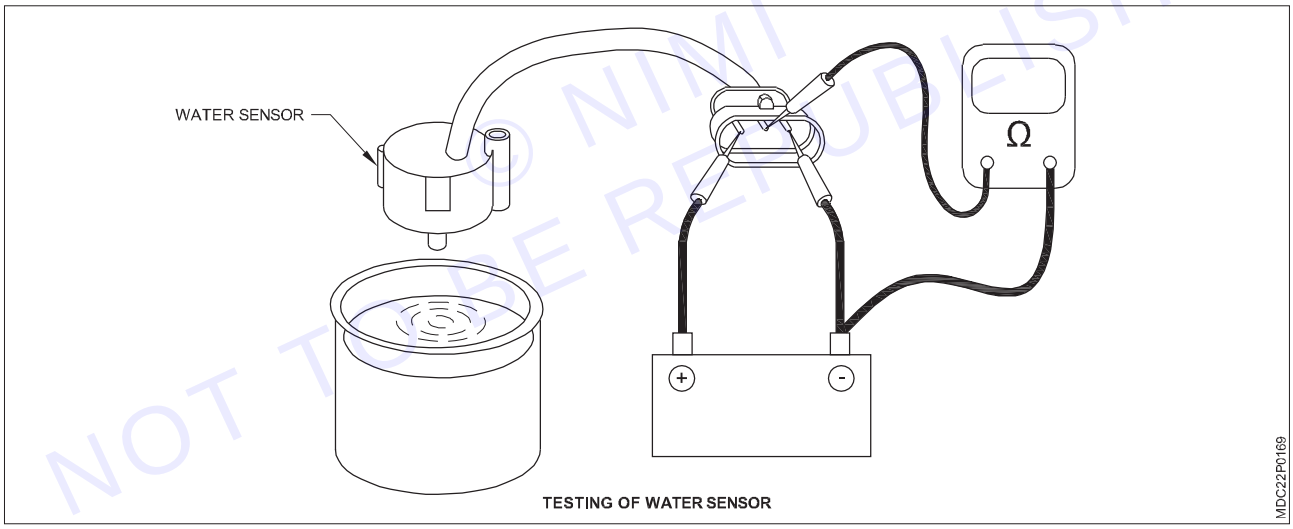
6 Remove water level sensor.

7 Remove the fuel filter cowl top cover.

8 Remove fuel filter assembly.

9 Connect battery and ohm meter to fuel filter water level sensor as shown in the figure.





TESTING OF WATER SENSOR

10 Check the continuity between power supply and ground terminal when water level sensor is immersed in water and Diesel Fuel . It should show continuity while immersion in water and no continuity for immersion in fuel. If not, replace the water level sensor.

11 Remove fuel temperature sensor.

12 Check resistance between fuel temperature sensor terminals at different temperatures of fuel and compare with the service manual reference value. If the values are out of specification, Replace the fuel temperature sensor.

13 Clean the filter casing. Dry and wipe out the filter case.

14 Tighten the bleed screw.

15 Replace the fuel filter element and O ring with new one.

16 Install the filter top cover.

17 Fix water level sensor and Fuel temperature sensor and connect wiring harness connector.

18 Connect fuel filter inlet and outlet hoses.

19 Turn ignition On and operate fuel pump ON for five minutes. Turn off ignition after 5 seconds. Repeat it six times and then start the engine.

Check Fuel leakage

1 Turn the ignition switch ON.

2 Check the fuel leakage on fuel pipe joints, Hoses and complete fuel circuit.

3 Run the engine at 4000 RPM for about 30 seconds and then stop engine.

4 Check the fuel leakage on fuel pipe joints, Hoses and complete fuel circuit.

— — — — —

EXERCISE 17.2: Servicing of CRDI High pressure fuel supply circuit

Objectives

At the end of this exercise you shall be able to

- remove and refit of high pressure pipe and high pressure pump
- remove and refit common rail and fuel pressure sensor
- checking of fuel pressure regulator
- remove and refit crdi fuel injector
- checking of fuel injector leak.
- checking of high pressure fuel circuit.

Requirements

Tools/Equipments

- Trainee's toolkit - 1 No.
- Multi meter - 1 No.

Equipments

- Scan tool - 1 No.
- A LMV with CRDI engine - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Fuel pipe line and Hoses - as reqd.
- Diesel - as reqd.

Procedure

TASK 1: **Removal and Refitting of High pressure pipes**

1 Open the vehicle bonnet.

2 Locate and identify the fuel pump relay of the vehicle.

3 Remove the Fuel pump relay and Run the engine till the engine stops.

4 Connect the scan tool to data link connector with ignition switched off.

5 Turn ON the Ignition switch. Confirm the fuel pressure line is not under pressure using the scan tool current data.

6 Switch off Ignition and disconnect scan tool.

7 Disconnect the battery negative cable.

8 Remove the engine cover.

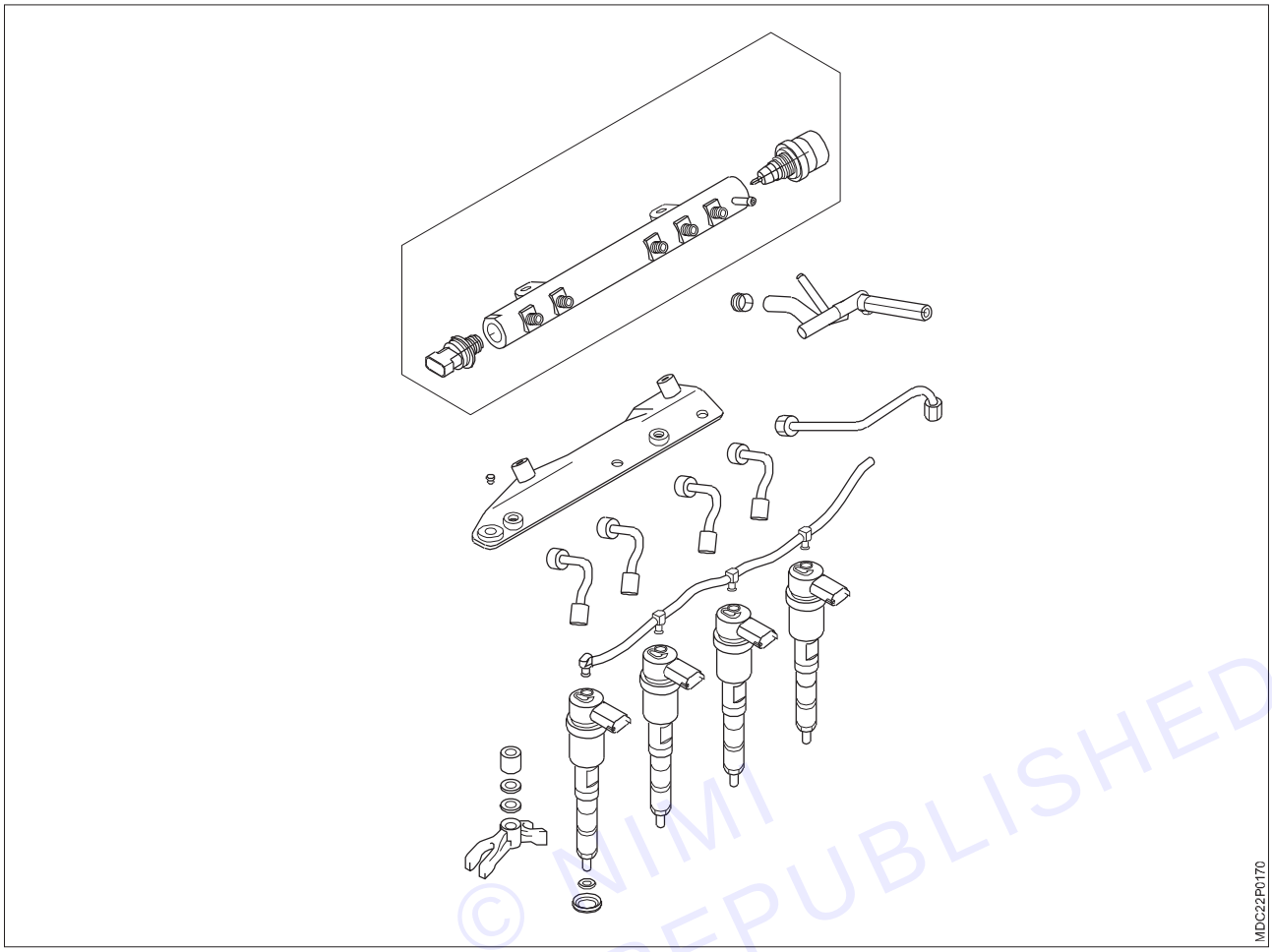
9 Disconnect the fuel feed hose of high pressure pump and fuel return line to the fuel tank.

10 Loosen the union nuts of high pressure pipes of HP pump to common rail and common rail to CRDI injectors

Note: Wrap a cotton cloth around high pressure union joints while removing the high pressure pipes

11 Check the high pressure pipes for any crack or damage. Replace if necessary.

12 Tighten the high pressure pipe as specified in the service manual.



TASK 2 : **Removal and Refitting of CRDI Injector**

1 Disconnect the battery negative cable and Injectors wiring connectors.

2 Remove the engine cover and high pressure pipe of fuel injector and common rail pipe.

3 Remove the lock clip and remove the fuel return line from injector.

4 Remove the fuel injector bracket nut

5 Remove the Fuel injectors along with brackets.

6 Remove the sealing rings from camshaft housing.

Note: Injectors are provided with calibration codes(IMA coding) hence they should not be interchanged. Note down the injectors removed from the cylinders.

7 Connect ohm meter and measure the resistance value between injector terminals. If the resistance value is out of specification, Replace the injectors.

8 Install new sealing washer to fuel injector.

9 Install fuel injectors to camshaft housing and the fuel injector bracket.

10 Tighten the fuel injector bracket nut to the specified torque.

11 Tighten the high pressure pipe union nuts to specified torque.

12 Connect the fuel injector return hose pipe on each injector and put lock clips.

13 Connect the fuel injectors high pressure pipes.

14 Refit the engine cover and tighten with specified torque.

15 Reconnect the battery negative cable and Injector wiring connector

16 Perform Injector coding registration on ECM using scan tool in case any injector is replaced with new one

— — — — —

TASK 3: **Removal and Refitting of common rail and fuel pressure sensor**

1 Relieve the fuel pressure

2 Disconnect the battery negative cable

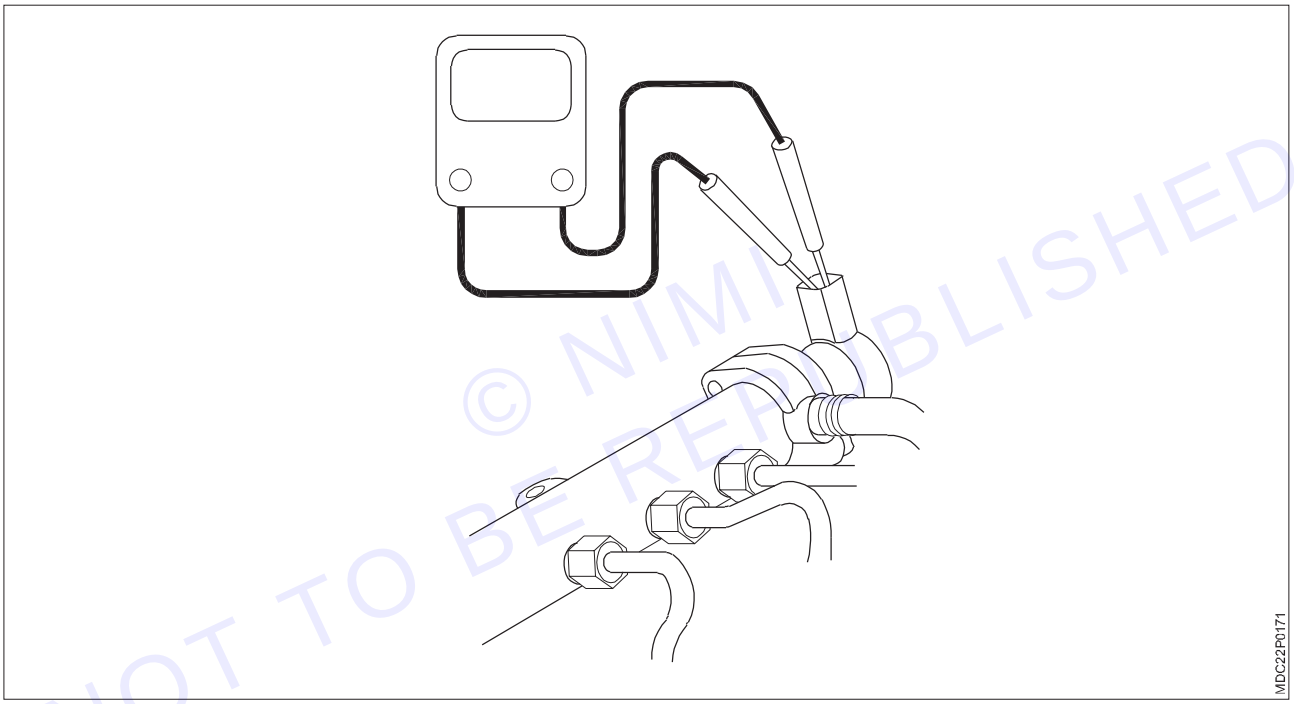
3 Remove the engine cover and high pressure pipe of fuel injector and common rail pipe

4 Remove common rail return line to fuel tank

5 Disconnect the Fuel pressure sensor and Fuel pressure regulator wiring connector

6 Remove fuel pressure sensor from common rail

Checking of Fuel pressure regulator



7 Check the resistance between terminals of fuel pressure regulator, compare the resistance value with manufacturers service manual. If the values are out of specification, replace the common rail with pressure regulator

8 Clean the common rail

9 Mount the common rail pipe and tighten the common rail mounting bolts

10 Reconnect all the high pressure pipes and tighten with specified torque

11 Install the fuel pressure sensor to common rail and tighten with specified torque

12 Connect fuel return line to fuel pressure regulator,

13 Reconnect wiring connector of fuel pressure sensor and fuel pressure regulator.

14 Reconnect the battery negative cable and check the fuel leakage

— — — — —

TASK 4: **Removal and Refitting of High pressure pump**

1 Relieve the fuel pressure on the high pressure circuit
2 Disconnect the battery negative cable
3 Remove Engine cover
4 Remove high pressure pipe between high pressure pump and common rail
5 Remove fuel return hose from high pressure pump
6 Disconnect the high pressure pump metering solenoid connector
7 Remove High pressure pump supporting Bolts on Engine
8 Remove high pressure pump from engine
9 Check the High pressure pump drive gear/coupling. If it is damaged, Replace with new one
10 Clean mating surface of high pressure pump and engine
11 Install a new gasket
12 Mount the pump and Tighten the mounting bolts with specified torque
13 Reconnect the High pressure pipe line to common rail and Fuel return line
14 Reconnect the metering solenoid wiring connector
15 Re fix the engine cover
16 Connect Battery negative cable
17 Start engine and Check for fuel leakage

— — — — —

TASK 5: **Checking of fuel Injector leak**

1 Turn OFF ignition switch.
2 Disconnect all Injectors wiring connectors.
3 Remove the lock clips from Injectors and Disconnect the fuel return hose from all fuel Injectors.
4 Plug the fuel return hoses.
5 Connect the measuring Jars (special tools) with fuel Injectors.
6 Crane Engine for 5 seconds.
7 Check the fuel return Quantity from each Injector is approximately same and little. If more volume of fuel returns replace that fuel Injector.

— — — — —

TASK 6: **Checking of high pressure fuel circuit**

1 Turn Ignition switch off.
2 Disconnect the wiring connectors from all Injectors.
3 Connect the scan tool to Data line connector.
4 Crane the engine for 5 seconds.
5 Check the fuel pressure shown on scan tool.If it is more than 300 bar when the engine speed is more than 200 rpm then it is ok.If not check and replace fuel pressure sensor and fuel pressure regulator.

— — — — —

EXERCISE 17.3: Servicing of CRDI Injector

Objectives

At the end of this exercise you shall be able to

- dismantle crdi injector
- clean and inspect crdi injector components
- assembling of crdi injector
- testing of crdi injector.

Requirements

Tools/Equipments

- Trainees Tool kit - 1 No.
- CRDI Injector Holding Fixture - 1 No.
- Metal tray - 1 No.
- Torque wrench (0...25 Nm) - 1 No.
- Torque wrench (25...100 Nm) - 1 No.
- Torque wrench (40...200 Nm) - 1 No.

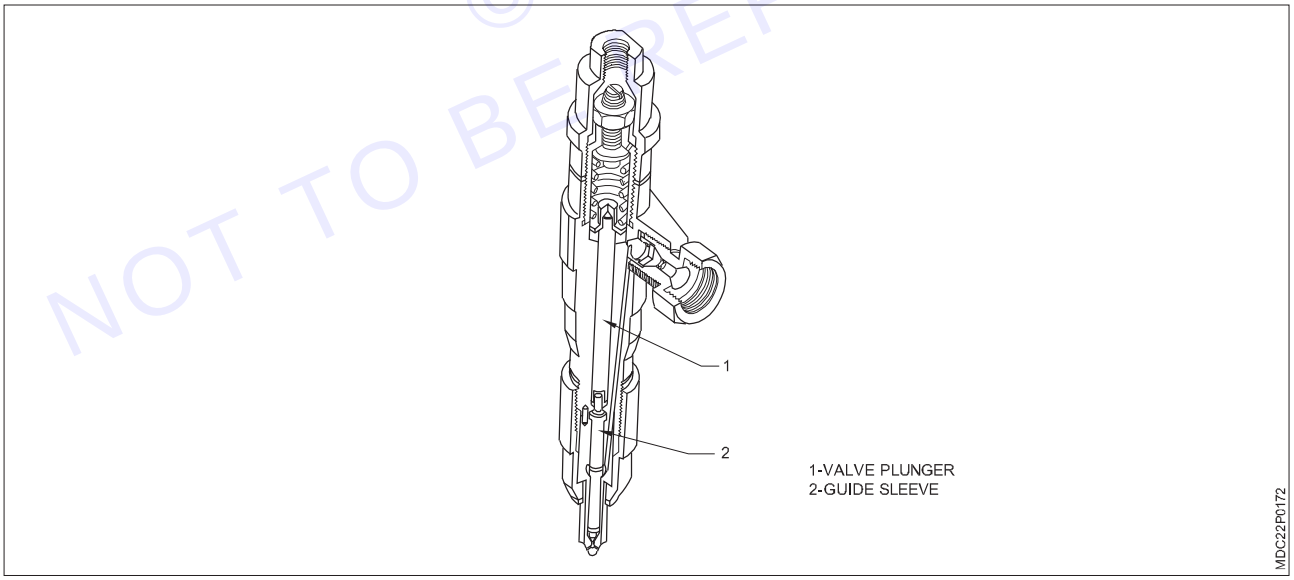
Machines

- CRD-I Injector Testing Machine - 1 No.
- Nozzle tester with adaptor - 1 No.
- Ultrasonic Injector Machine - 1 No.

Materials

- CRDI injector - as reqd.
- Cotton cloth - as reqd.
- Diesel - as reqd.
- Ultrasonic cleaning Solution - as reqd.
- Calibration Oil - as reqd.

Procedure



Test and repair Pre instructions.

Common rail injectors 1. and 2. generation are restricted to nozzle replacement.

On nozzle replacement, a new retaining nut must always be fitted.

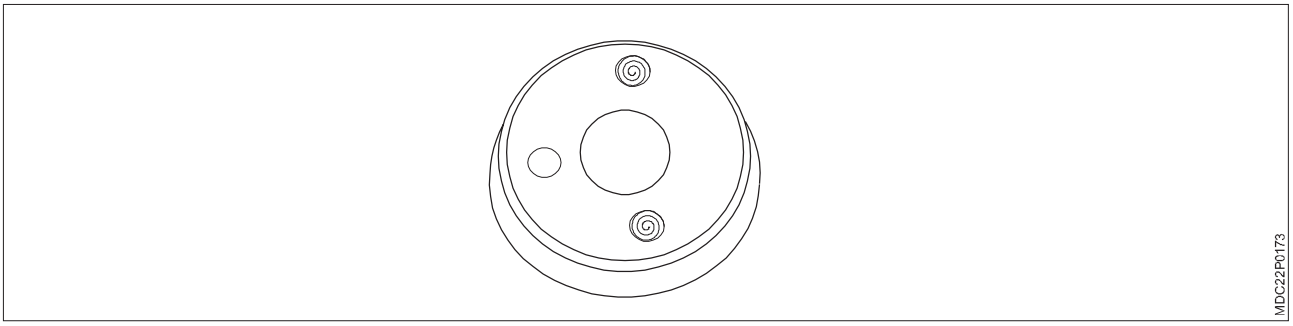
The inlet connector with packing plate can be replaced in the event of leaks in the area of High- pressure connection.

Repair is not possible in the case of a micro-encapsulated inlet connector.

Repair is not possible in the event of leakage at the injector connections or injector body.

Repair operations involving removal of the solenoid valve retaining nut are not permissible.

Common rail injector with helical locating pins cannot be repaired.



The Common rail injector with straight pins can be repaired, however the straight pins must be replaced.

Re-use the thrust pieces, sleeves, springs and shims removed.

The use of unsuitable or poor quality tools can lead to injury and component damage.

Store cleaned parts and add-on components in clean, well organized containers.

Clean the outer surface of Injector body thoroughly after removing from Engine. Use a cap to seal the Inlet and Return connection and the nozzle cone.

Note: DO not use wire brush to clean nozzle cone it may damage nozzle orifices

Ultrasonic cleaning Of CRDI Injector Nozzle.

Remove the protective cap of nozzle cone

Clamp the Common rail injector in the clamping fixture and suspend it in the ultrasonic cleaning bath such that the nozzle retaining nut is completely immersed in the cleaning agent.

Set the temperature of the cleaning agent to 140...158 °F.

Take the Injector out of the cleaning bath after 15 minutes. Dry the components with compressed air and place it in a clean container.

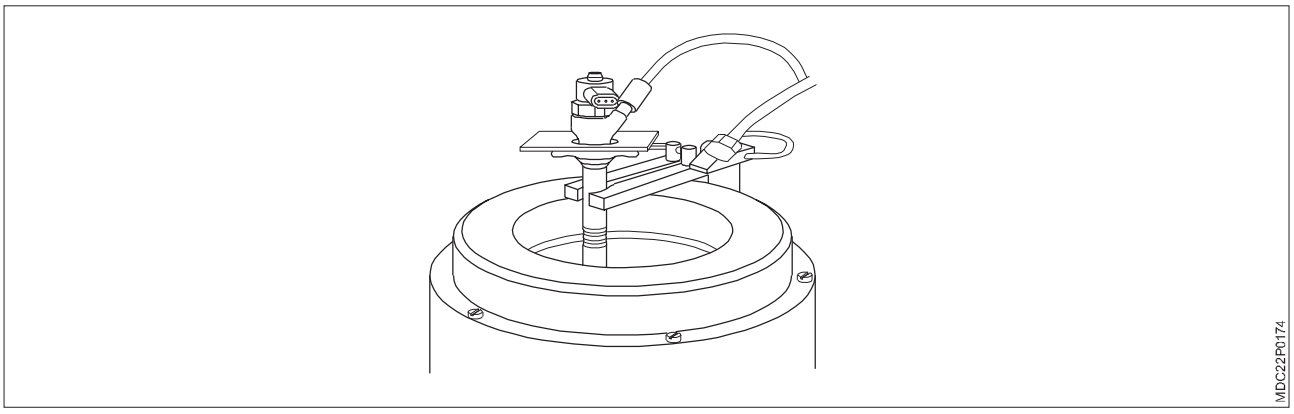
Visual Inspection before service

Check the Common rail injector for external contamination, coke deposits, corrosion and mechanical damage. If contamination is slight then repair is possible

Note: If a Common rail injector is severely damaged or heavily corroded or if the electrical connection is damaged, the Injector should not to be repaired.

Check the Guide collar of CRDI injector. If no wear on guide collar, repair is possible incase more wear repair is not possible

Pressure test



Use a suitable adapter to clamp and connect the cleaned Common rail injector to the nozzle tester.

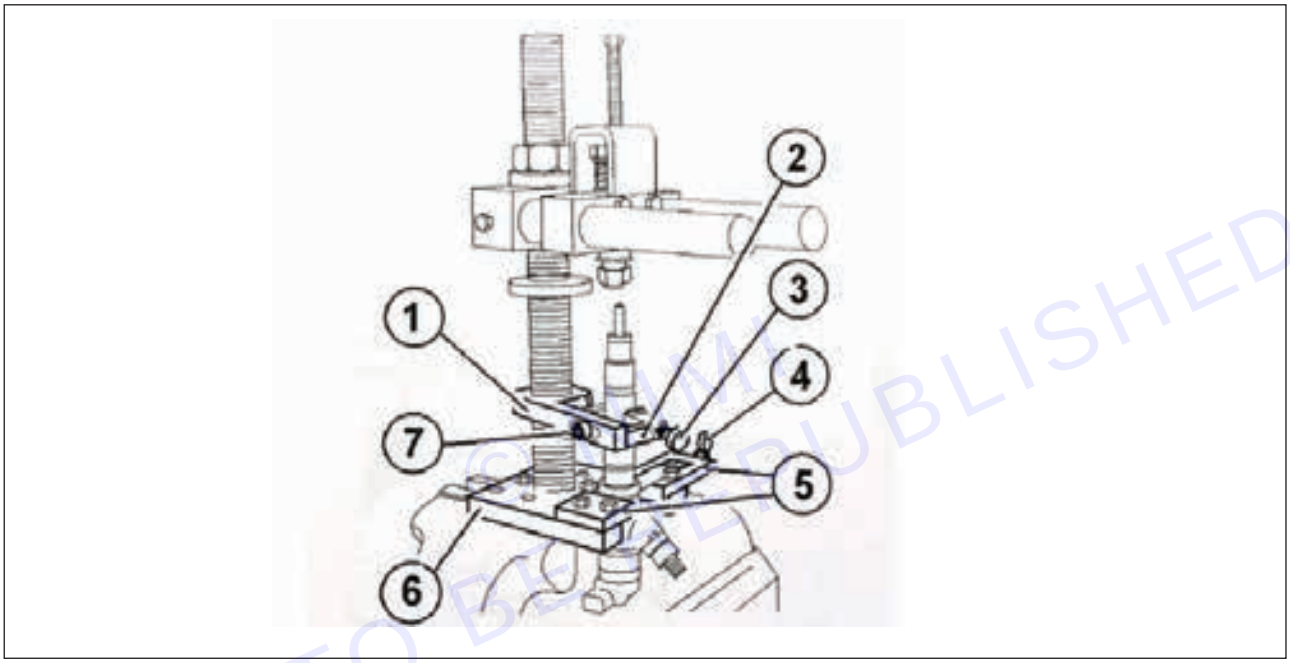
Use the nozzle tester to build up a pressure of > 30 MPa (300 bar) and maintain the pressure by way of constant lever action.

Note: If pressure build-up is possible and calibrating oil only emerges at the return connection, the component Common rail injector can be checked on the pump test bench.

If calibrating oil emerges at the nozzle, the nozzle retaining nut or in the area of the High-pressure connection common rail injector cannot be tested but it may be possible to perform repair.

Note: On completion of repair work, the component must be checked again with the nozzle tester.

If calibrating oil emerges at the solenoid valve retaining nut, the return connection or the injector body the Common Rail injector cannot be repaired. Replace the Common rail injector with a new one.



Clamp Common rail injector

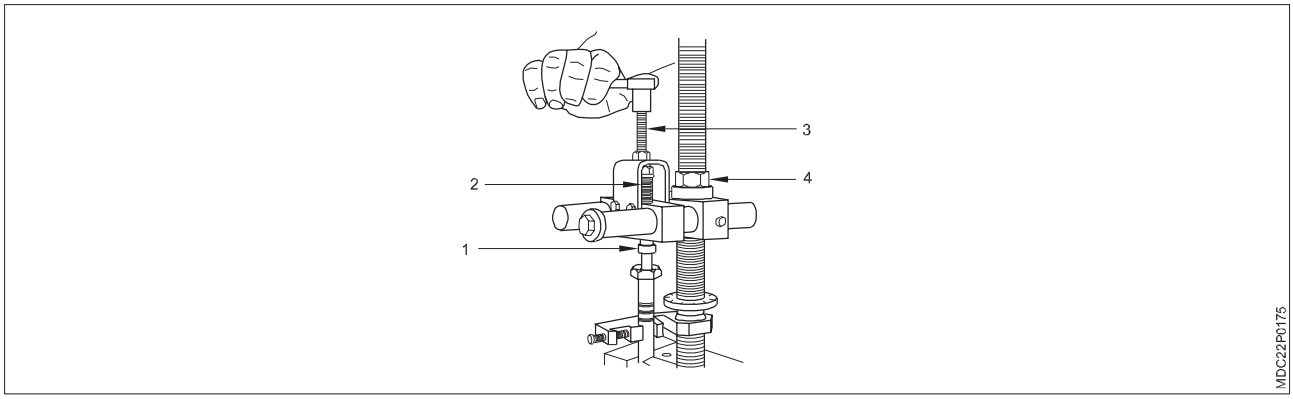
Select and fit suitable clamping pieces (5) for the lower clamping fixture (6).

Insert the holder of the component in the lower clamping fixture (6) and clamp in position.

Position the fixed end of the upper clamping fixture (1) at the injector body Tighten the bolt (7) of the clamping saddle (2).

Tighten the clamping bolt (3) at the clamping saddle (2).

Tighten the clamping bolt (4) at the lower clamping fixture (6).

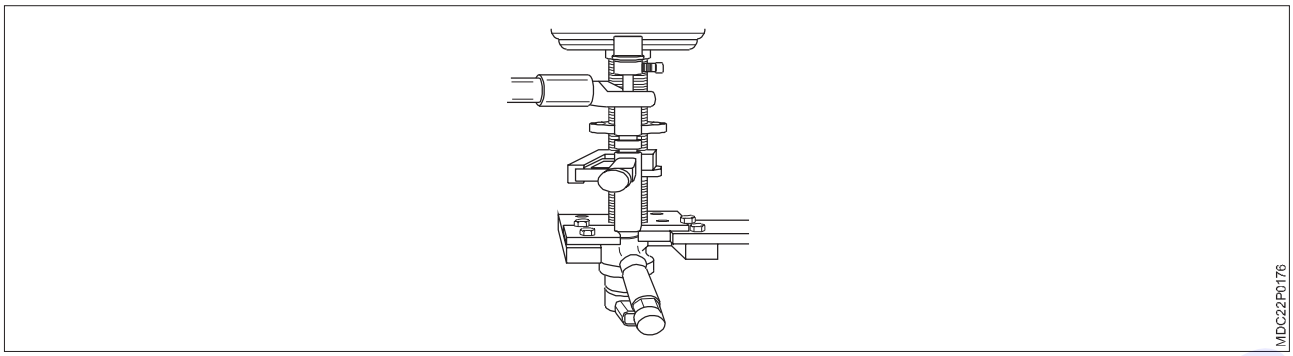


Note: Repeat the clamping procedure if the component is not fixed vertically in position in the clamping fixtures.

Note: The spring assembly with pressure pin (2) must be in retracted position.If the spring assembly with pressure pin (2) is not in retracted position, screw out the adjusting screw (3).

Hand-tighten lock nut (4).

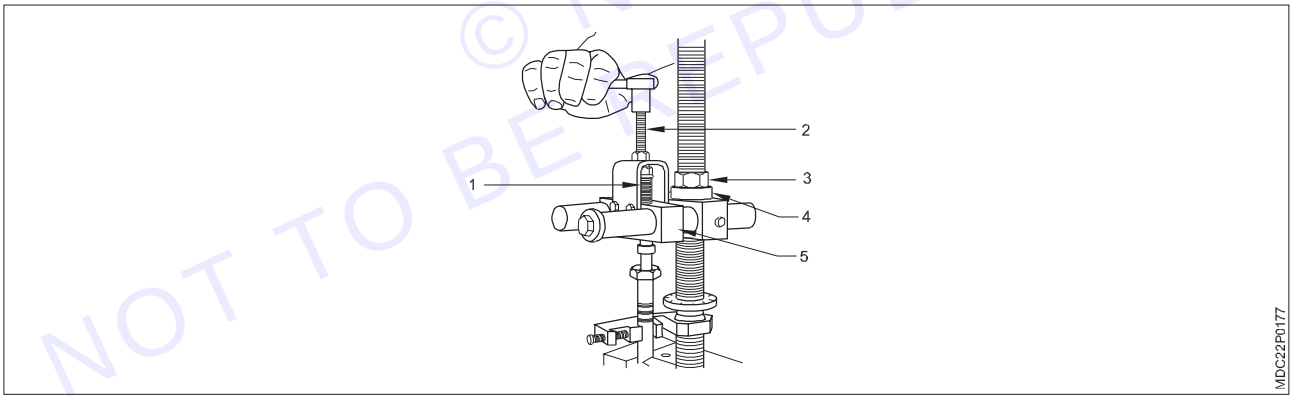
Screw in the adjusting screw (3) of the pressure pin (2) until there is no longer any visible clearance between the two fitting piece sleeves (1).



Unfasten the nozzle retaining nut.

Note: If the slackening-off torque is > 150 Nm, the Common rail injector is not to be repaired. A slackening-off torque of > 150 Nm may damage the sealing surfaces. The Injector should be replaced.

Use the adjusting screw (2) to fully release the holding force at the pressure pin (1).

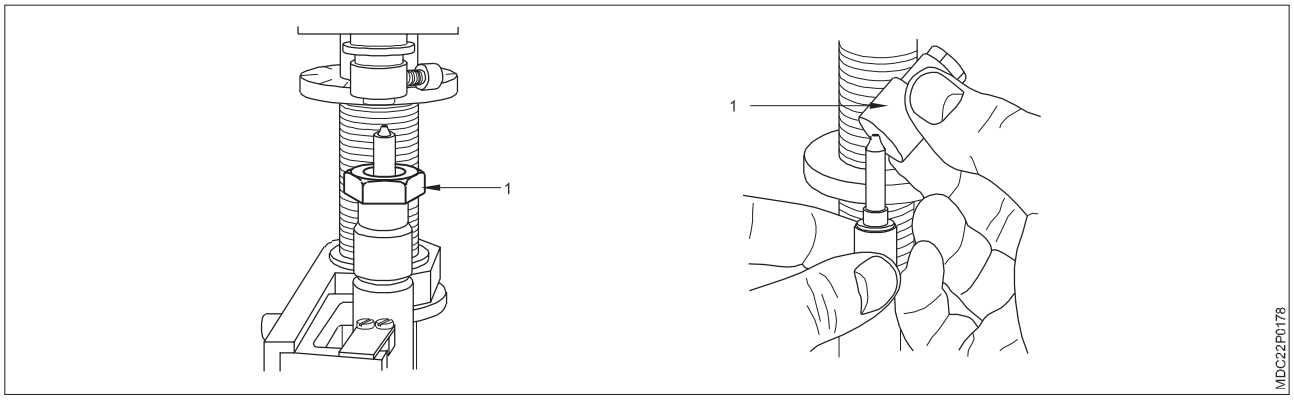


Slacken off lock nut (3).

Turn the adjusting nut (4) of the hold- down arm with clamping slide (5) until the hold-down arm can swivel freely.

Detach hexagon adapter (1).

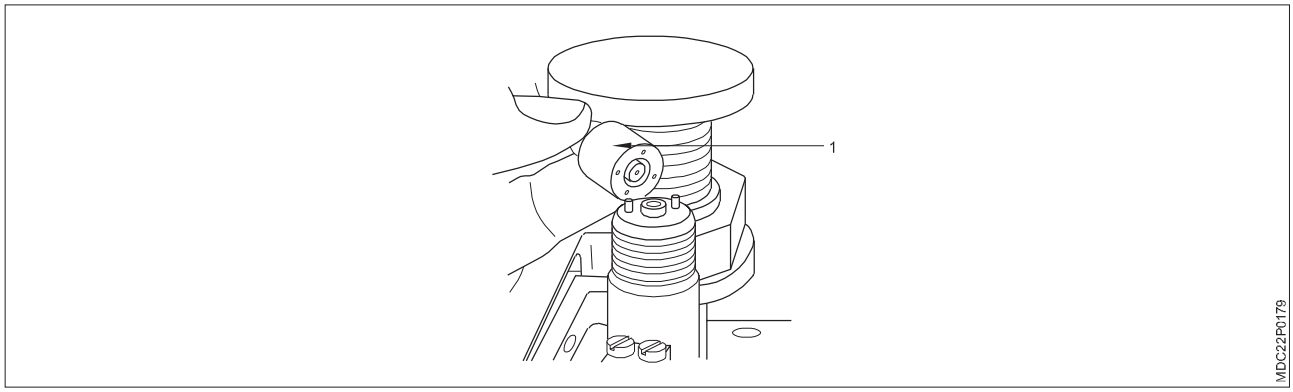
Unscrew and detach the nozzle retaining nut (1).



Note: Make sure the nozzle does not drop out and become damaged.

Remove nozzle:

Detach the nozzle (1)



CRI 1/CRI 2 with nozzle-guided valve plunger.

Remove straight pins (1), thrust piece (2), guide sleeve (3), nozzle spring (4) and shim (5).

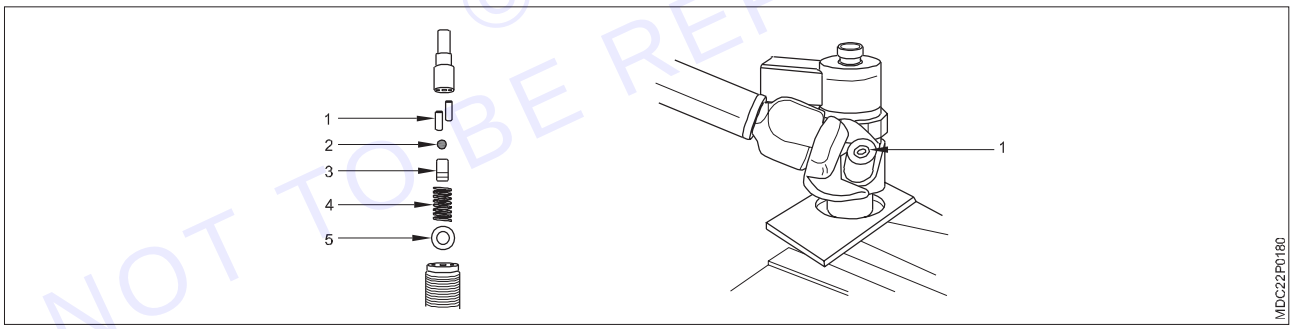
Carefully place parts removed in a clean container.

Note: Re-use the thrust pieces, sleeves, springs and shims removed.

If necessary, remove the inlet connector.

Clamp the common rail injector in a vice with soft jaws.

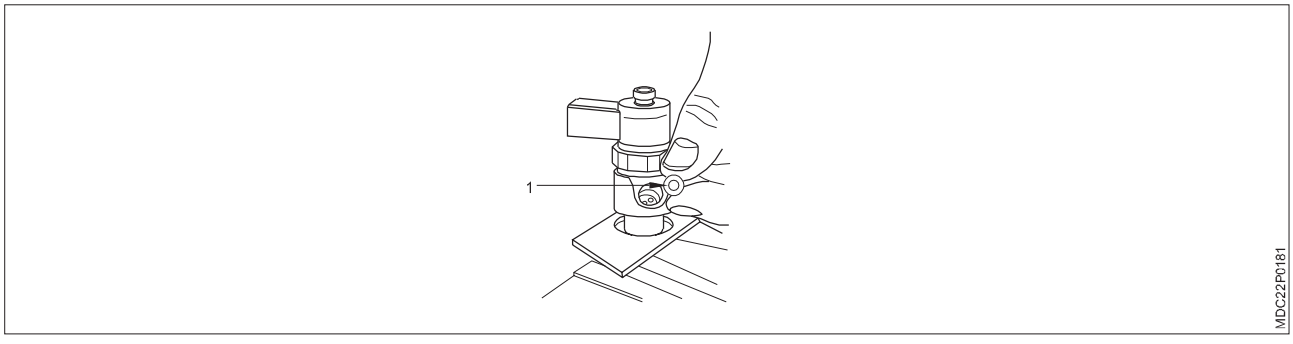
Slacken off and screw out the inlet connector (1).



Note: If the slackening-off torque is 80 Nm, the Common rail injector is no to be repaired. A slackening-off torque of 80 Nm may damage the sealing surfaces.Replace the Common rail injector with a new one.

Use a suitable tool to remove the packing plate (1) from the hole.

Place parts removed in a clean container.



Clean the injector body and the components to be re-used in an ultrasonic cleaning bath.

Set the temperature of the cleaning agent to 140... 158 °F after approx. 15 min, take the component out of the cleaning bath.

Dry all parts with compressed air.

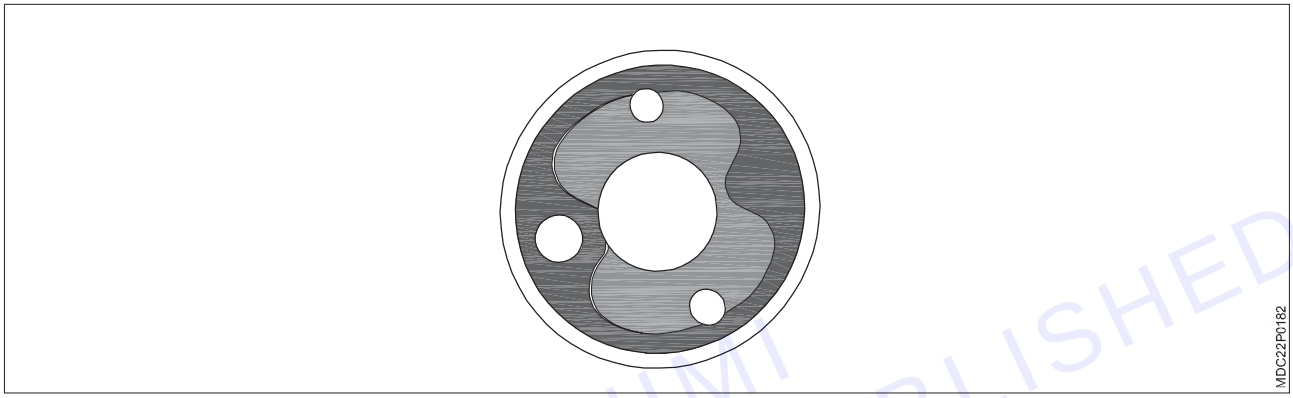
Use a suitable tool, e.g. a suction pump, to clean the sealing surfaces at the injector body.

Inspection of the components

Check the thread for the nozzle retaining nut for contamination coke deposits corrosion and mechanical damage. If The thread is in perfect condition. Repair is possible.

Check nozzle resting surface

Use a magnifying glass to check the resting surface for damage and corrosion. If the resting surface is in perfect condition, Repair is possible. If it is corroded, Replace the injector.



Check hole in body

Use a magnifying glass to check the hole in the injector body for damage and corrosion. IF the hole in the body is in perfect condition, Repair is possible.IF Hole in body damaged/corroded (1), Repair is not possible. Replace the common rail injector

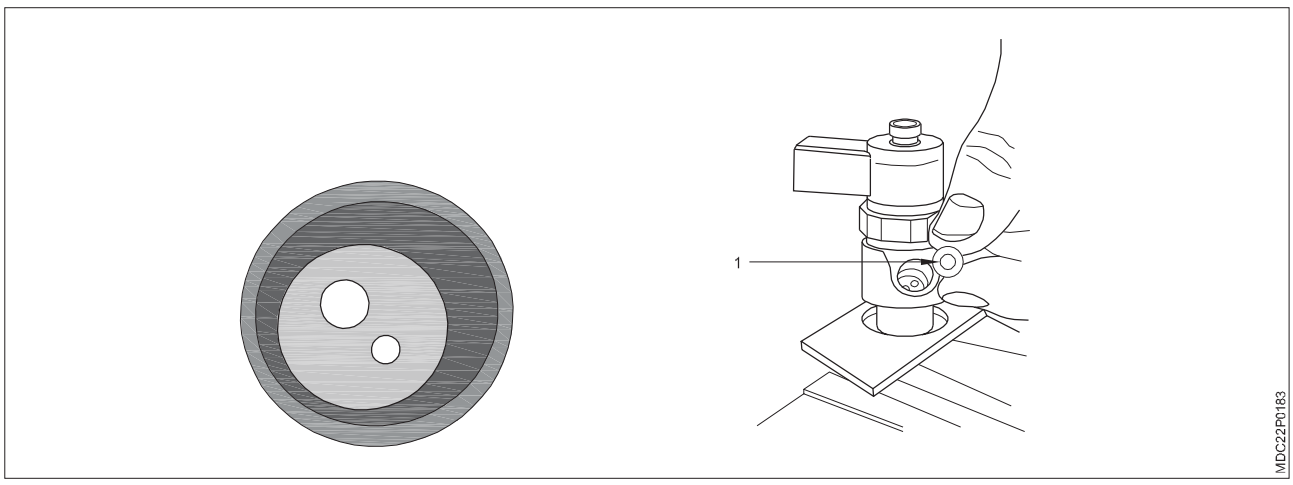
Check thread for inlet connector

Use a magnifying glass to check the thread for the inlet connector for damage and corrosion. IF Thread for inlet connector in perfect condition, Repair is possible If Thread for inlet connector damaged , Repair is not possible. Replace the Common rail injector.

Check resting surface for inlet connector

Use a magnifying glass to check the resting surface for damage and corrosion. If The resting surface is in perfect condition, Repair is possible. IF Resting surface damaged/corroded, Repair is not possible. Replace the Common rail injector with a new one.

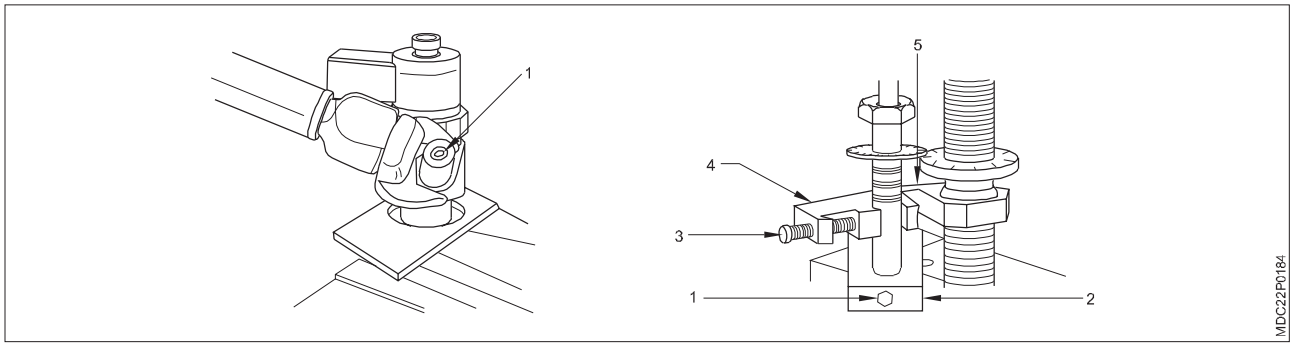
Assembling Of CRDI Injector



Clamp the Common rail injector in a vice with soft jaws. Moisten new inlet connector with fresh assembly oil.

Insert the packing plate (1) in the hole.

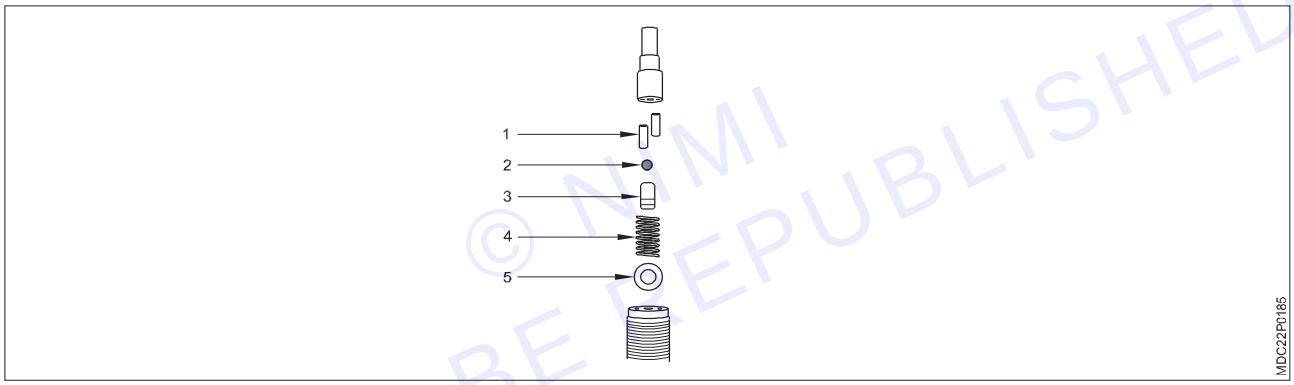
Screw in and tighten the inlet connector(1) to the specified torque.



Insert the holder of the component in the lower clamping fixture (2) and clamp in position.

Position the fixed end of the upper clamping fixture (5) at the injector body. Tighten the clamping bolt (3) at the clamping saddle (4). Tighten the clamping bolt (1) at the lower clamping fixture (2).

Note: Repeat the clamping procedure if the component is not fixed vertically in position in the clamping fixtures.



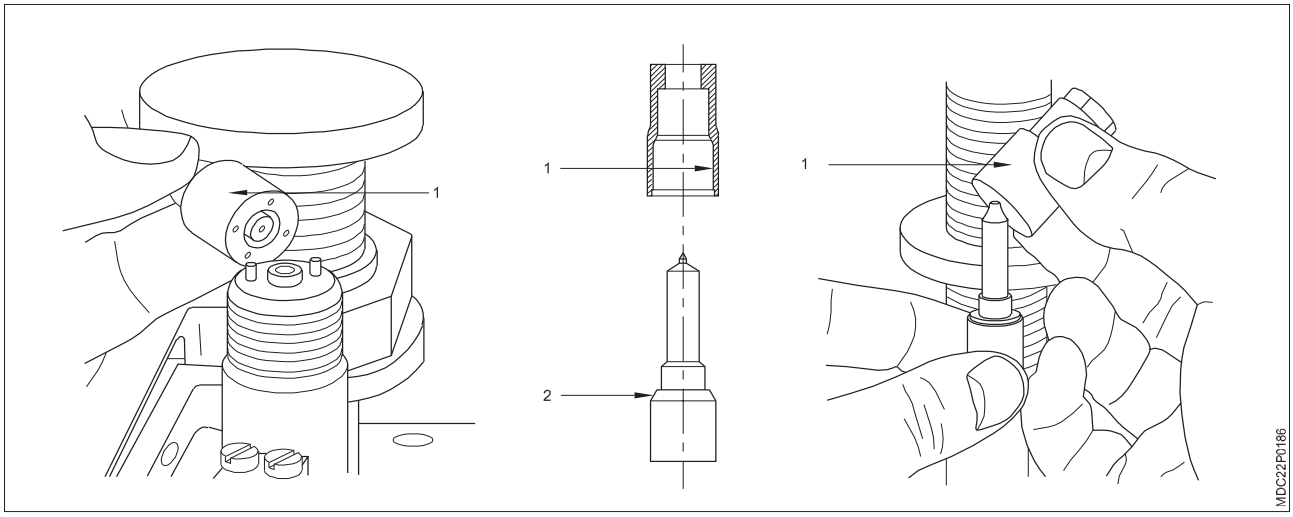
Insert shim (5), nozzle spring (4), thrust piece (2) and, if applicable, guide sleeve (3).

Insert new straight pins (1).

Note: The holes for the straight pins have a smaller diameter than the fuel inlet bore.

Fit a clean new nozzle (1) on the injector body.

Use new nozzle retaining nut Moisten the thread (1) of the nozzle retaining nut and the chamfered shoulder (2) of the nozzle with fresh engine oil.



Fit nozzle retaining nut (1) and screw on by hand

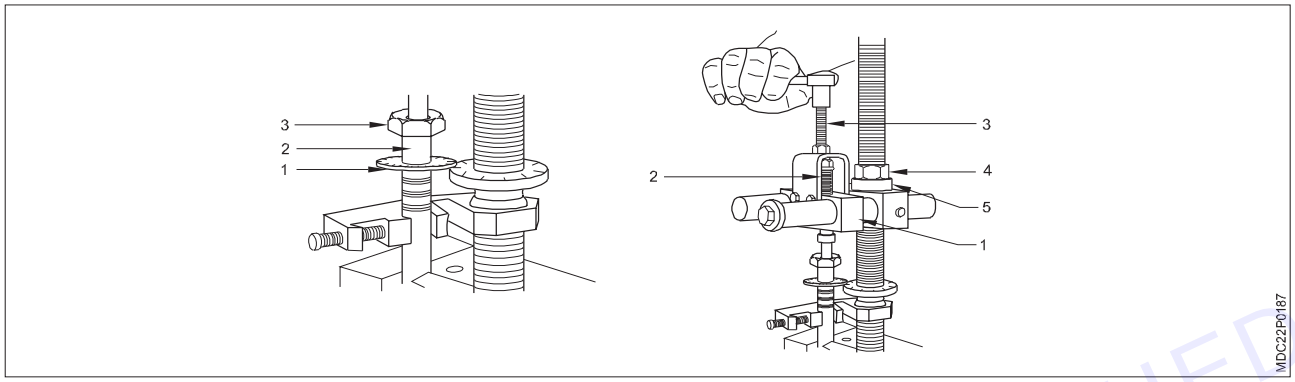
Place a suitable protractor (1) on the nozzle retaining nut

Select a suitable hexagon adapter (3) and mount it on the nozzle retaining nut (2).

Note: The spring assembly with pressure pin (2) must be in retracted position.If the spring assembly with pressure pin (2) is not in retracted position, screw out the adjusting screw (3).

Align the hold-down arm with clamping slide (1) over the nozzle cone.

Turn the adjusting nut (5) of the hold- down arm until the pressure pin (2) is resting on the nozzle cone. Hand-tighter: lock nut (4)



Screw the nozzle retaining nut.

Note: Keep to sequence. Non-compliance could lead to damage.

- Pre-tightening torque.

Depending on design, tighten the nozzle retaining nut to the specified tightening torque/angle

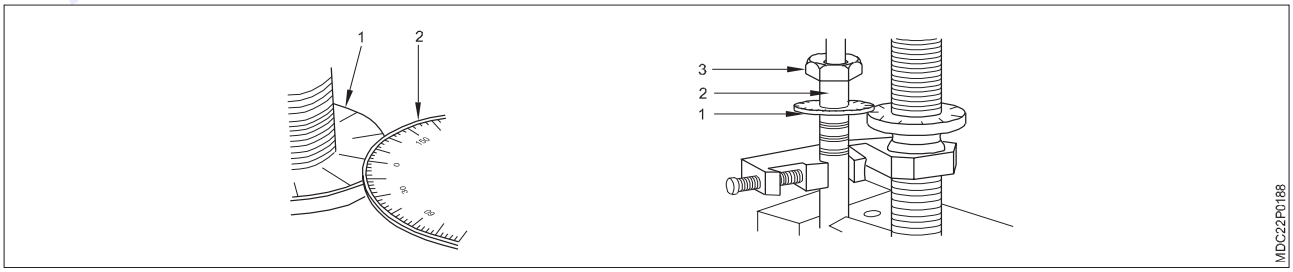
- Release
- Apply.
- Finish tightening:

Align the protractor (2) with the dial(1) and set to 0◦

Use the adjusting screw (3) to fully release the holding force at the pressure pin (2).

Slacken off lock nut (4).

Turn the adjusting nut (5) of the hold- down arm with clamping slide (1) until the hold-down arm can swivel freely.

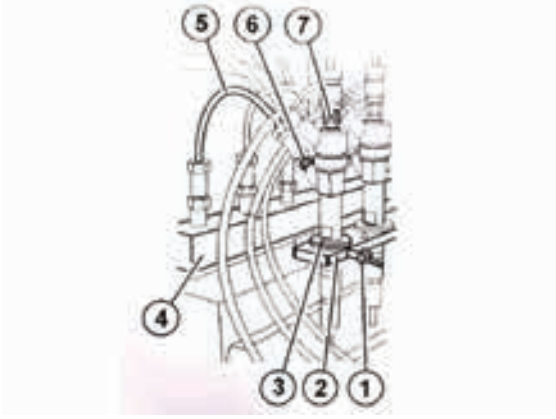


Detach the hexagon adapter (3) from the nozzle retaining nut (2)

Detach the protractor (1).

Remove the Injector from the clamp and place it on a clean surface.

Testing of CRDI Injector on CRDI Injector test bench.



Clamp the Common rail injector on the pump test bench:

Screw the test pressure line (5) to the inlet connector (6) of the Common rail injector and to the rail (4) and tighten.

Tighten the bolt(s) (1) of the Common rail injector

Insert suitable clamping bushes (3) in the mounting rail (2).

Insert the common rail injector in the mounting rail (2).

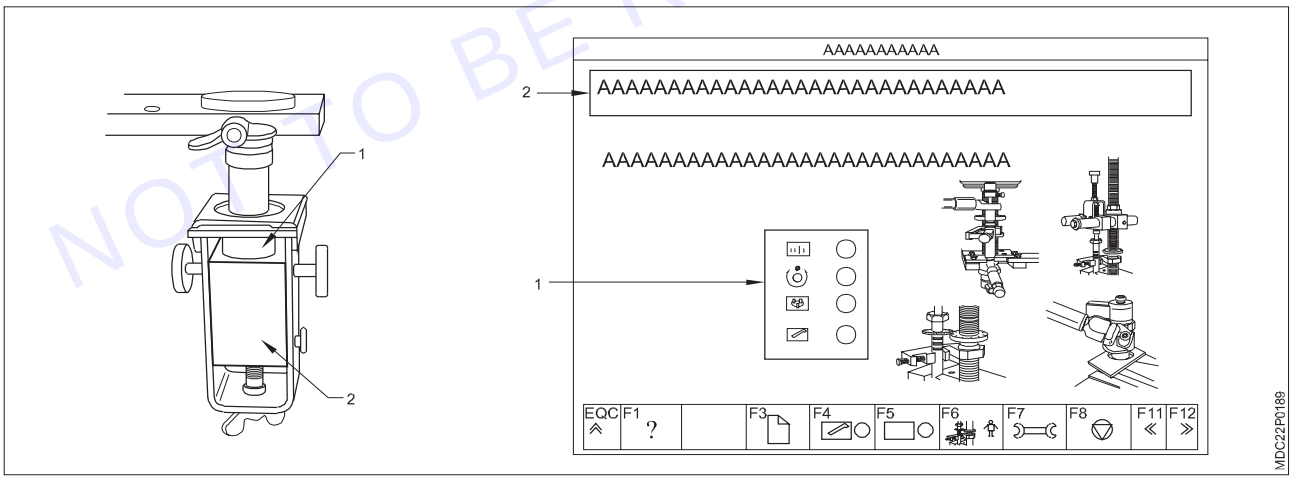
Note: Use an appropriate adapter (7) to connect the fuel return pipe to the component.

Select the appropriate adapter lead and connect to the actuation electronics of the pump test bench. Connect the adapter lead (1) to the Common rail injector

Insert suitable guide sleeves (1) in the injection chamber (2) and fix in position

Switch on pump test bench, voltage stabilizer and PC processor. Set the voltage at the voltage regulator to 13,5 14,5 V

Set the current limitation at the voltage regulator to <Maximum>



Call up the software.

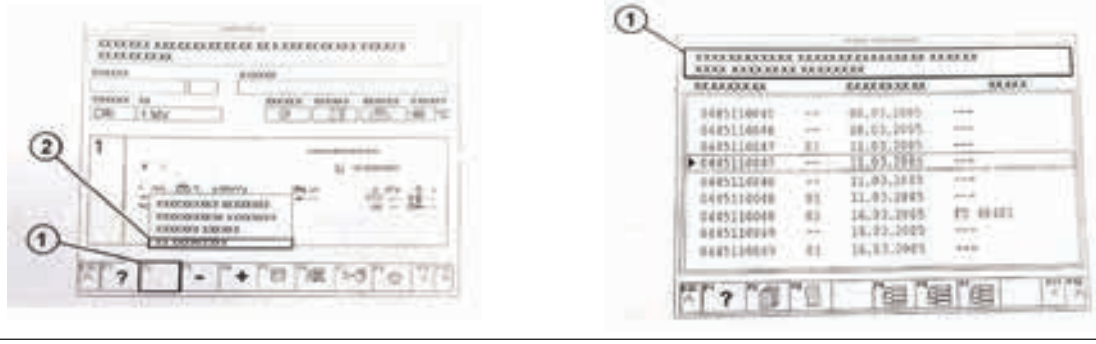
The software implements initialization. If all units and components have been successfully identified, the status displays (1) must light up in green .If one of the status displays (1) lights in red, check the electrical connections and the voltage setting at the voltage egulator.

Note: Switch on the calibrating oil pump, the converter and the calibrating oil heater and issue controller release.

Switch on lubricating oil pump and calibrating oil heating. Follow the monitor instructions in the dialog box (2).

Select component.

Press the function key (1) in the dialog window, select the menu item <CD TestData> (2) and confirm.



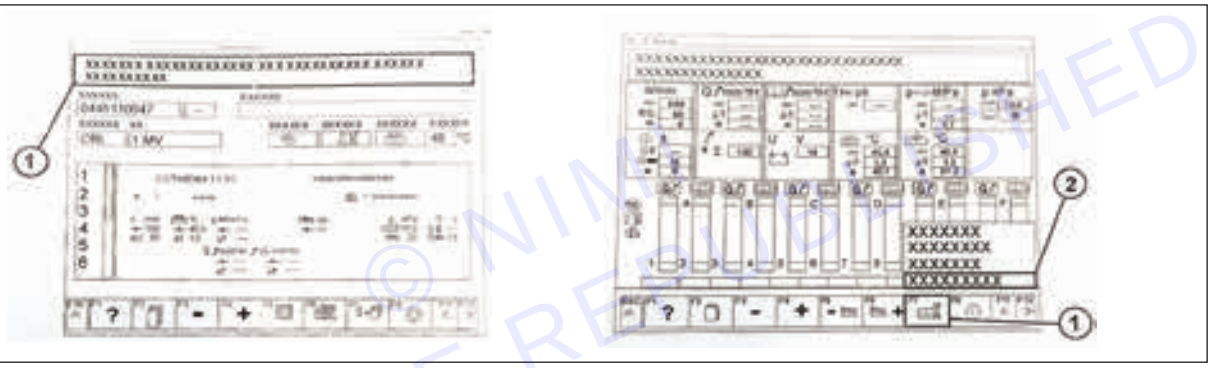
Select the component to be tested in the dialog window.

Follow the monitor instructions in the dialog box (1).

Check component

Follow the monitor instructions in the dialog box (1)

Press the function key (1) in the dialog window, select the menu item <Settings> (2) and confirm.



Activate the connected components in the input box (1).

Enter the serial numbers of the components in the input box (2).If applicable, select the classification group (3) and/or enter the IMA identifier of the Common rail injector (4).

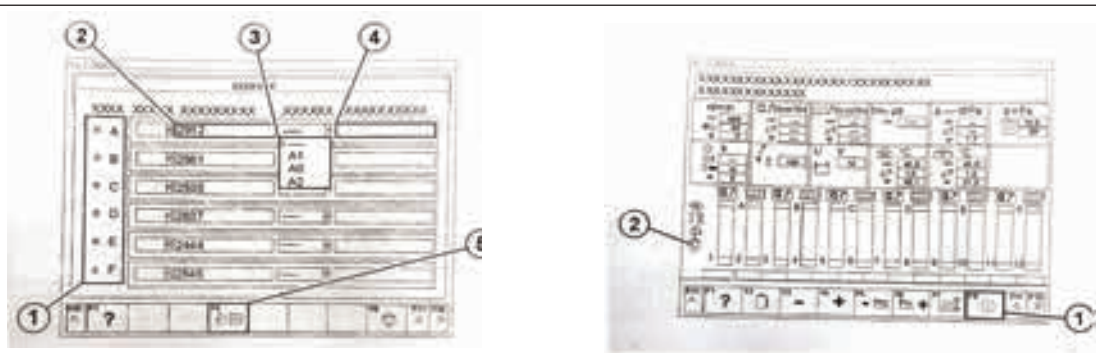
Confirm the entries with the function key (5).

1 Test step

Press the function key (1) in the dialog window, select the menu item <Automatic on/off> (2) and confirm

Note: The symbol for automatic (2) flashes.

Start the test sequence by way of the function key (1) and follow the monitor instructions.



The inlet pressure (2) and return pressure (3) of the component <High-pressure pump> are checked.

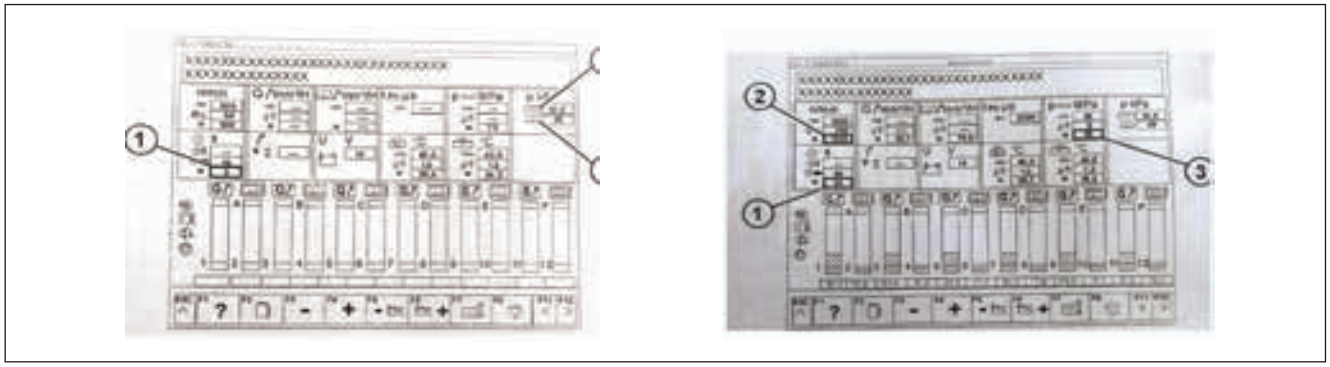
The next test step is selected automatically on completion of the waiting time (1).

2 Test step

The speed (2) and the rail pressure (3) are regulated to the set value.

The waiting time (1) for flushing is started.

The next test step is selected automatically on completion of the waiting time (1).



3 Test step

Remove all injection chambers from the nozzles.

Attention: Danger of burns.

Close the test bench doors.

Start the test sequence by way of the function key (1) and follow the monitor instructions.

The speed (1) and the rail pressure (2) are regulated to the set value.

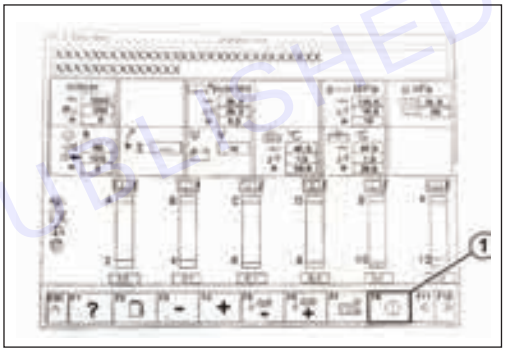
The waiting time (3) for measurement channel recognition (4) is started.

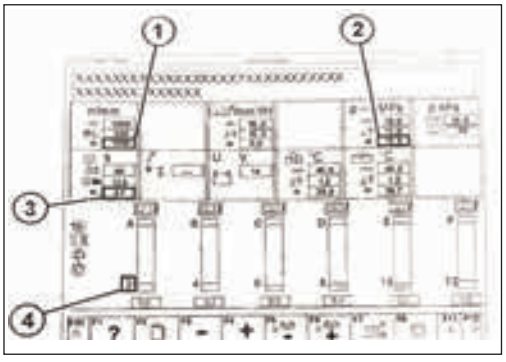
On completion of measurement channel recognition, the speed (1) and rail pressure (2) are slowly regulated to the maximum value.

The function <Leak test> only measures the return quantity.

The return quantities of the components are shown in the quantity measurement bars (3).

The waiting time (4) for the function <Leak test> is started.





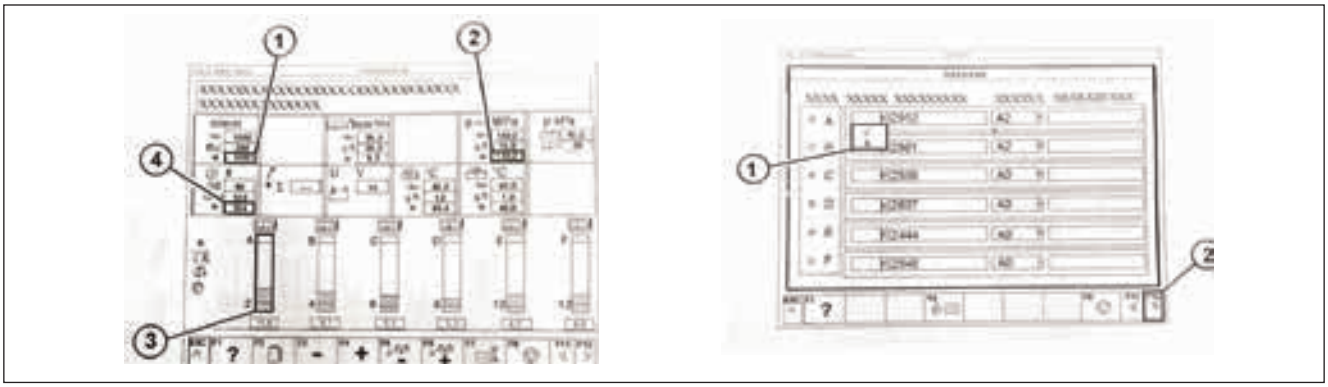
Attention

If calibrating oil emerges during the function <Leak test> at the Common rail injector, the test step must be terminated.

Remove the defective component <Common rail injector>. Seal the component <High- pressure connection> at the rail with a dummy plug. In the dialog window <Settings>, deactivate the defective component <Commonail injector and select <Leak test not successful>

Continue test

On completion of the function <Leak test>, the dialog window <Settings> opens Mark the component accordingly in the selection box <Leakage> (1) and confirm Position all injection chambers over the nozzles, lock in place and tighten. Close the test bench doors.



Continue with key F8. for further test. At the end of last test step, save the data and call up the result log.

Test results Interpretation

Quantity measurement point and return quantity OK: Common rail injector is OK.

Quantity measurement point OK and return quantity too high: Repair the Common rail injector.

Quantity measurement point and return quantity too high: Repair the Common rail injector.

Quantity measurement point too low and return quantity too high: Repair the Common rail injector.

Quantity measurement point too low and return quantity OK: Repair the Common rail injector.

Quantity measurement and return quantity too low: Common rail injector defective.

Note: At least 1 quantity measurement point must be within the tolerance range.

Other combinations of quantity measurement point and return quantity are possible.

Repair may be successful.

If not all test items are within the tolerance range following nozzle replacement, replace the relevant Common rail injector with a new one.

EXERCISE 17.4: Overhauling of CRDI Diesel engine

Objectives

At the end of this exercise you shall be able to

- dismantle CRDI injector
- clean and inspect CRDI injector components
- assembling of CRDI injector
- testing of CRDI injector.

Requirements

Tools/Equipments

- Trainees Tool kit - 1 No.
- Box Spanner set - 1 No.
- Metal tray - 1 No.
- Torque wrench (0...25 Nm) - 1 No.
- Torque wrench (25...100 Nm) - 1 No.
- Torque wrench (40...200 Nm) - 1 No.
- Dial Test Indicator - 1 No.
- Piston ring compressor - 1 No.
- Piston ring expander - 1 No.
- Cylinder Bore gauge - 1 No.
- Vernier caliper 0-300mm - 1 No.
- Outside Micrometer(0-25mm, 25-50mm,50-75mm,75-100mm,100-125mm,125-150mm) - 1 No.
- Piston feeler gauge - 1 No.
- Flywheel holder - 1 No.
- Pilot bearing puller - 1 No.
- Surface plate with plain tabe - 1 No.
- Spring tension tester - 1 No.
- Connecting rod alignment Fixture - 1 No.
- Straight edge - 1 No.
- Compression gauge - 1 No.
- Vacuum gauge - 1 No.
- Oil seal installer - 1 No.
- Bearing installer - 1 No.
- Valve guide reamer inner and Outer Diameter - 1 No.
- Valve guide Installer - 1 No.
- Bearing puller - 1 No.
- Bearing installer - 1 No.
- Cam shaft pulley holder - 1 No.

Machines

- A LMV with CRDI engine - 1 No.
- Engine stand - 1 No.
- Engine hoist - 1 No.
- Air compressor - 1 No.
- High pressure water get - 1 No.

Materials

- Engine major overhauling gasket kit - 1 No.
- Engine Bearings - 1 Set
- SAE 20W-40 Engine oil - 15 litres
- Coolant - 05 litres
- Chemical adhesives- asreqd.
- Engine bolts - as reqd.
- Cotton cloth - as reqd.
- Plastic gauge - as reqd.
- Diesel - as reqd.
- Cotton waste - as reqd.
- Calibration Oil - as reqd.

Procedure

Dismantling of CRDI Engine

1 Disconnect battery Positive and Negative cable.

2 Remove engine Top cover.

3 Remove air cleaner assembly with MAF sensor.

4 Remove Intercooler.

5 Remove water pump/Alternator drive belt.

6 Remove ECM.

7 Drain Engine oil and Transaxle oil.

8 Drain coolant.

9 Disconnect the intercooler hoses, Fuel inlet and return hoses, Radiator inlet and outlet hoses and Water engine outlet hose.

10 Disconnect the electrical wiring connections of MAP sensor, A/F Sensor, ECT sensor, CMP&CKP sensor, Injectors, Glow plug, EGR valve, Oil pressure switch, Fuel pressure regulator, fuel pressure sensor, Alternator, Starter and engine Ground.

11 Remove the exhaust pipe line.

12 Remove clutch and gear shifting lever connections.

13 Remove any other parts which obstructs to remove the engine.

14 Loosen the engine mounting bolt and support the engine by engine hoist.

15 Remove the engine from Vehicle.

16 Fix the engine on engine supporting stand.

17 Remove engine accessories like alternaror, power steering pump, AC compressor pump and starter motor.

18 Remove oil pan.

19 Remove water pump, Inlet and Exhaust manifold, remove high pressure pipe lines from pump to common rail and common rail to injectors.

20 Remove common rail and CRDI injectors.

21 Remove crank shaft pulley, Timing chain cover, timing chain tensioner and Timing chain.

22 Remove cam shaft housing assembly ,Vacuum pump and High pressure pump.

23 Remove camshaft timing sprocket, Timing gears and cam shaft.

24 Remove glow plugs, oil separator, oil pressure switch, CMP sensor, Hydraulic valve lash adjuster with valve rocker arm.

25 Remove cylinder head bolts as per sequence and takeout the cylinder head and Head gasket.

26 Dismantle the cylinder head assembly and remove the valves, valve springs, Valve stem seal and valve spring seat.

27 Remove connecting rod caps and remove the piston assembly from engine and keep as per sequence no engine cylinders.

28 Dismantle the piston and connecting rod assembly.

29 Remove the Flywheel.

30 Remove the Main bearing caps, CKP sensor, crankshaft front and rear end supports.

31 Remove crankshaft.

Cleaning and Inspection

Remove the carbon particles deposited on the piston, valves, cylinder head combustion chamber and Intake and exhaust ports.

Clean all the parts dismantled from the engine.

Clean the cylinder block and Cylinder head with water jet .Clean the oil and water passages with water jet and compressed air.

Inspection of Parts

1 Checking of crankshaft

Check the crankshaft main journals and crank pin diameters for taper and ovality wear and cracks if any cracks found or wear limit is out of specification of manufacturer, replace the crankshaft or recondition the crank shaft.

Check the crankshaft thrust play, if it is out of specification, Replace with oversize bearing.

2 Checking of Main bearings

Visually inspect the bearings for pitting, scoring, wear or any scratch. If necessary replace with standard size bearing.

Check the crank shaft journal bore diameter, Journal diameter and bearing oil clearance using plastic gauge, refer with manufacturer's service manual, if it is out of specification replace the bearing.

3 Checking of Cylinder Block

Check the cylinder bore taper and ovality wear using cylinder bore guage, If it is out of specification, Reboring , honing or replacing liner is to be done.

Check the cylinder block mating surface warpage. If necessary machine the surface

4 Checking of Piston assembly

Visually check the piston for scoring ,pitting, Wear or any damage, If necessary replace with new standard piston

Measure the piston diameter using outside micrometer, Measure the piston pin diameter, Measure Piston clearance, Piston ring groove side clearance and piston ring end clearance If necessary replace the component

5 Checking of connecting rod assembly

Measure the connecting rod small end bore diameter, Measure the connecting rod big end bore diameter if it is out of specification replace the connecting rod

Check the connecting rod bend and twist using connecting rod alignment fixture if necessary, replace it

6 Checking of camshaft

Check the camshaft lobe height, Straightness of the shaft, cam shaft journal diameter, Cam lobe flatness if necessary replace it

7 Checking of cylinder head assembly

Check the cylinder head mating surfaces for warpage. If necessary Machine the mating surfaces.

Check the rocker arm, Rocker arm shaft, rocker arm springs, Adjusting screws, Hydraulic tappet if necessary replace the part

Check the valve face, valve seat, Valve length, valve guide, valve springs if necessary replace the component.

8 Checking of flywheel

Check the flywheel surface for any scoring, Pitting or wear and check the flywheel ring gear if necessary replace it

Assembling of CRDI engine

Reassemble all the engine parts in the reverse order of dismantling

Note: While reassembling valve timing has to set properly. After assembling of engine, set and adjust the valve tappet clearance as per the specification provided by the Manufacturer.

MODULE 18: Stationary Engine and Sub System

EXERCISE 18.1: Servicing of PT Fuel System

Objectives

At the end of this exercise you shall be able to

- To dismantle clean, inspect and assemble the PT injector
- To dismantle clean, inspect and assemble the PT Pump
- To dismantle clean, inspect and assemble the fuel filter
- To test the spray pattern & opening pressure.

Requirements

Tools/Equipments

- Trainee'stoolkit - 1 No.
- PT fuel system Diesel engine - 1 No.
- PT Injector - 1 No.
- Injector holding fixture - 1 No.
- Air compressor - 1 No.
- Bench vice - 1 No.

Materials

- Tray - as reqd.
- Cottoncloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.

Procedure

TASK 1: **Servicing of PT fuel filter**

1 Shut down the main fuel tank fuel cock.

2 Remove the drain plug of fuel filter and drain the fuel .

3 Remove the fuel filter inlet hose pipe and hold the pipe at a higher level than the float tank fuel level.

4 Remove the fuel filter outlet line hose pipe to the PT fuel pump .

5 Remove fuel filter mounting bolts and place the fuel filter on metal tray .

6 Remove the center bolt of the fuel filter casing .

7 Detach the filter casing, cover and filter element.

8 Clean the filter casing thoroughly inner and outer side and as well as filter cover.

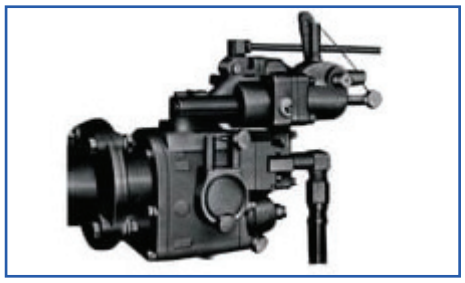
9 Fix the drain plug on the filter casing .

10 Replace with a new fuel filter element and new gasket on the casing .

11 Refix and tighten the center bolt as per manufacturers recommended torque.

— — — — —

TASK 2: **Servicing of PT fuel Pump**



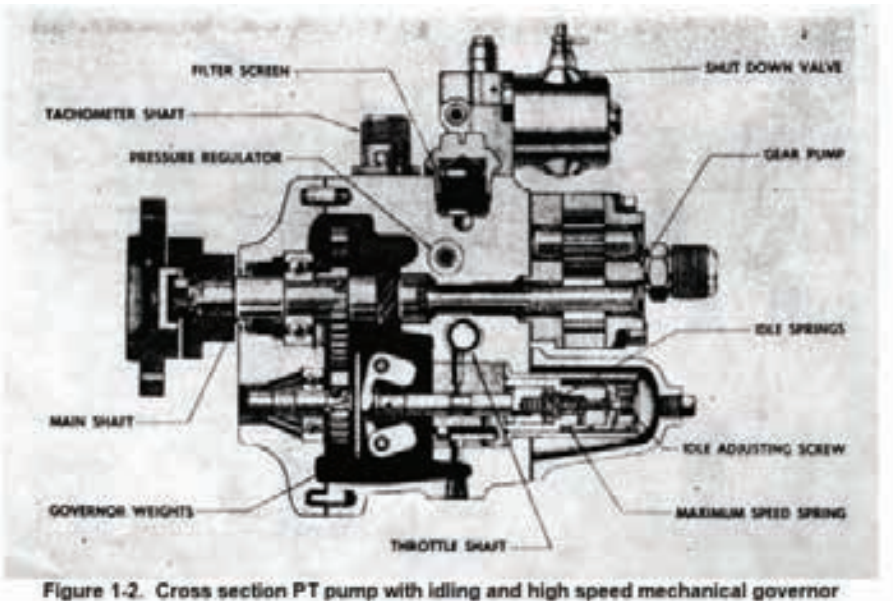


Figure 1.2. Cross section PT pump with idling and high speed mechanical governor

Dismantling of PT fuel pump

1 Disconnect the pt pump speedometer cable

2 Remove the solenoid wires of PT pump.

3 Disconnect the fuel outlet on solenoid.

4 Use Allen key and remove the solenoid Allen screws and take out the solenoid.

5 Remove the PT pump fuel inlet by loosening hose nut.

6 Disconnect PT fuel pump return line and disconnect the PT pump throttle linkage.

7 Remove the PT pump Flange nuts and Hold the PT pump on a vice.

8 Remove the PT pump drive love jaw coupling. Remove the PT pump body bolts and remove drive shaft and drive gear.

9 Remove the damper gear.

10 Remove the governor flyweight unit.

11 Remove the governor unit casingcover.

12 Remove the snap ring.

13 Remove the idle adjusting screw unit.

14 Remove the governor maximum speed spring, shims, idle spring, washer and return spring.

15 Remove the plunger and fuel button unit.

16 Remove the throttle lever lock bolt nut.

17 Remove the throttle lever after marking on throttle lever and throttle shaft.

18 Remove the snap ring and seal plate.

19 Remove the throttle shaft.

20 Remove the pulsation damper unit cover.

21 Remove the adjusting screw, pulsation damper spring and shims.

22 Remove the magnetic filter screw lock bolt.

23 Remove the magnetic screw filter and spiral spring.

24 Remove the speedometer gear shaft.

25 Remove the gear pump return line .

26 Remove the gear pump body by loosening the allen screw.

27 Detach the gear pump

Cleaning

1 Clean all the removal parts using clean diesel .clean the pump body inner and outer parts.

Clean the gear pump body ,inner and outer gear .clean the all the fuel passage holes provide on the pump Body with compressed air clean the magnetic filter screen.

2 Inspect the gear pump drive gear and driven gear if it is worn out , replace with new parts.

3 Inspect the magnetic filter if necessary replace it.

4 Inspect the drive shaft gears, flyweight drive gear and flyweight free movement .if necessary or any part is worn our replace with new parts.

5 inspect the governer spring, governer shaft fuel button idle spring . replace the parts .

Inspection of solenoid unit

1 Dismantle the solenoid unit by unscrewing the allen screws .

2 Clean the fuel passage holes and check whether it is free from any blockage .

3 Connect the solenoid positive and negative with a 12 v supply .

4 Check the magnetism if the magnetism is weak replece the solenoid unit.

Assembling of PT fuel pump

Assemble all the parts already dismantled in the reverse order of dismantling

Note: All the oil seals,o rings and gaskets are to be replaced with new one.

— — — — —

TASK 3: **Servicing of PT fuel Injector**

1 Hold the PT fuel injector on holding fixture and fix on the bench vice.

2 Remove the fuel filter screen and retainer in the fuel inlet line.

3 Remove the top stop screw.

4 Remove the Injector link.

5 Remove the lock nut of PT injector.

6 Remove the spring washer and Injector spring.

7 Remove the plunger and Barrel.

8 Remove the cup retainer.

9 Remove the nozzle cup.

10 Clean all the parts with clean diesel.

11 Clean all fuel passages and orifices with compressed air.

12 Replace the o rings and gaskets with new one.

13 Assemble the Injector in the reverse order.

— — — — —

EXERCISE 18.2: Test For Continuity and Insulation Resistance of Alternator

Objectives

At the end of this exercise you shall be able to

- read and interpret the name-plate details of an alternator
- identify the terminals of a 3-phase alternator
- test the alternator windings for continuity
- test the insulation resistance between the stator and rotor windings
- test the insulation resistance, between the windings and the alternator frame.

Requirements

Tools/Equipments

- Cutting pliers 200mm - 1 No.
- Spanner set 5mm to 200mm - 1 Set
- Screwdriver 200mm - 1 No.
- Screwdriver 100mm - 1 No.
- Megger 500V - 1 No.

Equipment/Machines

- Alternator, 3-phase, 3 KVA 415V - 1 No.

Materials

- P.V.C. insulated copper wire 23/0.2 mm size - 5 m
- Insulation tape - 1 m.
- Test lamp 60W / 240V - 1 No.

Procedure

TASK 1: **Read and interpret the name plate details of an alternator**

1 Read and interpret the name-plate details of the 3-phase alternator and enter in Table 1.

2 Identify the terminals of the alternator as you did in Exercise No.3.5.151. Task : 3.

Table 1

Name Plate Details

Manufacturer, Trade mark : .....
Type, model or list number : .....
Type of current : ..... Fabrication or Serial number : .....
Function: ..... Alternator : .....
Type of connection: ..... P.F : .....
Rated voltage: .....Volts Rated current : ..... amp
Frequency: .....Hz Rated speed : .....r.p.m.
Rated power: .....kVA Rated exc. current: .....amps
Rated exc. voltage: .....Volts Direction of rotation: .....
Rating class: ..... Protection class: .....
Insulation class: .....

— — — — —

TASK 2: **Conduct continuity test by using a lamp**

1 Take the test lamp and identify the cable to which the S.P. switch and the fuse are connected in series with the lamp. Use this as Prod 1.

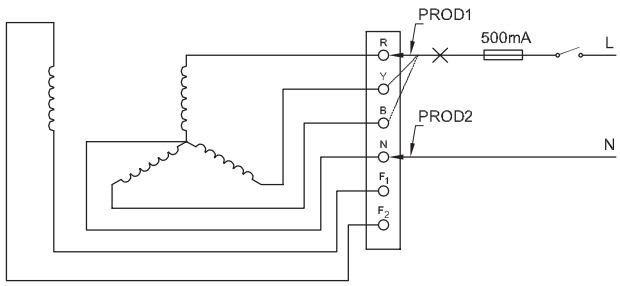
2 Connect Prod 2 to terminal `N' and touch the terminals R, Y and B alternatively by Prod 1. (Fig 1) Observe the lamp condition and enter the same in Table 2.

The phase wire should be identified in the test lamp as Prod 1, and should be connected through the switch and fuse to the test lamp. Care should be taken to see that the phase wire does not touch the body or frame of the alternator. Do not touch any terminal while testing with AC supply.

Table 2

S.No.	Connection between	Condition of lamp
1	R and N	
2	Y and N	
3	B and N	
4	F1 and F2	

Fig 1

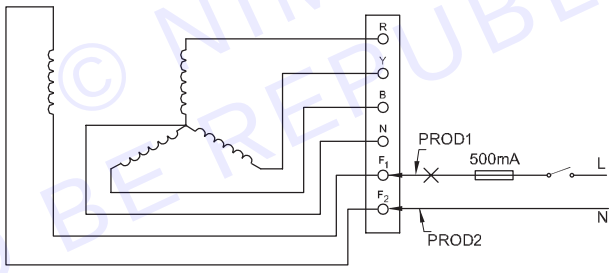


CONTINUTY TEST ON MAIN WIRING

MDC22P0211

3 Check the continuity between F_1 and F_2 (Fig 2) and enter the finding in Table 2.

Fig 2



CONTINUTY TEST ON FIELD WINDING

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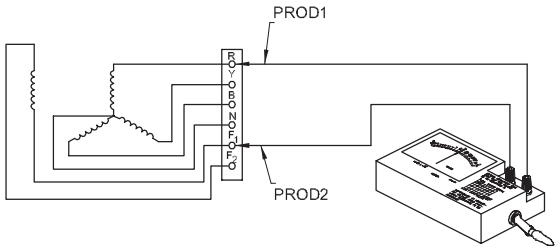
TASK 3: **Measure insulation resistance between windings**

1 Connect one prod of the Megger to any one of the terminals R,Y,B,N and the other prod to the terminal F1 or F2 as shown in Fig 3.

Fig 3



INSULATION TEST BETWEEN WINDINGS

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You can connect to any one of the terminals R, Y, B and N as all of them are having continuity as ascertained earlier.

2 Rotate the Megger at its rated speed and measure the insulation value and record it in Table 3.

The measured value should not be less than 1 megohm.

Table 3

S. No.	Insulation resistance between windings	Value in megohms
1	Between RYBN and field winding F1 & F2	

— — — — —

TASK 4: **Measure the insulation resistance between the windings and the body**

1 Connect one of the prods of the Megger to any one terminal, RYBN and the other prod to the body/frame of the alternator.

2 Rotate the Megger at its rated speed and measure the insulation resistance. Record it in Table 4.

Table 4

S. No.	Insulation resistance between winding and the body	Value in MΩ
1	Between armature winding R/Y/B/N and the body	
2	Between field winding F1 & F2 and body	

3 Connect the Megger prod to terminal F1 or F2 and the other prod to the body.

Rotate the Megger at its rated speed and measure the insulation resistance value, and record it in Table 4.

The measured insulation value should not be less than 1 megohm.

4 Compare these values of insulation resistance with those entered in the alternator maintenance card available in the section, and discuss the variations in the reading with your instructor.

— — — — —

EXERCISE 18.3: Connect, start and run an alternator and buildup the voltage

Objectives

At the end of this exercise you shall be able to

- read and in terpret the name-platede tails of an alternator
- test and identify the terminals of an alternator
- connect,start,run,adjust the speed and frequency of the alternator
- adjust and settherated voltage of analternator
- determine the magneti sation character is ticofan alternator.

Requirements

Tools/Equipments

- Insulatedcuttingpliers200mm - 1 No.
- Screwdriver150mm - 1 No.
- Screwdriver100mm - 1 No.
- VoltmeterAC0to500volts - 1 No.
- AmmeterDC0to5amps - 1 No.
- Tachometer0to3000r.p.m. - 1 No.
- Singlephasefrequencymeter 250V-45to55Hz. - 1 No.

Materials

- PVCinsulatedcoppercable 2.5sqmm600Vgrade - 10m.
- Insulationtape - 30cm.
- Fusewire5A,15A - as reqd.
- T.P.I.C.switch16amps500V - 1 No.
- D.P.I.C.switch32amps250V - 2 Nos.

Procedure

Connect, start,run, adjust thespeed and frequency of an alternator

1 Read and interpret the name-platede tails inTable 1.

2 Test and identify the terminals of the alternator.

3 Test the alternator for insulation resistance between the windings,the winding and the ground,and record the values separately.

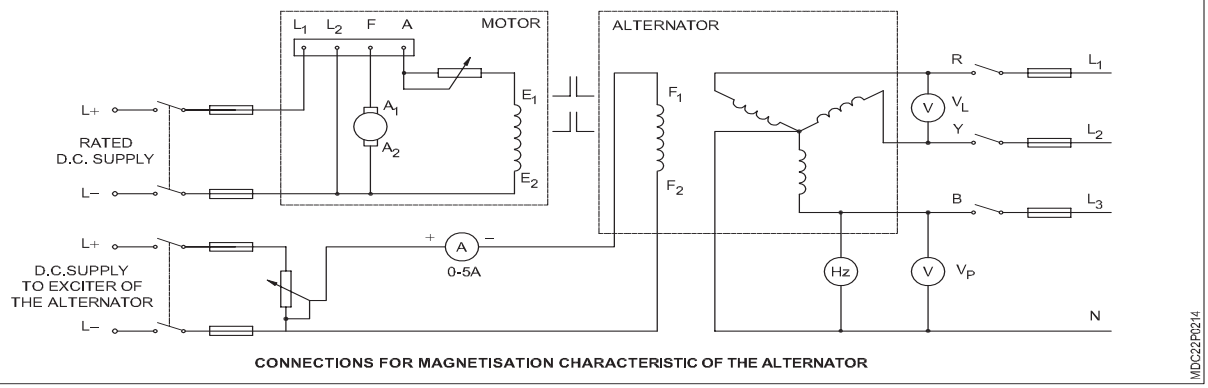
The insulation resistance value should not be less than one megaohm.

4 Select a suitable range of rheostats, ammeters, voltmeters, switches and cables according to the specification of the available alternator

You may have to change the ranges of the meters and rheostat according to the rating of the available alternator with respect to Fig 1.

5 Make the connections as per the circuit diagram. (Fig1)

Fig 1



CONNECTIONS FOR MAGNETISATION CHARACTERISTIC OF THE ALTERNATOR

6 Adjust the field rheostat of the prime mover to cut out position, and the field rheostat of the exciter in the minimum voltage position

7 Check the couplings

Table1

Name plate details

Manufacturer,TradeMark:.....

Type,modelorlistnumber:.....

TypeofCurrent	:.....	Fabricationorserialnumber	:.....
Function	:.....	Alternator	:.....
Typeofconnection	:.....	P.F.	:.....
Ratedvoltage	:.....Volts	Ratedcurrent	: amps
Frequency	:.....Hz	Ratedspeed	: r.p.m.
Ratedpower	:.....kVA	Ratedexc.current	: amps
Ratedexc.voltage	:.....Volts	Directionofrotation	:.....
Ratingclass	:.....	Protectionclass	:.....
Insulationclass	:.....		

8 Switch `ON' the prime mover and start the prime mover through the starter switch.

9 Adjust the speed of the prime mover throug hits field rheostat to the rated speed of the alternator.

10 Switch`on'the DC supply to the exciting winding of the alternator. Note down the field current, line voltage and phase voltage of the alternator in Table 2.

11 Note down the frequency (ifpossible,forthe frequency meter may not read at a low voltage) in Table 2.

12 Increase the field current in10to12equals teps.For each step measure the phase voltage, line voltage frequency and field current and enter the values in Table 2.

S.No.	Fieldcurrent I_F	Linevoltage V_L	Phasevoltage V_P	Frequency V_F	Remarks

13 Until the alternator output voltage reaches its rated value.

The field current should be varied gradually in equal steps in the ascending order. Otherwise it will disturb the shape of the plotted curve.

14 Increase the excitation current such that the alternator line voltage is about 10% above the rated value.

15 Draw the curve IF versus VP taking IF on the `X' axis and VPonthe `Y'axis.The curve shows the O.C.C. or the magnetization on characteristic of the alternator.

16 Write your conclusion regarding the relation between the field current and phase voltage as well as the line voltage and phase voltage.

EXERCISE 18.4: Determine the load performance and voltage regulation of a 3-phase alternator

Objectives

At the end of this exercise you shall be able to

- connect, start, run, and build up the voltage of an alternator
- connect the resistive, inductive load to the 3 phase alternator
- determine the voltage regulation of an alternator.

Requirements

Tools/Equipments

- Combinationpliers200mm - 1 No.
- Roundnosepliers150mm - 1 No.
- Electrician'sknife - 1 No.
- M.I.ammeter0to20 amps - 3 Nos.
- M.I.voltmeter0to500volts - 1 No.
- M.C.voltmeter0-300V - 1 No.
- M.C.ammeter0-5A
- Frequency meter 500V,45 to 50Hz - 1 No.
- Power-factormeter 500V, +0.5to -0.5 P.F. - 1 No.
- Tachometer300to3000r.p.m. - 1 No.

Equipment/Machines

- 3-phase alternator100 KVA coupled with Diesel genset engine having facilityforspeedcontrol - 1Set
- 3-phase lamp load 415/400V5KW - 1 No.

Materials

- P.V.C.insulated stranded aluminium cable - 10 m
- T.P.I.C.switch32amps 500v - 2 Nos.

Procedure

TASK 1: **Connect,start,run,and build up the voltage of an alternator**

1 Note down the name-platede tails of the given alternator in Table 1.

Table1

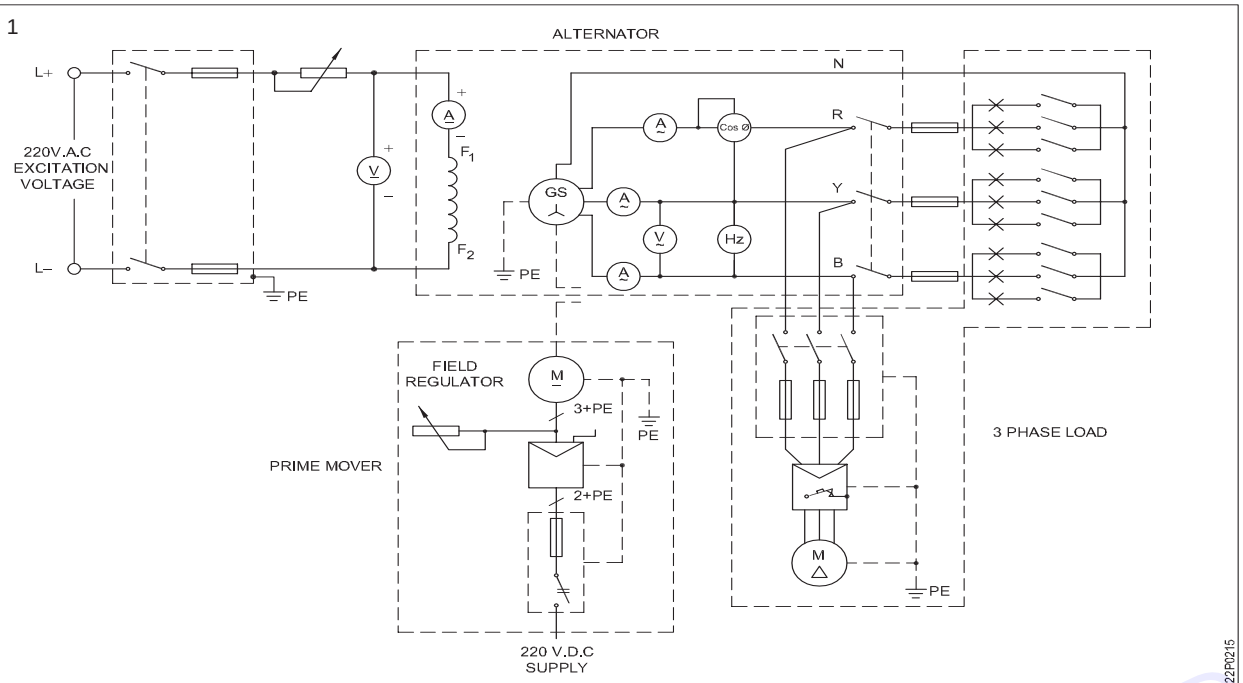
Name plate details

Manufacturer,Trade Mark: .....

Type,model or list number: .....

Type of Current	:	Fabrication or serial number	:.....
Function	:	Alternator	:.....
Type of connection	:	P.F.	:.....
Rated voltage	: .....Volts	Rated current	:.....amps
Frequency	: .....Hz	Ratedspeed	:.....r.p.m.
Ratedpower	: .....kVA	Ratedexc.current	:.....amps
Ratedexc.voltage	: .....Volts	Directionofrotation	:.....
Rating class	:	Protectionclass	:.....
Insulation class	:		

Fig 1



CONNECTIONS OF 3 - PHASE ALTERNATOR WITH LOAD

2 Select proper sizes of cables, fuse wires, switches etc., asper the name - plate ratings (rated capacity)of the given 3-phase alternator

3 Connect the exciter output terminals to the field of the alternator with the rheostat, ammeter and voltmeter. (Fig 1)

The exciter output voltage is shownin Fig1as 220V DC. Different manufacturers choose different exciter voltages suitable for their alternators. You may have to select the voltmeter and ammeter ratings according to the voltage rating of the field of the available alternator.

4 Connect the alternator terminals RYB and N to the load as per the circuit diagram (Fig 1). Keep the load switches and also all the lamp switches of the lamp load in the `off' position.

Check the voltage rating of the power factor and frequency meters whether they are for phase voltage or line voltage. Connect accordingly. Don ot forget to connect the star point of the lamp load to the neutral point of the alternator.The bulb watta gerating should be equal in all lamps.

5 Show the connection to your instructor and obtain his permission to start the prime mover.

6 Run the alternator at its rated speed. Measure and record the speed. Speed. r.p.m.

7 Build up its voltage by adjusting the field rheostat to the rated voltage of the alternator. Read and record it. Voltage.....volts.

TASK 2: **Loada 3-phase alternator with are sistive load**

1 Close the T.P.I.C.switch of the lamp load and note down the values of the load current, (which will be zero), the terminal voltage, P.F. and frequency in Table 2

S. No.	Loadcurrent equal in all the threephases I_L	Terminal Voltage V_L	Frequency kept constant	Power Factor cos Ø	Power = $\sqrt{3}E_L I_L \cos\phi$	Remarks

The frequency should be kept constant by adjusting the prime mover speed whenever necessary.

2 Slowly increase the load current to1ampbys witching`ON' the lamp sone by one.Record all the readings in Table2.

Switch on the lamps equally in all the three phases so that the load is balanced.

3 Increase the load current equally on all the three phases of the alternator to it srated value by switching on the lamps in steps of 1amp.Foreachstep,note down the current,voltage and the P.F.frequency and tabulate the readings in Table 2.

4 Reduce the load gradually to zero.Open the lamp load by switching off the T.P.I.C. switch.

— — — — —

TASK 3: **Loada 3-phase alternator by a3-phase motor (inductive) load**

1 Close the T.P.I.C. of the motor load and start the motor by the D.O.Lstarter.Read and record I_L,V_L,P.Fand frequency inTable 3. Switch `OFF' the T.P.I.C. switch of the motor load.

S. No.	Loadcurrent equal in all the three phases I_L	Terminal Voltage V_L	Frequency kept constant	Power Factor cos Ø	Power= $\sqrt{3}E_L I_L \cos Ø$	Remarks

— — — — —

TASK 4: **Determine the voltage regulation of an alternator**

1 Close the T.P.I.C. switch of the motor load and start the motor by the D.O.L starter.

2 Close also the T.P.I.C. switch of the lamp load and increase I_L upto the alternator'srated value in steps of one ampere. Read and record the values of I_L, VL&P.F. frequency in Table4.

3 Reduce the load and switch off the alternator.

4 Draw the three curves for the 3 sets of reading as recorded in Tables 2, 3 and 4 in the same graph showing the terminal voltage versus load current. Keep the terminal voltage in theYax is and load current in the X-axis.

5 Compare the power delivered to the

- resistive
- inductive (partially resistive)
- resistive/inductive loads
- With the corresponding line current and line voltage, and P.F.- at least three different line current values

6 Calculate the voltage regulation for the above different loads at 5 and 10 amperes by using the formula:

Percentage voltage regulation ($\%V_R$)

$$\%V_R = \frac{\text{No.load voltage} - \text{Full load voltage}}{\text{Fully load voltage}} \times 100$$

Conclusion 1

Conclusion 2

EXERCISE 18.5: Overhauling of Reciprocating Pump

Objectives

At the end of this exercise you shall be able to

- Service a reciprocating pump.

Requirements

Tools/Equipments

- Trainees tool kit
- Torque wrench
- Mallet
- Feeler gauge
- Puller

Equipments/Machinery

- Gear box coupled reciprocating pump

Materials

• Kerosene	- as reqd.
• beal	- as reqd.
• Grease	- as reqd.
• Oil	- as reqd.
• Cloth waste	- as reqd.
• Gasket material	- as reqd.

Procedure

Service a reciprocating pump

A Fluid end service

Fluid end removal

1 Disconnect suction and discharge lines, plunger oiler lines, and also any accessories such as stoke counters, pressure gauges, etc. from the fluid end.

2 Open the hinged cradle cover on the top of the crosshead housing, if equipped and disconnect the plungers from the extension rods by removing the extension rod clamps.

3 Slide the plungers into the fluid end as far as possible

4 Connect a hoist to the fluid end and tighten the lines they are snug only.

Make sure that hoisting slings are not too tight, because that may cause a strain on the fluid end and cause injury or damage when removing from the pump frame

5 Remove the head capscrews from the fluid end using a hydraulic torque wrench with a point socket or a hand tool combination of a torque multiplier, a drive torque wrench, a drive extension, and point socket.

6 Pull the fluid end assembly horizontally forward, straight away from the power end until it is completely clear of the dowel pins.

7 Move the fluid end to the service area for changing valves or other service.

Fluid End Installation

1 Clean the surfaces between the mating faces of the power end counter bores, stuffing boxes, and fluid end, removing any debris or surface imperfections such as corrosion or raised metal. Make sure the o-rings and gaskets are in place.

2 Orient the stuffing boxes so that the dowel pin holes are on top

3 Lift the fluid end until the dowel pins match the dowel pin holes in the stuffing boxes and push the fluid end toward the stuffing boxes.

4 As per fig 1, label the top row of bolt holes on the frame starting from the left corner to the right corner.

5 As seen in Fig 1 label the bottom row of bolts holes on the frame starting from the left corner to the right corner.

6 Install the bolts hand tight.

7 Check the clearance between the face of the fluid end and power frame. The clearance range is between 0.003” and 0.030”

This clearance should be approximately the same at all four corners before proceeding

If the clearance is not the same at all the four corners, remove the fluid end and clean the surfaces between the mating faces of the power end counter bores, stuffing boxes, and fluid end, removing any debris or surface imperfections such as corrosion or raised metal. Reassemble the unit and recheck the clearance.

8 Tighten the fasteners to required torque using a hydraulic torque wrench with a point socket or a hand tool combination multiplier drive torque wrench, a drive extension, point socket. Use the same tightening.

9 Check the clearance between the face of fluid end and power frame . The clearance of 0.003” - 0.030” should be approximately the same at each of the four corners.

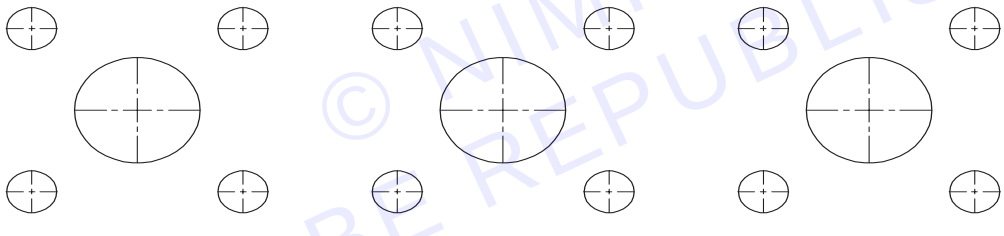
10 Tighten the fasteners to required torque.

11 Recheck the clearance between the face of fluid end and power frame. The clearance of 0.003” - 0.030” should be approximately the same at each of the four corners.

12 Verifying that each fastener is properly torqued as per manufactures instruction

13 Conduct a final check of the clearance between the face of the fluid end and power frame. The clearance of 0.003” - 0.030” should be approximately the same at each of the four corners.

Fig 1



FLUID END TIGHTENING SEQUENCE

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B Plunger and packing Replacement

This service procedure can be performed with this fluid end in place on the pump, and consists of the following steps:

1 Remove the suction cover retainer nut with the appropriate male hex wrench.

2 Remove the suction cover with a threaded “slide hammer type” puller.

3 If equipped, open the hinged cover on the top of the cross head housing to get access to the plunger/extension rod area.

4 Remove both cap screws holding the plunger clamp, then remove the clamp.

5 Loosen the packing nut to free the plunger from packing pressure.

6 Remove the plunger through the suction cover opening.

7 Remove the packing nut, packing , and spacers.

8 Inspect the plunger, the packing, the rod wiper, the stuffing box bore, and the packing nut for excessive wear, nicks burrs, or any other defects. Replace expendable parts as necessary.

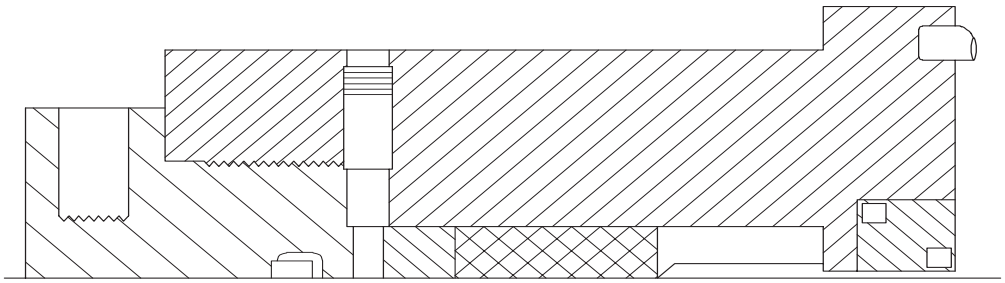
9 Coat packing and stuffing box bore with a light grease or oil.

10 Install the packing in the packing bore with the packing lips towards the front of the fluid end (Fig 2)

11 Install and hand tighten the packing nut to align the packing in the bore.

12 loosen the packing nut to allow for installation of the plunger.

Fig 2



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13 Apply a light coat of grease or oil to the clamp end of the plunger. Insert the plunger through the suction cover hole into the packing . It may be necessary to bump the plunger through the packing with a slide hammer. Be sure to keep the plunger level through installation

14 Tighten the packing unit.

15 Inspect the clamp surfaces of the plunger, and the extension rod for cleanliness

16 Install the plunger clamp and tighten the clamp screws to the specified torque

17 Tighten the packing nut again

18 Replace the o-ring and back-up rings on the suction cover and apply grease or o-ring lube.

19 Install the suction cover and tighten the suction cover retainer nut.

20 Make sure that the plunger lube line is in place before restating in the pump.

Never use damaged 'O' ring, gasket and packing material.

C Valve and Seat Replacement

This procedure can be performed with the fluid end on the pump.

Never try to remove or cut a valve seat with a torch. Serve damage to the fluid end may occur.

1 Remove the discharge cover retainer nut with the proper hex wrench.

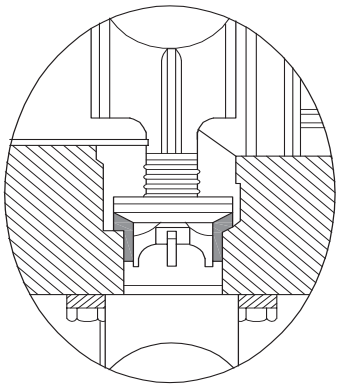
2 Remove the discharge cover with a "slide hammer type" puller.

3 Remove the suction cover retainer nut with the proper hex wrench.

4 Remove the suction cover with a "slide hammer type" puller

5 Remove the suction valve spring retainer. The suction valve spring and valve can now be removed by hand. (Fig 3)

Fig 3



VALVE CAGE SPRING RETAINER

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6 Remove the suction valve seat or discharge valve seat with a seat puller and a seat puller jack.

7 Clean the valve seat deck thoroughly using a non-petroleum based cleaner.

8 Clean the replacement valve seat using a non-petroleum based cleaner. Do not apply any type of lubricant to the seat or o-ring on the seat prior to installation.

9 Snap the replacement valve seat into the taper by hand to fit tightly

10 Place the winged valve on the top of the valve seat.

11 Bump the seat into the taper 2-3 times with a heavy bar to make the fit tight

12 Reinstall the valve spring and suction valve spring retainer cage.

13 Reinstall the suction valve cover and retainer nut.

14 Reinstall the discharge valve, spring, cover and retainer nut

15 Run the pump at 80% to 100% of the maximum discharge pressure until the seats “pop” into the fluid end tappered holes (Listen for 6 distinct loud “pops”)

D Power end service

Before attempting to service the power end of the pump, the following safety precautions

1 Shift the pump transmission in to the neutral gear

2 Shut off the pump engine and remove the key from the ignition to prevent starting the engine inadvertently.

i Extension Rod

1 Remove plunger guards.

2 Remove the plunger and push it into the fluid end.

3 Unscrew the extension rod with a pipe wrench on the knurled portion of the rod (be careful not to damage the seal surface). Remove the extension rod through the top of the cradle section.

4 Check the extension rod seal for wear. Replace if necessary.

5 Before replacing the extension rod, inspect the threads in the cross head and check for cracks on the extension rod. Apply a light coat of anti-seize to the extension rod threads.

6 Install extension rod in cross head.

7 Check to see that mating faces of extension rod and plunger are free of nicks or burrs. Any raised metal could cause misalignment, resulting in poor packing life.

8 Replace the plunger as detailed in the previous section.

ii Connecting Rod Bearing

1 Remove the rear cover from the power end.

2 Remove the locknuts from each rod cap to be removed

3 Remove the rod cap, labelling each for correct re-assembly.

4 Using a rubber hammer or wooden hammer handle, tap on one edge of the bearing from the crank journal.

5 Check the crankshaft journal surface for wear or damage. Polish if necessary.

6 Clean the new bearings and connecting rod thoroughly before replacing bearings. The grooved bearing half goes in the cap and the non-grooved half goes in the connecting rod.

7 Install the rod caps, making certain the correct cap is assembled with the correct rod.

8 Tighten the locknuts on the rod caps to apply correct torque.

Before the operating the pump, move the connecting rod from side to side with a large screwdriver to make sure the rod is free on the crankshaft. If new bearings are installed, perform the Run-in” procedure prior to field operation.

iii Connecting Rod and Cross head

1 Remove the side and rear covers from the power end.

2 Remove the plunger clamps and push the plungers into the fluid end

3 Remove the extension rods.

4 Using strong internal snap ring pliers, remove the snap rings from the from the cross head pin.

5 Using a slide hammer or partially threaded rod, remove the pin from the cross head.

6 Remove one cross head and connecting rod at a time. The middle crosshead pin can not be removed until the outer crosshead is removed.

7 Remove the two locknuts from each rod cap of the rod to be removed.

8 Remove the rod cap, labelling each for correct re-assembly.

9 Remove the studs in the connecting rod by the locking two nuts onto the stud. Remove the stud by loosening the inner nut against the outer nut.

10 Remove the main bearing retainers (bolt, nut and washers) opposite the crank throw.

11 Rotate the crankshaft to the back stroke of the rod to be removed and push the rod forward till it clears the throw and lower it to the bottom of the power end.

12 Rotate the crankshaft till the throw is on top (90 degrees from the back position) and remove the connecting rod out the back of the power end, being careful not to damage the crank throw

13 Clean and inspect all bearings and bearing surfaces. Replace any defective or worn parts.

14 Clean the oil port in the centre of the connecting rod

15 When replacing the wrist pin bushing in a connecting rod, make sure the oil grooves are placed toward the rear (crank end of the rod)

Use a hydraulic press to replace the wrist pin bushing, as hammering will destroy the bushing

If a hydraulic press is not available, place the bushing in a freezer overnight to allow the bushing to slip easily into the connecting rod

16 When re-installing the crossheads and connecting rods, start with the centre assembly.

17 Install the non-grooved rod bearing into the connecting rod.

18 With the crank throw at the top position, feed the connecting rod into the power end and place as far forward as possible.

19 Rotate the crank throw to the back stroke position, Lift and pull the connecting rod back until it is in place on the crank throw

20 Hand tighten the two studs into the connecting rod. Apply thread seal to the stud threads engaged in the rod. Make sure the studs are fully seated in the connecting rod.

21 Install the grooved rod bearing into the cap.

22 Install the rod cap with bearing onto the connecting rod

23 Install and torque the rod cap locknuts by applying correct torque as per manufacturers recommendation.

24 Lift the front of the connecting rod and slide the crosshead back until the wrist pin bores align

25 Install the wrist pin.

26 Install the snap ring into the groove in the crosshead.

27 Re-install the main bearing retainers.

28 Check the crosshead guide clearances prior to operation

iv Crosshead Guides

1 Remove the connecting rod and crosshead of the guides to be serviced.

2 Remove the lube system connections to the crosshead guides.

3 Remove the capscrews from each crosshead guide. Keep track of the crosshead guide shim packs if the same guide and crosshead is to be resused.

4 Thoroughly clean and inspect guide for pits, cracks, scoring. Replace if necessary.

5 If replacing a crosshead or crosshead guide(s) due to damage, both the upper and lower crosshead guides must be re-shimmed.

6 Place the new guides in the power frame, firmly seating the guides in the frame before bolting.

7 Install the crossheaad guide bolts. Do not use the rubber lined washers until the shimming is complete. Do not allow the bolt to pass above the guide thread.

8 Install the crosshead through the side inspection window. Rotate the crosshead about the center axis (roll upward and push down).

9 Install the extension rod

10 With the exension rod seals out of the seal bore in the frame, use an inside micrometer to measure the distance from the extension rod to the extension rod seal bore at the top and bottom

11 Subtract the bottom dimension from the top dimension and divide by two to obtain the shim pack required for the lower guide (TOP-BOTTOM) / 2. for example, if the distance from extension rod to the extension rod seal bore is 0.895 inches on top and 0.855 inches on bottom, the shim pack is calculated as follows: 0.895-0.855 = 0.040, 0.040/2 = 0.020. The lower guide shim pack would equal 0.020 inches to centre the extension rod in the seal bore.

12 Remove the extension rod and crosshead.

13 Remove the lower crosshead guide.

14 Install the calculated shim pack. Shim packs are placed between crosshead guide and each of the two frame supports.

15 Install the lower crosshead guide.

16 Install the cap-screws into the lower guide.

Do not allow guide bolt to pass above thread.

17 Install the crosshead with both guides in place (lower guide has been shimmed, upper guide has no shims yet).

18 To shim the upper guide, measure the clearance between the top of the crosshead and upper guide. For best results, use long feeler gauges and average the clearance along the width of the crosshead.

19 To obtain the upper guide shim pack, subtract the average opening clearance (0.012 inches) from the measured feeler gauge clearance. For example, if the measured feeler gauge clearance between the crosshead and upper guide was 0.032 inches the shim pack would be calculated as follows: 0.032 - 0.012 = 0.020 inches shim pack

20 Remove the crosshead.

21 Remove the upper crosshead guide.

22 Install the calculated shim pack. Shim packs are placed between crosshead guide and each of the two frame supports.

23 Install the upper crosshead guide

24 Install the cap-screws into the upper guide. Do not allow guide bolt to pass above thread.

25 Install the crosshead.

26 Slide crosshead form front to back, checking for clearance of 0.009 inches to 0.015 inches.

27 Shims make require minor adjustments if areas of tight clearance occur.

28 Once proper clearance is measured, remove guide bolts and re-install with ring of silicone and rubber washers under the bolt heads with proper torque.

29 Re-assemble crossheads and connecting rods.

v Gearbox

1 Remove the companion flange from the pinion shaft by removing the cap-screw holding the pinion shaft retainer to the end of the pinion. Pull the companion the flange off the pinion.

2 Remove the outer hearing and seal retainers, and pinion shims.

3 Remove housing cover (hold the pinion shaft in the place while the cover is removed).

4 Remove the pinion shaft bearings and the pinion shft. Replace bearings or pinion shaft if severely pitted, scored, or worn (apply low heat to the inner race to remove from the shaft).

5 Remove the crankshaft bearing snap ring and bearing.

6 Remove the gear snap ring.

7 Remove the gear with the puller holes provided. Inspect thegear for pitting, cracks and scoring and replace if necessary.

8 If case is being repositioned, hammer out the freeze plugs.

9 Remove the socket head cap-screws that retain the gearbox housing to the pump frame.

10 Remove the gearbox from the power frame.

11 Throughly clean and inspect all parts prior to re-assembly.

12 Using a silicone seal, form a gasket around the outside of the sperical bearing adapter on the power end.

13 Install the gearbox housing onto the power frame in the correct orientation of socket head cap-screws.

14 If previously removed hammer in the freeze plugs with silicone sealer.

15 If new bull gear is being installed fit key to shaft and gear. Key must fit with 0.000 to 0.001 inches clearance (slip fit). Do not drive key in with excessive force.

16 Coat the crankshaft extension with some light oil and install the gear with the long hub side inward.

17 Install the gear snap ring with snap ring pliers. Be sure snap ring is seated in groove.

18 Install the crankshaft bearing and snap ring. be sure snap ring is seated in groove.

19 Install the pinion bearings onto the pinion shaft. Heat the bearings to 250 degrees F in an oven or oil bath to install on the pinion shaft.

20 Install the pinion shaft into the pinion bore of the gearbox housing

21 While holding the pinion shaft in place, install the gearbox housing cover. Use silicone seal as gasket material.

22 Install the pinion bearing races into the gearbox housing.

23 Install the pinion bearing retainer (off drive) and pinion bearing seal retainer (drive) without shims. Tighten the retainers while moving the pinion back and forth. When the pinion begins to tighten and move with resistance, stop tightening the retainers. Use the shims in the shim pack to measure the clearance between the housing and retainer. Remove the retainers, add the measured shim pack between the retainer and the housing and re-install the retainers. Recheck the movement in the pinion. If the pinion does not move, continue adding shims until the pinion moves back and forth without resistance. The bull gear bearing retainer needs no shims but needs silicone seal as a gasket.

24 Install the companion flange.

25 Install the pinion shaft end retainer using the cap screw to hold the companion flange in place.

vi Crankshaft

1 Remove the pump from the trailer and move it to a service area with an overhead lift, where the frame can eventually be turned on its die.

2 Remove the gearbox, connecting rods, and cross heads.

3 Remove the rotary lube union.

4 Remove the crankshaft cover bolts from the off drive side.

5 Remove the four bolts from inside the frame, threaded into the crankshaft cover.

6 Remove the crankshaft cover.

7 Place the power end on its side with the crankshaft extension pointing upwards. Lift the crankshaft upwards using a lifting eye adapted to 4"-8 threads in the end of the cranks haft extension. It may necessary to heat the power end around the spherical bearing retainer (less than 250 degrees F oven or oil bath) to break the bearing retainer away from the frame. Be careful when pulling the crankshaft roller bearings through the outer races, as not to cratch the inner surfaces of the races. Rotating the crankshaft while pulling up aids removal.

8 Remove the bearing retainer, adapter, and spherical bearing from the crankshaft. It may be necessary to heat the adapter and bearing to remove.

9 Remove all the roller bearing retainers (cap screws, nuts and washers) from the crankshaft.

10 Remove the bearings from the crankshaft. It may be necessary to apply low heat to remove the bearings from the crankshaft.

11 Remove all the roller bearing retainers in the power end.

12 Remove the outer races of the bearings in the frame by tapping them out with a soft metal (brass) bar.

13 Thoroughly clean and inspect all parts for cracks, pits, or scoring and replace if necessary prior to re-assembly. Frame bores should be clean and smooth, free of nicks and raised metal.

14 Label the three straight roller bearings and outer races as match sets for proper re-assembly.

15 For easiest assembly, place the outer bearing races in the freezer for at least 8 hours to allow the bearing races to shrink.

16 On the inner side of the two inner main bearing rings of the frame (closest to the centreline), install three (3) cap screws with main bearing retainer washers between the frame and bolt head. On the opposite side of the frame, install a nut on the capscrew. The washers will act as stop for the outer bearing races during re-assembly and center the outer bearing race in the bore of the frame.

17 One at a time, remove the outer bearing races from the freezer and install in the two inner bearing bores of the frame by passing the race through the outer frame bores. The outer bearing races should shoulder against the installed washer. Keep the races as level as possible during the assembly process.

18 On the inner side of the off drive outside main bearing ring of the frame, install three (3) cap screws with main bearing retainer washers between the frame and bolt head. On the opposite side of the frame, install a nut on the cap screw. The washers will again act as a stop for the final main bearing outer race.

19 Remove the final outer bearing race from the freezer and install in the off drive main bearing bore of the frame. Keep the race as level as possible during the assembly process.

20 The outboard bearing bore on the input side of the frame should be left open.

21 Remove the nuts on the main bearing retainer bolts and install retainer washers and locknuts (the off drive outside main bearing retainers in the frame can not be installed until the crankshaft cover is installed)

22 On the inner side of the two inner cheeks of the crankshaft (closest to the centreline), install three capscrews with main bearing retainer washers between the crankshaft cheek and bolt head. On the opposite side of the crankshaft, install a nut on the cap screw. The washers will act as a stop for the main bearings during re-assembly and center the bearing on the crankshaft.

23 One at a time, heat the straight roller bearings (less than 250 degrees F oven or oil bath) and install on the two inner cheeks of the crankshaft by passing the bearing over the outer crankshaft cheeks. The roller bearings should shoulder against the installed washer. Keep the bearings as level as possible during the assembly process.

24 On the inner side of the off drive outside crankshaft cheek, install three cap screws with main bearing retainer washers between the crankshaft and bolt head. On the opposite side of the crankshaft cheek, install a nut on the cap screw. The washers will again act as a stop for the final main roller bearing.

25 Heat the final main roller bearing and install on the off drive main bearing check of the crankshaft. Keep the race as level as possible during the assembly process.

26 The outboard bearing cheek on the input side of the crankshaft should be left open.

27 Heat and install the spherical bearing onto the drive side crankshaft cheek.

28 Install the spherical bearing retainer onto the crankshaft.

29 Heat and install spherical bearing adapter onto the spherical bearing.

30 Lift the crankshaft with a lifting eye screwed into the end of the crankshaft and lower into the power frame (the power frame should still be on its side with the input end up). Rotating the crankshaft while lowering will aid the installation. Tap the spherical bearing adapter to complete the installation.

31 Re-install the crankshaft cover using silicone seal as a gasket.

32 Install the eight in, socket head cap screws holding the crankshaft cover to the outside of the frame.

33 Install the four caps crews and main bearing retainer washers on the inside of the frame through to the crankshaft cover.

34 Re-install the rotary union, crossheads, connecting rods, and gearbox.

35 Remount pump on skid or trailer.

36 If new bearings were installed, repeat the new pump run-in procedure.

Do not drive against rollers or bearing cage. Drive only against the bearing race, as severe damage to the bearings could occur.

When reassembling the crankshaft assembly, make sure to follow these steps:

1 Freeze the outer bearing races or pack in dry ice before assembling in the frame.

2 Heat the roller bearings (straight and spherical) before installing on crankshaft. (250 F max. oven or oil bath)

Failure to follow these direction may result in serious damage to the pump.

EXERCISE 18.6: Servicing of Rotary Pump

Objectives

At the end of this exercise you shall be able to

- dismantle the rotary pump
- assembling the rotor pump.

Requirements

Tools/Equipments

- Trainees Tool kit - 1 No.
- Rotory pump - 1 No.

Materials

- Gasket
- Cotton waste
- Kerosene
- Grease

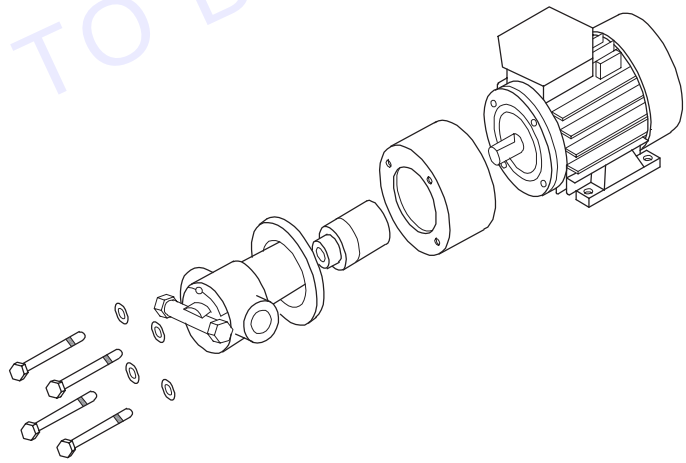
Procedure

TASK 1: **Dismantle a rotary pump**

- Rotor pump dismantling (Fig 1).
- Unscrew the 4 screws H M8 and washer M8.
- Remove the pump
- Remove the trundle
- Dismantle the coupling on the pump side : 2 screws M5 x 6.

It is useless to dismantle the coupling on the engine side. Motor pump reassembling should be carried out the opposite way.

Fig 1



Mechanical seal dismantle

1 At first realize the Motor pump dismantling operation (see above).

2 Remove the wedge.

3 Remove the circlip for bores.

4 Remove the circlip for shafts.

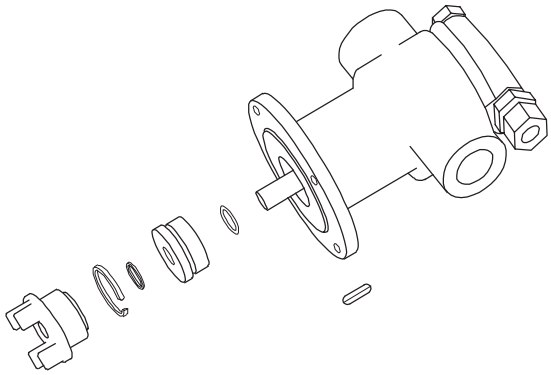
5 Remove the mechanical seal and replace it when reassembling.

6 Remove the support washer

7 Mechanical seal reassembling should be made in the opposite order.

Pump dismantlingin (Fig 2)

Fig 2



1 At first realize the Mechanical seal dismantling operating (see above)

2 Unscrew the 4 screws M6 and the 2 screws.

3 Remove the cap.

While dismantling the cap, make sure you have recovered the indx hand which assures the stator positioning with the cap.

1 Remove the O-ring seal.

2 Remove the 2 blades and replace it when reassembling.

3 Remove the circlip for shafts.

4 Remove the rotor and replace it.

5 Remove the stator and replace it too.

6 Pump reassembling should be made in the opposite order.

By-pass dismantling and control

By-pass calibration has already been done. While dismantling it, is important to memorize the number o funscrew rotation in order to reassemble it correctly. (Fig 3, 4)

1 Unscrew the cap nut.

2 Remove its copper joint

3 Unscrew the counter nut.

4 Remove its copper joint.

5 Unscrew the regulating screw and memorize the number of unscrew rotation.

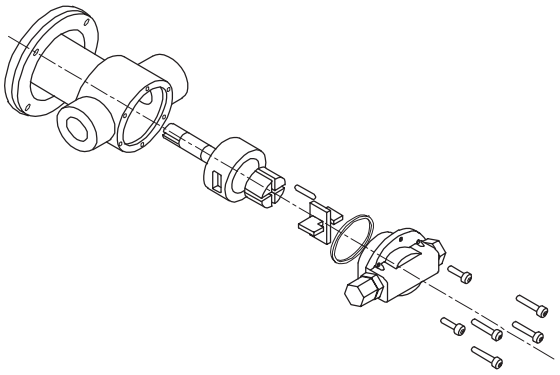
6 Remove the spring.

7 Unscrew the plug.

8 Remove the copper joint

9 Remove the slide valve.

Fig 3



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By-pass assembling

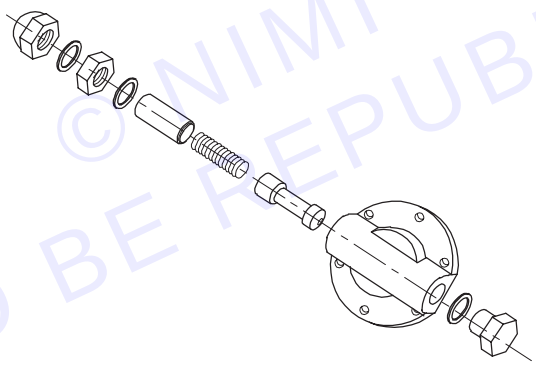
It should be done in the opposite order:

1 Check the good flap state and its seat. Screw the screw with the same number of rotation as during the dismantling.

2 This is by-pass designed as safety equipment it has to be used only in case of incident or cold start but it must not be used as a discharge regulator.

3 If you notice any flap or seat deterioration one must control the instant pressure.

Fig 4



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TASK 2: **Assembling of rotor pump**

Assembling should be done in the opposite way of dismantling.

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EXERCISE 18.7: Service of Centrifugal Pump

Objectives

At the end of this exercise you shall be able to

- dismantle a centrifugal pump
- clean a centrifugal pump
- assemble a centrifugal pump
- starting a centrifugal pump.

Requirements

Tools/Equipments

- Trainees Tool kit
- 10” - 36” pipe wrenches
- 75 mm - 250 mm chain wrenches

Materials

- Gate valve
- Globe valve
- Check valve
- Packing material

Procedure

TASK 1: **Dismantling of a centrifugal pump**

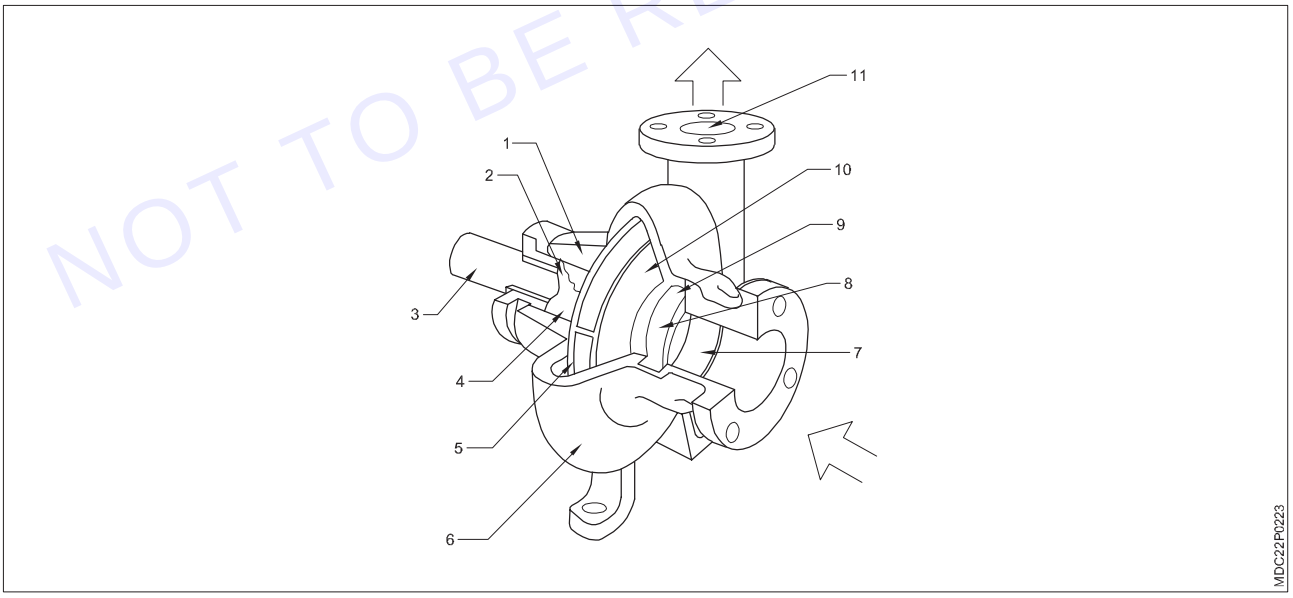
1 Before dismantling drain the Bearing Bracket of oil.

2 Unscrew filling and drain plug.

3 Drain the oil into bucket.

4 Remove the nuts which hold the bearing bracket to pump casing.

5 Pull the bearing bracket to remove the complete bearing bracket with rotor, impeller, bearings and shaft.



6 Remove the O Ring.

7 Remove the Impeller nut, washer and lock washer.

8 Pull the impeller off the rotor.

9 Pull the rotor off the shaft.

10 Pull rotor housing off the recess pump casing.

11 Remove 'O' ring.

12 Unscrew Allen screws and remove the near plate from bearing bracket.

13 Remove the shaft seal key.

14 Pull the shaft seal off the shaft.

15 Pull the shaft seal seat carefully out of the recess of the rotor hub.

16 Remove key from the shaft and remove screws.

17 Pull the bearing cover with oil sealing ring off the shaft.

18 Remove the paper gasket.

19 Pull out the shaft with bearing bracket, allowing inspection of the bearing.

— — — — —

TASK 2: **Cleaning of centrifugal pump**

1 Clean all the parts by wiping with soft waste cloth.

2 Use cleaning oil to clean the parts.

3 Clean the recess in the rotor.

4 When fitting the seat remove the pretective coating if any without scratching the upper surface.

— — — — —

TASK 3: **Assembling of a Centrifugal pump**

1 Place O-ring on the collar of the rot housing and press into place in the inlet of the pump casing.

2 Fasten rear plate to the bearing bracket with allen screws.

3 Lead the shaft into the bearing bracket.

4 Mount oil sealing ring in bearing cover.

5 Place paper gasket on the bearing cover and lead cover over the shaft.

6 Fasten with Screws.

7 Mount the key in the shaft.

8 Dip the outer rubber ring of the seat into soapy water.

9 Press the seal into place with the fingers and check that all the parts are correctly embedded.

10 Lubricate the inner diameter of the slide ring rubber bellows with soapy water and push it over shaft.

11 Push the slide ring over the shaft with hand. (Note : If rubber bellows is tight, use a fitting tool and take care that the slide ring is not damaged). (If the carbon ring is not fixed, it is important to check that is fitter correctly.

12 The carbon ring can be held by a little grease.

13 Fit key for rotor is the shaft and lead the rotor over the shaft and all the way to the shoulder of the shaft.

14 Place the two guide pins is front of the rotor.

15 Place the impeller on the rotor in such a way that the two guide pins are located in the impeller looks.

16 Secure the impeller with a disc, a lock washer, and an allen screw.

17 Place the O-ring that seals between pump casing and bearing bracket on the bearing bracket where it can be held with a little silicone grease.

18 Lead the bearing bracket into place and faster with screws.

19 Mount filling and drain plug.

20 Fill the bearing bracket with oil (SAE 15W40) until half the shaft is covered.

21 When the pump has been assembled, check that the shaft rotates freely.

TASK 4: **Start up of a centrifugal pump**

1 Check that the shaft rotates freely without noise.

2 Check that the pump casing is filled with liquid.

3 Switch on the pump for a moment to check the direction of rotation.

4 If the direct is correct the pump may be started.

Do not missing any hand tools into the centrifugal pump. Do not use damaged gasket.

Pos. No	Description	Qty	Item No.
01	Allen screw M8x25	6	705254
02	Counter flange	2	190534
03	O-ring	1	710952
04	Check valve	1	190543
05	Flange gasket	2	710942
06	Pump casing	1	590790
07	Stud M10x25 A4	6	700218
08	O-ring	1	710953
09	Seat for check valve	1	590800
10	Filling and drain plug ½"	2	705020
11	Stud M10x30 A4	4	700219
12	Impeller	1	190535
13	Rotor	1	190537
14	Nut M10	8	704012
15	Shaft seal	1	710949
16	Allen screw M6x40	4	704180
17	Inspection cover	1	590810
18	Gasket for inspection cover	1	190541
19	Disc M8	1	710954
20	Allen screw M8x20 A4	1	704367
21	Rotor housing	1	190538
22	Bearing bracket	1	700982
23	Rear plate	1	702387
24	Ball bearing 6206	1	590820
24A	Ball bearing 6206 IRS	1	700835
25	Shaft	1	590830
26	Oil sealing ring	1	700835
27	Bearing cover	1	590830
28	Guide pin □4x8	2	706284
29	Key for rotor	1	700012
30	Key for shaft	1	700899
31	Filling and drain plug 3/8"	2	2037505
32	Paper gasket	1	190544
33	Stud M6x20	4	706287
34	Nut Nyloc M10	2	703135
35	Lock washer M8	1	710948