

MECHANIC DIESEL

NSQF LEVEL - 4

2nd Semester

TRADE PRACTICAL

SECTOR: Automobile



Directorate General of Training

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



**NATIONAL INSTRUCTIONAL
MEDIA INSTITUTE, CHENNAI**

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Sector : Automobile

Duration : 1 - Years

Trades : Mechanic Diesel 2nd Semester - Trade Practical - NSQF LEVEL 4

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Mechanic diesel, 2nd Semester Trade Practical NSQF Level - 4 in Automobile Sector under Semester Pattern**. The NSQF Level - 4 Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

RAJESH AGGARWAL

Director General/ Addl. Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabus under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and video clips are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032

R. P. DHINGRA
EXECUTIVE DIRECTOR

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Practical)** for the trade of **Mechanic Diesel** under the **Automobile** Sector for ITIs.

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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.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the Fourth Semester course of the Electronic Mechanic trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4

The manual is divided into Eight modules. The distribution of time for the practical in the Eight modules are given below.

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

Module 1	Diesel engine over view	50 Hrs
Module 2	Diesel engine components	175 Hrs
Module 3	Cooling & lubricating system	75 Hrs
Module 4	Intake and exhaust system	25 Hrs
Module 5	Diesel fuel system	75 Hrs
Module 6	Marine & stationary engine	25 Hrs
Module 7	Emission control system	25 Hrs
Module 8	Starting and charging	25 Hrs
Module 9	Trouble shooting	50 Hrs
	Total	<hr/> 525 Hrs <hr/>

The material is not the purpose of self learning and should be considered as supplementary to class room instruction

TRADE THEORY

The manual of trade theory consists of theoretical information for the Second Semester course of the Mechanic Diesel Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptual capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Understand basics of engine types construction, working.**
- **Dismantle & assemble of Diesel Engine from vehicle (LMV/HMV) along with other accessories (torqueing methods, handling parts.)**
- **Overhaul, service and testing Diesel Engine, its parts and check functionality.**
- **Trace, Test & Repair cooling and Lubrication System of engine (types of coolants and oils relevant to the engines).**
- **Trace & Test Intake and Exhaust system of engine. (cleaning egr valves, exhaust inlet valves, ports and manifolds)**
- **Service Diesel Fuel System and check proper functionality (calibration of mechanical and electronic pumps, checking injectors, filters)**
- **Plan & overhaul the stationary engine and Governor and check functionality.**
- **Monitor emission of vehicle and execute different operation to obtain optimum pollution as per emission norms.**
- **Carryout overhauling of Alternator and Starter Motor.**
- **Diagnose & rectify the defects in LMV/HMV to ensure functionality of vehicle**
- **Checking the condition of hoses, mounts, radiators and fans.**
- **Electronic control diagnostics of CR engines.**

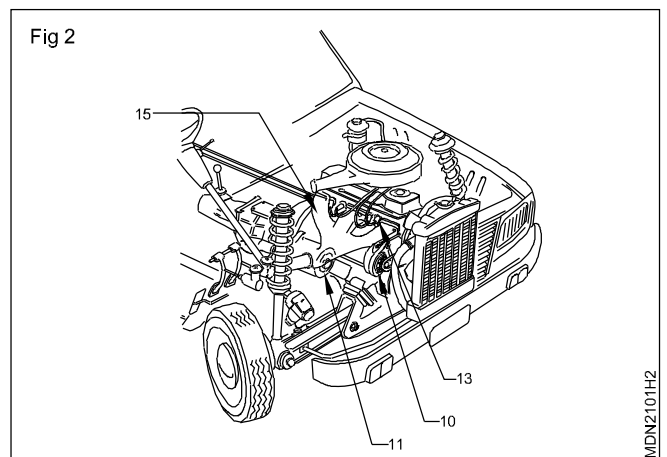
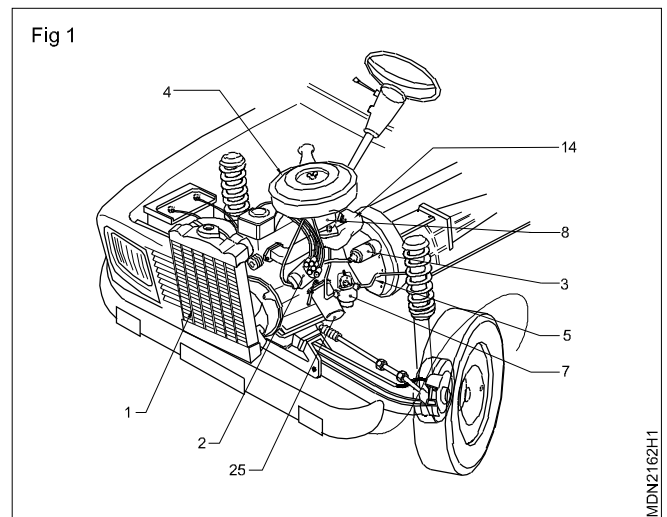
Identify the different parts of I.C Engine

Objective: At the end of this exercise you shall be able to
 • locate various components in the engine.

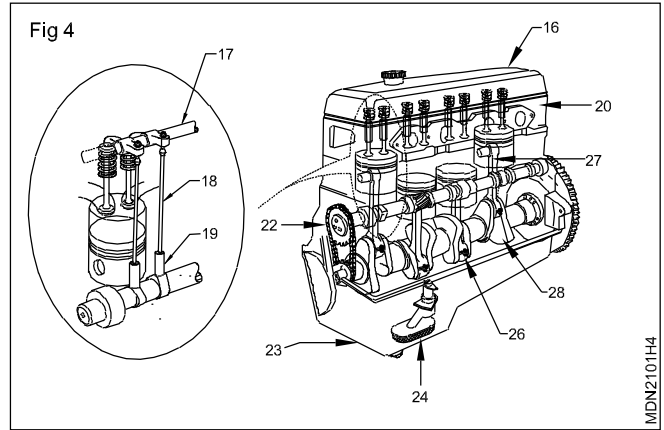
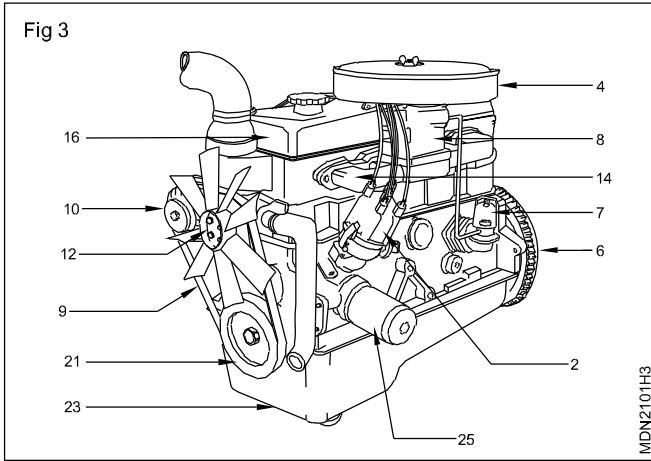
Requirements	
Tools / Instruments	
• Trainee's tool kit	- 1 No.
• Box spanner	- 1 Set.
Equipments	
• Cut sectional model of multicylinder engine	- 1 No.
Materials	
• Tray	- as reqd.
• Cotton cloth	- as reqd.
• Kerosene	- as reqd.
• Soap oil	- as reqd.

PROCEDURE

- 1 Locate the radiator (1) (Fig.1)
- 2 Locate the distributor (2) and ignition coil (3) (Fig.1)
- 3 Locate the air cleaner (4). (Fig.1)
- 4 Locate the fuel pipes (5). (Fig.1)
- 5 Locate the flywheel (6) (Fig.3)
- 6 Locate the fuel pump (7) (Fig.3)
- 7 Locate the carburettor (8) (Fig.3)
- 8 Locate the fan belt (9) (Fig.3)
- 9 Locate the dynamo (10) (Fig.2)
- 10 Locate the self-starter (11) (Fig.2)
- 11 Locate the water pump assembly (12) (Fig.3)
- 12 Locate the spark plugs (13) (Fig.2)
- 13 Locate the inlet (14) (Fig.1) and exhaust manifold (15) (Fig.2)
- 14 Locate the valve cover (16). (Fig.4)
- 15 Locate the rocker assembly (17) and the cylinder head(20) (Fig.4)
- 16 Locate the push rods (18) (Fig.4)
- 17 Locate the tappet side covers on the engine block.
- 18 Locate the tappets (19). (Fig.4)
- 19 Locate the cylinder head (20)
- 20 Locate the crank shaft pulley (21) (Fig.3)
- 21 Locate the turning cover in front of the engine.
- 22 Locate the the timing gear and chain (22) (Fig.4). Note down the timing marks).
- 23 Locate the camshaft (29). (Fig.4)
- 24 Locate the oil sump (23) (Fig.3)



- 23 Locate the oil pump (24) (Fig.4)
- 24 Locate the oil filter (25) (Fig.1)
- 25 Locate the connecting rod caps (26). (Fig. 4)
- 26 Locate the piston and connecting rod in the engine(27) (Fig.4)



Identify the different parts in a diesel engine of LMV/HMV

Objective: At the end of this exercise you shall be able to
 • identify diesel engine parts.

Requirements	
Tools / Instruments	
• Trainee's tool kit	- 1 No.
• Box Spanner set	- 1 No.
• Ring compressure, ring expander, valve lifter	- 1 No each.
Equipments	
• Multi cylinder diesel engine cut sectional model	
Materials	
• Tray	- as reqd.
• Cotton cloth	- as reqd.
• Kerosene	- as reqd.
• Soap oil	- as reqd.

PROCEDURE

- 1 Place the cut - section model diesel engine on the work bench
- 2 Trace the radiator, FIP, injector air cleaner, fuel feed pump, fuel feed, alternator, self starter, water pump, dipstick, inlet & Exhaust manifold, engine head & valve assembly, rocker arm, valve cover, piston, timing gear oil pump, fly wheel & housing, connecting rod, crankshaft and etc.
- 3 Identify the parts in the diesel engine cut-section model shown fig 1,2,3.
- 4 Write the name of the parts in the table 1.

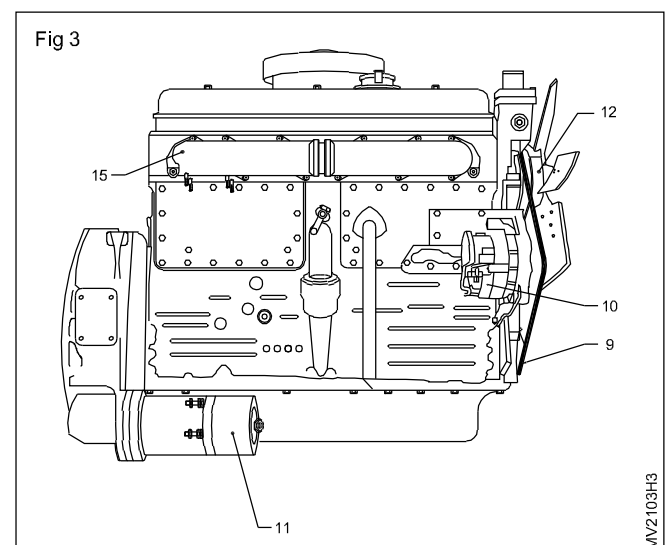
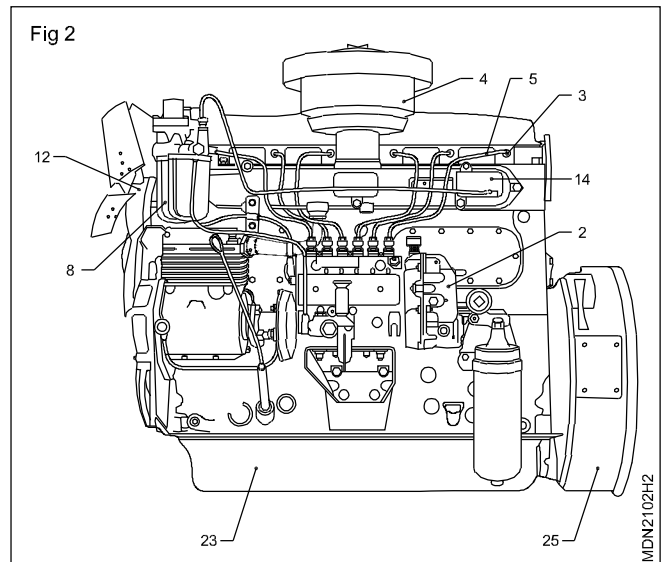
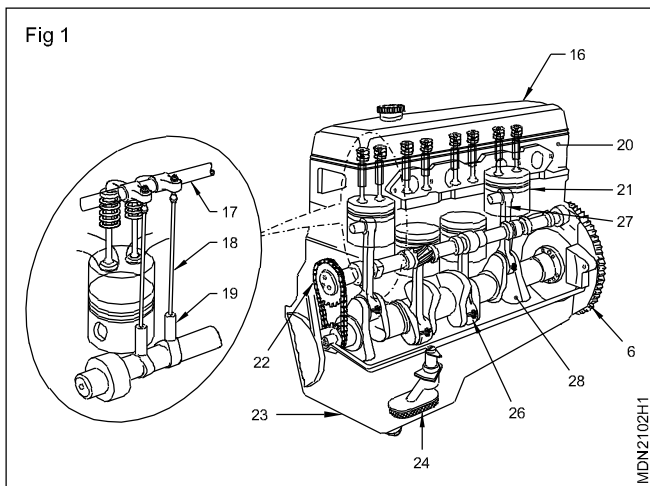


Table - 1

Sl.No.	Lable no	N ame of the parts
1	17	
2	18	
3	19	
4	22	
5	18	
6	20	
7	22	
8	27	
9	6	
10	28	
11	24	
12	26	
13	23	
14	11	
15	12	
16	15	
17	10	
18	9	
19	12	
20	8	
21	23	
22	25	
23	2	
24	14	
25	3	
26	5	
27	4	

Starting and stopping of diesel engine

Objective: 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**
- **stop the engine.**

Requirements			
Tools / Instruments		Materials	
• Trainee's tool kit	-	1 No.	• Tray
• Lead acid battery 12V with cables	-	1 No.	• Cotton cloth
Equipments		• Kerosene	- as reqd.
• Multicylinder four stroke diesel engine	-	1 No.	• Diesel
• Running condition of diesel LMV vehicle	-	1 No.	• Soap oil
			• Engine oil
			• Coolant

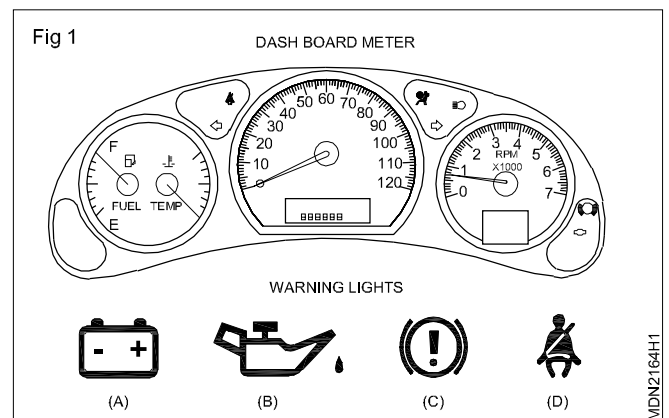
PROCEDURE

TASK 1: Prepare the engine for starting

- 1 Check the water level in the radiator and top-up if needed.
- 2 Check the engine oil level and top-up if needed.
- 3 Check the electrolyte in the battery and top up with distilled water.
- 4 Insert the key in the main switch and turn the key to the 'ON' position.

Note down the warning lights in dashboard.

- a Battery lights glows in red (i.e. battery discharging) (Fig 1A)
- b Engine oil light glows in red (i.e. oil is low (or) nil) (Fig 1B)
- c Parking brake light glows in red (i.e parking brake is applied) (Fig 1C)
- d Seat belt light glows in red (i.e. driver not wear the seat belt) (Fig 1D)



- 5 Release the parking brake (now light not shown red)
- 6 Wear the seat belt properly (now light not shown red)
- 7 Shift the gear to neutral position.
- 8 Observe the fuel gauge reading it shows empty to full.
- 9 Observe the temperature gauge reading it shows minimum temperatures.

TASK 2: Start the engine (Fig.1)

While starting don't press the accelerator pedal

- 1 Press the starter push button Fig.2 or turn the ignition key further to start the engine.

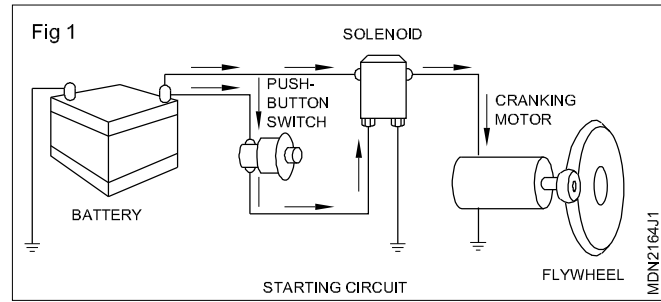
- 2 Release the starter button / ignition key as soon as the engine has started.

While engine running don't operate the starter button / key.

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 overheated.

- 3 Check the idling speed R.P.M in R.P.M meter.
- 4 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

- 1 Observe the battery warning light it's not glow (ie. Battery is charging)
 - 2 Observe the engine oil warning light it's not glow (i.e. oil pump is working)
 - 3 Observe the oil pressure gauge.
 - 4 Observe the water temperature in temperature gauge.
 5. Observe the reading of tachometer
 6. Observe the odometer reading during vehicle (moving) running
 7. Observe the trip meter reading
-

TASK 4: Stop the engine

- 1 Remove the foot from accelerator pedal
 - 2 Turn the ignition key to the OFF position to stop the engine.
-

Practice on dismantling diesel engine.

Objective: At the end of this exercise you shall be able to
 • **Dismantle the diesel engine.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No
- Torque wrench - 1 No
- Tray - 1 No

Equipments/ Machineries

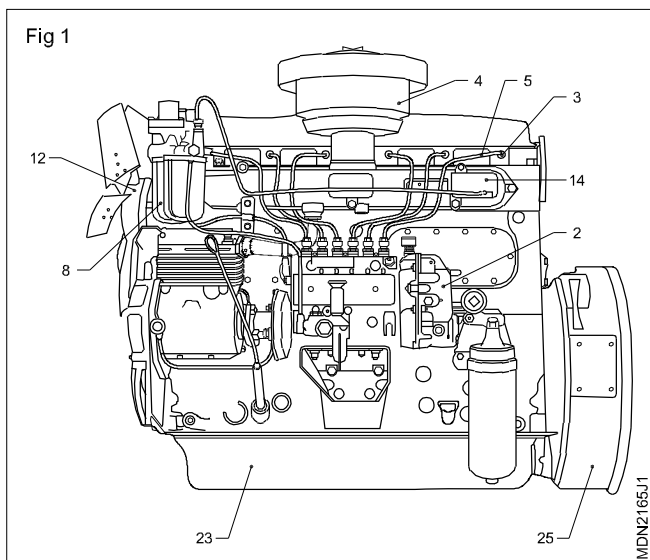
- Diesel engine vehicle (LMV) - 1 No.
- Engine lifting crane - 1 No.

Materials

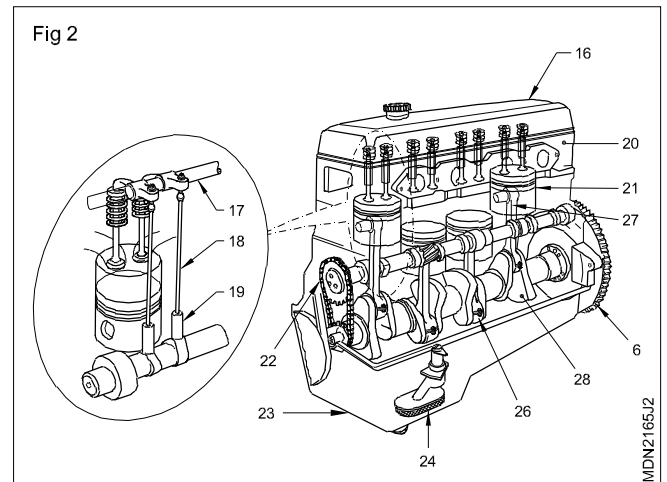
- Cotton cloth - as reqd.
- Soap oil - as reqd.
- Kerosene - as reqd.
- Engine stand - as reqd.
- Wheel choke - as reqd.

PROCEDURE

- 1 Drain the oil (if provided)
- 2 Drain the water (if provided)
- 3 Remove the radiator (if provided)
- 4 Disconnect electrical connections
- 5 Disconnect the fuel pressure pipes (5) (Fig 1)

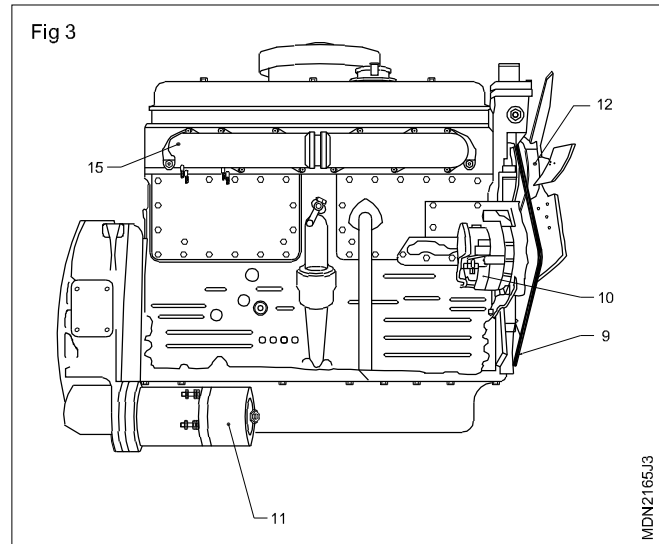


- 6 Remove the air cleaner (4) and keep it in a vertical position.
- 7 Disconnect the accelerator linkages.
- 8 Remove the FIP (2) and injectors (3)
- 9 Remove the fuel filter assembly (8)
- 10 Remove the flywheel (6)
- 11 Remove the fan belt (9)
- 12 Remove the dynamo/alternator (10)
- 13 Remove the self-starter (11). (Fig 3)



- 14 Remove the water pump assembly (12)
- 15 Remove the inlet (4) and exhaust (15) manifold
- 16 Remove the valve cover (16). (Fig 2)
- 17 Remove the rocker assembly (17) from the cylinder head.
- 18 Remove the push-rods (18).
- 19 Remove the tappet side covers.
- 20 Remove the tappets (19).
- 21 Remove the cylinder head mounting bolts and remove the cylinder head (20).
- 22 Remove the cylinder head gasket
- 23 Remove the crankshaft pulley using the special puller.
- 24 Remove the timing cover.
- 25 Remove the timing gear and chain (22). (Note down the timing marks)
- 26 Remove the crankshaft.

- 27 Remove the oil sump (23).
- 28 Disconnect the oil pipes from the oil pump
- 29 Remove the oil pump and strainer (24).
- 30 Remove the oil filter.
- 31 Remove the connecting rod caps. (Note down marks/ No's on the caps.)
- 32 Remove the piston (21) and connecting rod (27) from the engine. (Note down the marks/Nos. on the pistons.)
- 33 Remove the main bearing caps. (Note down the marks/Nos. On the caps.)
- 34 Remove the flywheel housing (25).
- 35 Remove the crankshaft (28).



Overhauling of cylinder head assembly

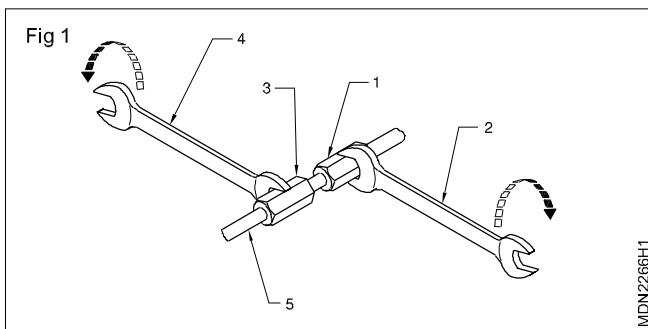
Objectives: At the end of this exercise you shall be able to

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

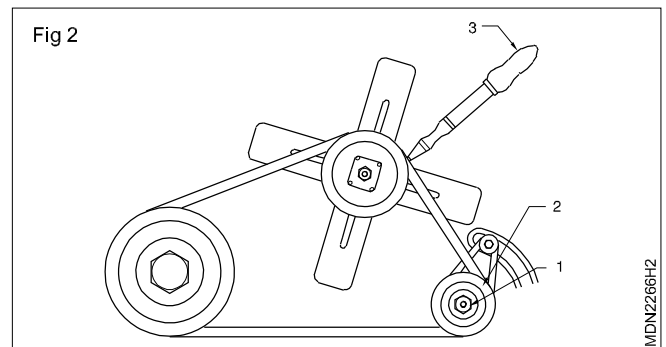
Requirements	
Tools/Instruments	
• Trainee's tool kit	- 1 No.
• Box spanner set	- 1 Set.
• Torque wrench	- 1 No.
• Wire brush, Scrapper	- 1 No each.
Equipments/Machineries	
• Multi cylinder diesel engine	- 1 No.
• Zib crane/engine hoist	- 1 No each.
Materials/Components	
• Tray	- 1 No.
• Cotton cloth	- as reqd.
• Kerosene	- as reqd.
• Soap oil	- as reqd.
• Lube oil	- as reqd.
• Wooden block	- as reqd.

PROCEDURE

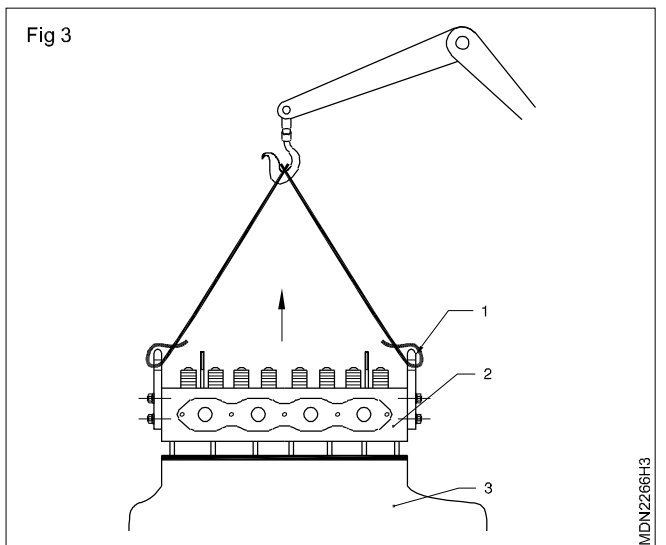
- 1 Remove the air cleaner and keep it in a vertical position on a plain surface to avoid spilling of oil.
- 2 Remove the valve cover.
- 3 Disconnect the fuel delivery lines. Hold the inner nut (1) with the help of a double end spanner (2), then loosen the outer nut(3) with the help of another double end spanner (4). Remove the pipe (5). (Fig 1)



- 4 Remove the fuel pipes and the injectors.
- 5 Loosen the fuel injection pump mounting nuts, by loosening each screw, two turns at a time. Ensure that these nuts do not fall anywhere.
- 6 Remove the F.I.P. and keep it in a vertical position on a plain surface.
- 7 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)
- 8 Remove the fan assembly with the water pump pulley.
- 9 Take out all the push-rods.
- 10 Remove the tappet side cover and remove the tappets.

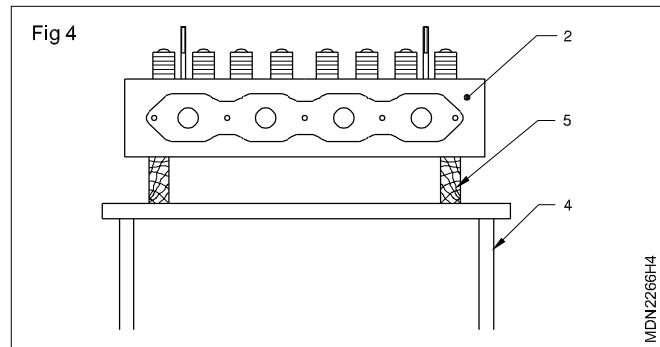


- 11 Remove all the cylinder head nuts/bolts.
- 12 Fix the lifting hooks (1) at both ends of the cylinder head (2). (Fig 3)



- 13 Lift the cylinder head with the help of lifting hooks from the cylinder block (3).

- 14 Ensure that the cylinder head does not tilted while removing, so as to avoid damage to the cylinder head studs.
- 15 Place the cylinder head (2) on a workbench (4) over two wooden block stands (5). (Fig 4)
- 16 Remove the cylinder head gasket and keep it in a safe place.
- 17 Remove the carbon deposit on the cylinder head.
- 18 Clean the cylinder head with cleaning solvent used.
- 19 Visually check the cylinder head for its damages and cracks



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

Practice on removing rocker arm assembly & 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			
Tool/Instruments		Materials/Components	
<ul style="list-style-type: none"> • Traniee's tool kit - 1 No. • Box Spanner set - 1 No. • Wire brush,scrapper - 1 No. 		<ul style="list-style-type: none"> • Tray - 1 No • Cotton waste - as req • Soap oil - as req • Lube oil - as req • Gasket - as req 	
Equipments/Machinaries			
<ul style="list-style-type: none"> • Multi cylinder diesel engine - 1 No. 			

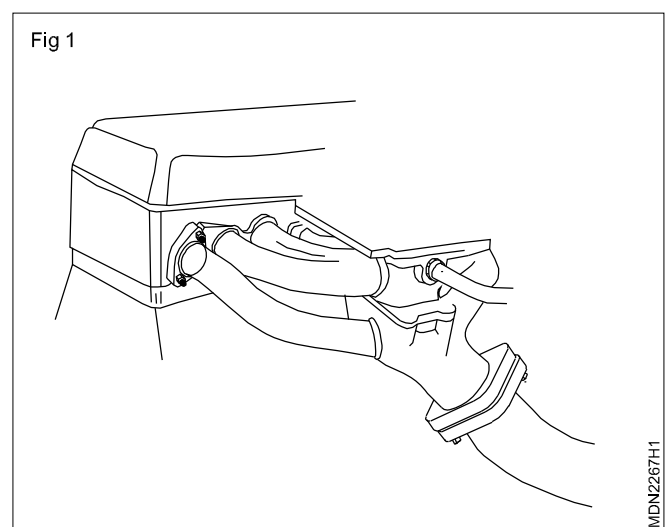
PROCEDURE

TASK 1 : Removing rocker arm assembly

- 1 Remove the head cover (value door)
- 2 Remove the mounting nuts of the rocker shaft supports.
- 3 Takeout the rocker shaft along with supports in the horizontal position.
- 4 Ensure that the shaft does not tilt to avoid bending and breakage of the shaft.
- 5 Place the rocker arm assembly on the work bench in tray
- 6 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)

- 1 Remove the exhaust manifold flange nuts and bolts.
- 2 Disconnect the exhaust pipe line from exhaust manifold.
- 3 Loosen the exhaust manifold mounting bolts.
- 4 Remove the turbo charger before loosen the exhaust manifold mountings.
- 5 Remove the manifold mountings and take out from the cylinder head and place it on the work bench.
- 6 Remove the air cleaner or air intake hose from the inlet manifold
- 7 Loosen mounting bolts of inlet manifold.
- 8 Remove the inlet manifold mounting bolts and take out from the cylinder head and place it on the work bench.
- 9 Ensure the manifold are safety placed on the work bench.



- 10 Visually inspect the manifolds for any damages on the manifold.
- 11 If any damages found make repair and clean it thoroughly.

Practice on removing the valves from the cylinder head

Objective: At the end of this exercise you shall be able to

- remove the valves and its parts from cylinder head and cleaning the parts

Requirements

Tool/Instruments

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

Equipments/Machinaries

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

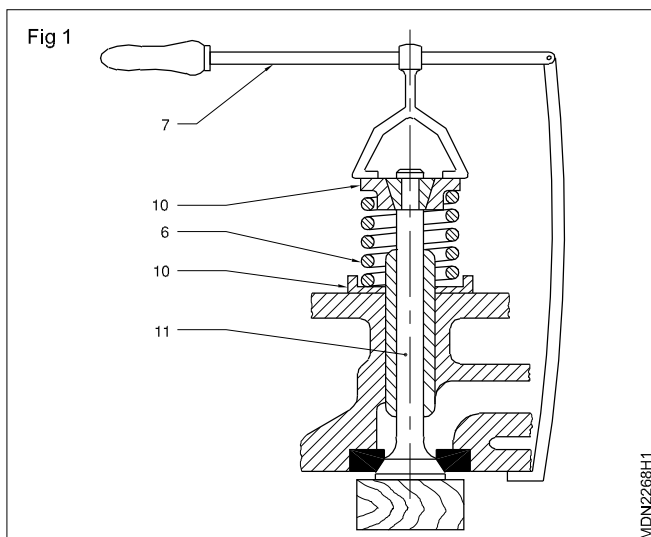
Materials/Components

- Tray - 1 No
- Cotton cloth - as req
- Kerosene - as req
- Lube oil - as req

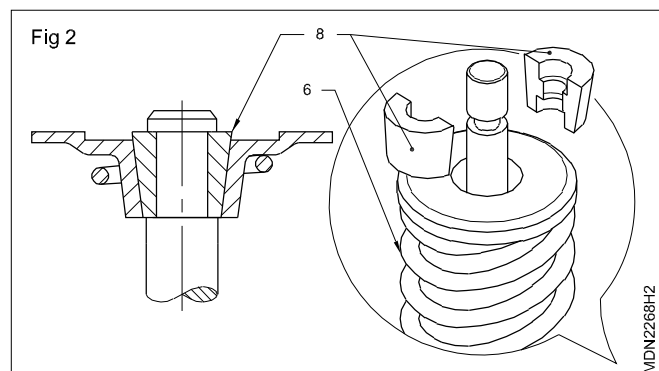
PROCEDURE

TASK 1: Remove valves

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



- 5 Release the valve spring and take out the special tool (7).
- 6 Remove the spring, (6) and the valve (11) and retainer (10). (Fig 2)
- 7 Keep the valves in order.
- 8 Clean the valves, springs and spring retainers, cotters and head surfaces using kerosene.



- 9 Remove the carbon deposits, using a wire brush, from the valve seats and combustion chamber's surroundings.
- 10 Inspect the valve stem for bend, using a 'V' block and dial gauge.
- 11 Check the valve face visually, for pitting and damage.
- 12 Check the cotter collar for damage.
- 13 Check the valve spring for tension, on a spring tester.
- 14 Check the valve spring, for breakage/damage.

Checking flatness of cylinder head and manifold surfaces

Objectives: At the end of this exercise you shall be able to

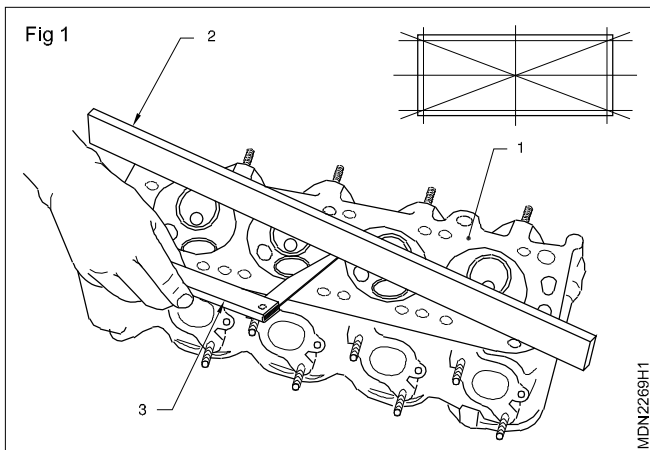
- check the flatness of cylinder head surface by the straight edge and feeler gauge
- check the flatness of manifold by the straight edge and feeler gauge.
- check valve seat and valve guide.

Requirements			
Tool/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Straight edge	- 1 No.	• Cotton waste	- as req
• Feeler gauge	- 1 No.	• Soap oil	- as req
• Wire brush, scrapper	- 1 No.	• Lube oil	- as req
Equipments/Machinaries		• Emery sheet	- as req
• Diesel engine	- 1 No.		

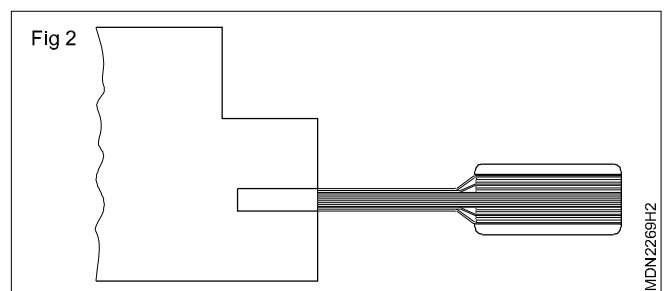
PROCEDURE

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

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



- 6 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.
- 7 Clean the feelers gauge thoroughly by using a cloth.
- 8 Clean the gap of the work to be measured.
- 9 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)



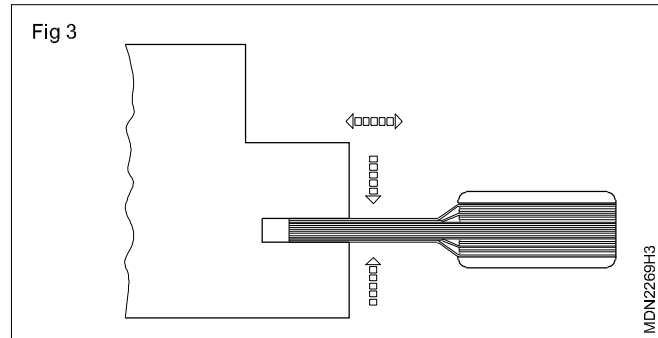
- 4 Insert the feeler gauges (3) leaves between the straight edge (2) and the surface.

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.

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

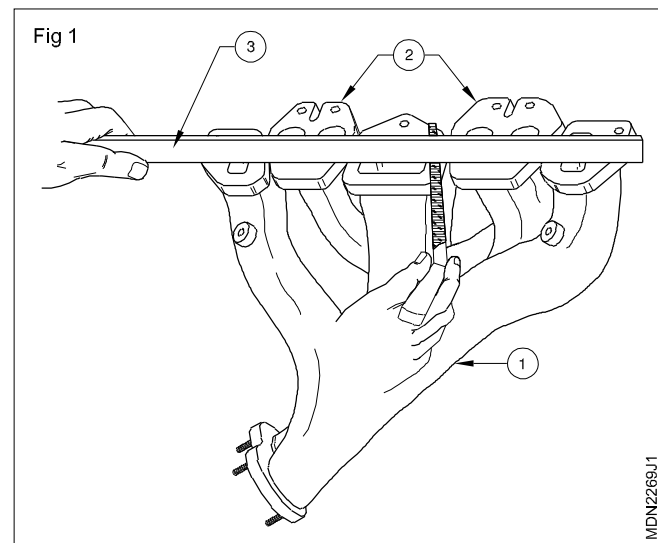
- 5 Repeat above steps in four directions and note down the maximum face out in all the four directions.

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



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

- 1 Clean the mounting surface of the manifolds (1) free from carbon deposit (1) (Inlet of exhaust)
- 2 Place the manifold surface parts upward to be checked
- 3 Visually check the surface for damages/cracks
- 4 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)
- 5 Repeat the above steps in four directions and note down the maximum face out in all the four directions
- 6 Recommend for resurface/replacement of the manifold if wear more than the limit specified by manufacturer or damaged



Job sequence

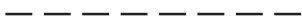
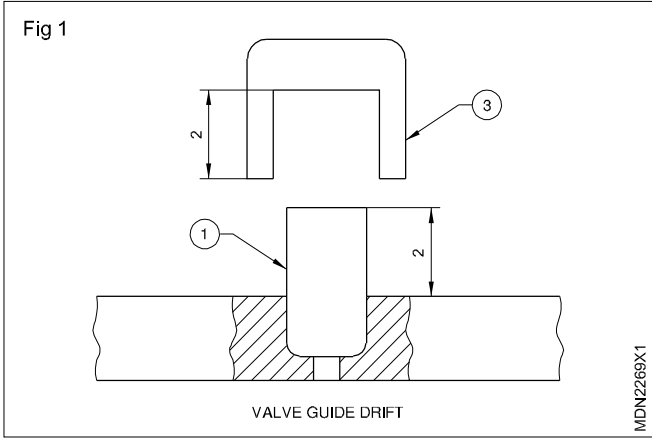
Checking valve seat and valve guide

Objective: At the end of this exercise you shall be able to

- check valve seat and seat insert
- check valve guide.

TASK 1 : Check valve seat insert and valve guide

- 1 Take out the valve seat insert, using the special tool.
- 2 Drive the new valve seat insert carefully to its position, using a special punch.
- 3 Assemble the valve to the valve seat and check its height with reference to the cylinder head surface.
- 4 De-glaze the seat with an emery paper.
- 5 Apply lapping compound on the valve face seat.
- 6 Gently turn the valve on the seat with the help of the special tool using light force.
- 7 Repeat this until a clear seating of the valve and valve seat is obtained.
- 8 Remove the lapping compound using kerosene and visually check the surface of valve seat of valve face.
- 9 If found any damages in valve seat and valve guide, replace it.
- 10 Measure the valve stem diameter.
- 11 Measure the internal diameter of the valve guide.
- 12 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.
- 13 Drive out the old valve guide from the cylinder head using a suitable drift.
- 14 Place the new valve guide (1) on the cylinder head. (Fig.1)
- 15 Place the valve guide drift (3) on the valve guide and press the valve guide.
- 16 Measure the height (2) of the valve guide from the spring seating surface (use depth gauge).



Check valve leakage & overhauling rocker arm assembly

Objectives: At the end of this exercise you shall be able to

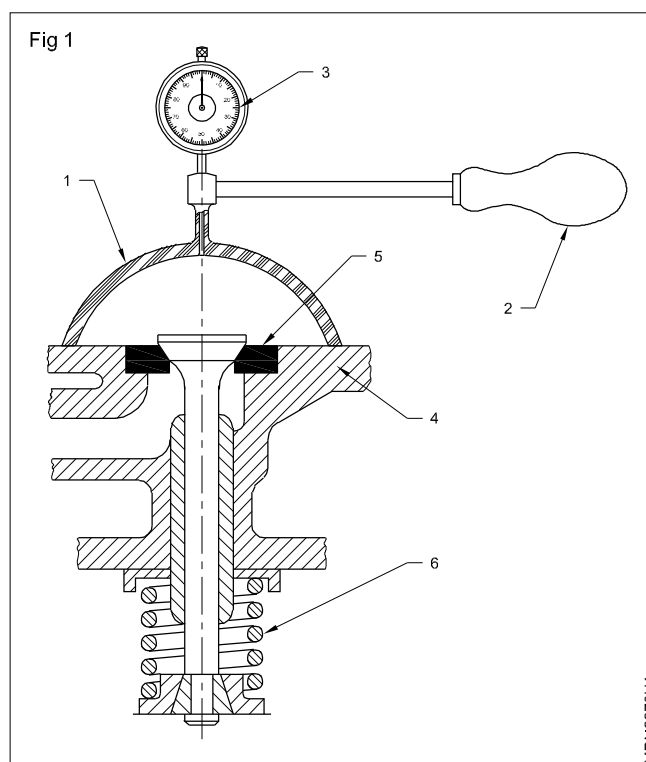
- check the valve seat leakage with special tool
- check the rocker shaft and levers for wear and cracks
- method of reassemble the rocker shaft and levers.

Requirements	
<p>Tool/Instruments</p> <ul style="list-style-type: none"> • Trainee's tool kit - 1 No. • Valve leakage test tool - 1 No. <p>Equipments/Machinaries</p> <ul style="list-style-type: none"> • Work bench - 1 No. • Wooden block - 2 Nos. • Diesel engine - 1 No. 	<p>Materials/Components</p> <ul style="list-style-type: none"> • Tray - 1 No. • Cotton cloth - as req • Soap oil - as req • Valve grinding stick - as req • Valve lapping paste - as req

PROCEDURE

TASK 1: Checking valve leakage (Fig 1)

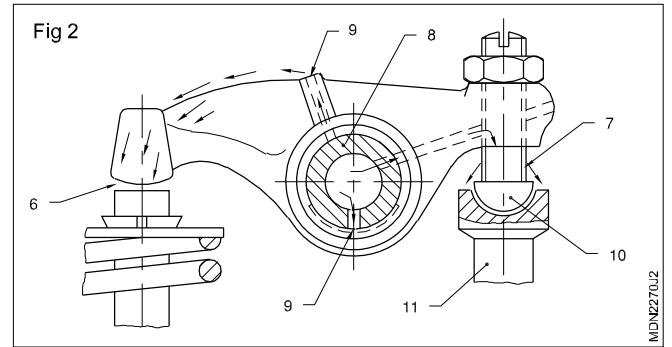
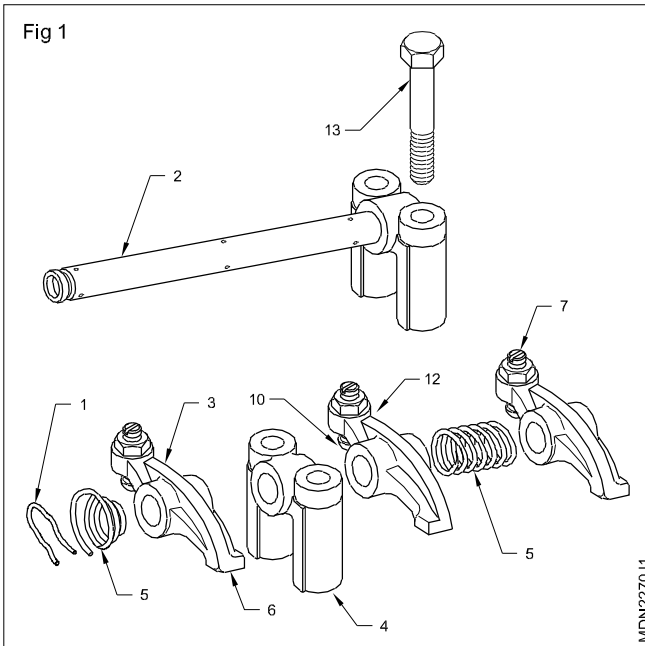
- 1 Check the valve leakage using the special tool (Fig 1)
- 2 Attach a suction cup (1) with a suction bulb (2) and vacuum gauge (3) on the cylinder head (4)
- 3 Covering the cylinder head valve seat (5) and create a vacuum with the help of the suction bulb (1) (rubber bulb)
- 4 Wait for 3 minutes and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



TASK 2: Overhauling Rocker Arm Assembly (Fig 1 & 2)

- 1 Remove the lock-screw/circlips (1) at both ends of the rocker shaft.(2)
- 2 Remove the rocker levers (3) rocker lever bracket (4); springs (5) and spacers from the rocker shaft. (Fig 1)
- 3 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).

- 4 Clean the dismantled parts of rocker arm assembly.
- 5 Check the tension of the rocker spring(5). Replace it, if necessary.
- 6 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.
- 7 Check the rocker shaft (2) visually for cracks and damage.
- 8 Check the rocker arm bushing (8) for wear and tear and alignment of lubricating holes.(9) (Fig 2)



- 9 Check the rocker arm ball pins (10) for wear and damage.
- 10 Clean the base of the rocker shaft supports, and the seats on the cylinder head.
- 11 Fix the ball pins on the rocker arm.
- 12 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
- 13 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.

Assembling the cylinder head

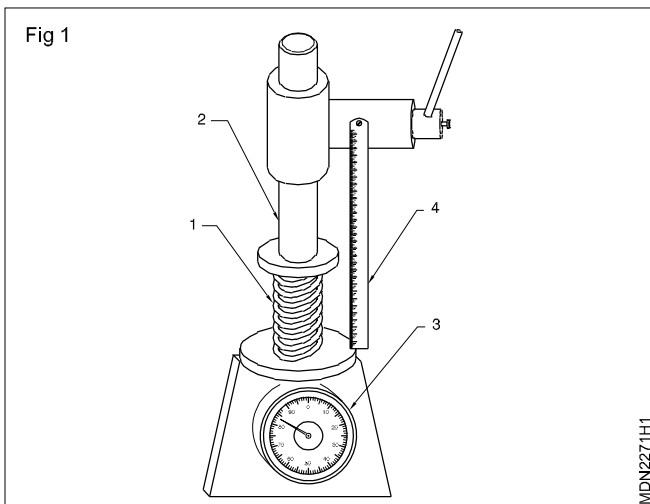
Objectives : At the end of this exercise you shall be able to

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

Requirements		Materials/Components	
Tool/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Cotton cloth	- 1 No.
• Valve spring compressor	- 1 No.	• Engine oil	- as req
• Feeler gauge	- 1 No.	• Head gasket	- as req
Equipments/Machinaries		• Valve springs	- as req
• Spring tester	- 1 No.	• Head stud nuts	- as req
• Torque wrench	- 1 No.		
• Oil can	- 1 No.		

PROCEDURE

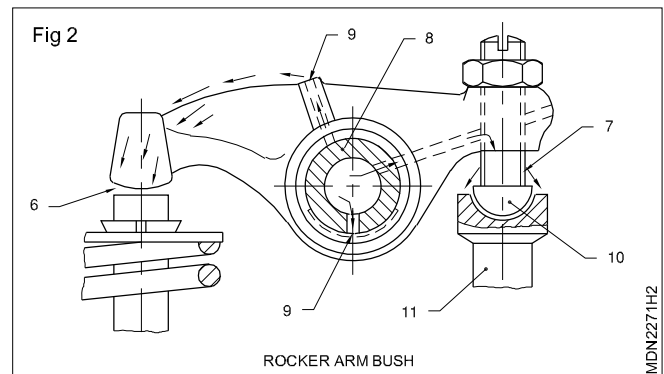
- 1 Clean the spring to be tested.
- 2 Clean the spring tester.
- 3 Place the spring (1) vertically on the spring tester. (Fig 1) Ensure that the moveable spindle (2) does not touch the spring (1).



- 4 Note down the height of the spring (1) on the graduated scale (4). This is the free length of the spring.
- 5 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.

- 6 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.
- 7 Check visually the rocker lever for cracks and pitting on the tip (Fig 2)



- 8 Check the condition of the threads of the adjusting screw for wear, if necessary replace.
- 9 Check the rocker arm bush and drill holes.
- 10 Check the rocker arm ball pins for wear and damage
- 11 Check the push-rod for bend and the socket end for wear
- 12 Impact the valve stem for bend, using a 'V' block and dial gauge
- 13 Check the collar and stem end for damage.
- 14 oil the valve stem.
- 15 Inspect the valve in the valve guide.
- 16 Support the valve poppet, so that it is held firmly on its seat.

- 17 Fit the valve spring washer on the cylinder head.
- 18 Insert the valve spring.
- 19 Place the valve spring retainer over the spring.
- 20 Compress the valve spring with the special tool

- 21 Insert cotters with the smaller dia. at the bottom and release pressure on the valve springs (1) gradually (Fig 2).
- 22 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)

Skill Sequence

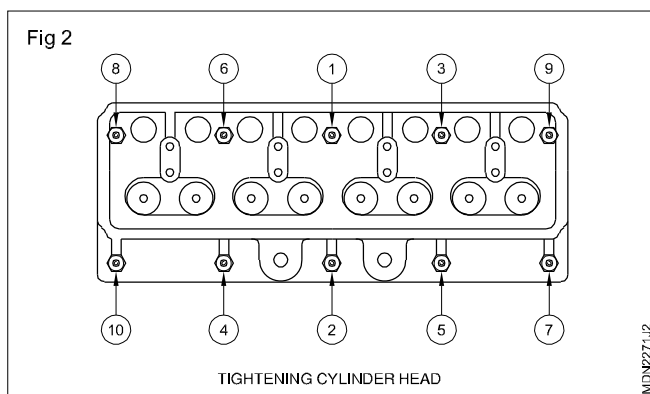
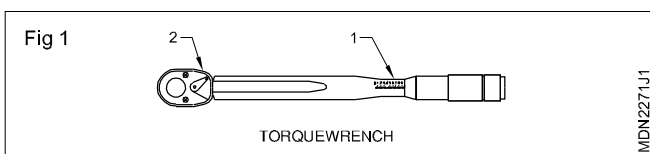
Refit the cylinder head, manifolds and adjusting valve tappet clearance

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.

PROCEDURE

- 1 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
- 2 4-cylinder engine is cylinder head is shown in Fig.2 and torque wrench is shown in (Fig 1).



- 3 Assembling and fitting the rocker arm assembly. Turn the crankshaft 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.
- 4 Hold firmly the tappet adjusting screw with a good screwdriver. (Fig 3)
- 5 Loosen the lock-nut with a ring spanner.
- 6 Insert a feeler gauge (1) of the specified thickness between the valve stem and the rocker tip (4).
- 7 Tighten the adjusting screw (5) by a screwdriver (2) and at the same time move the feeler gauge to and fro.

- 8 Stop tightening of the adjusting screw when the feeler gauge can be slid with a slight effort, but it should not be jammed.
- 9 Rotate the push-rod. It should also rotate with a slight load but it should not be jammed.
- 10 Hold the adjusting screw in position with the screwdriver firmly and tighten the lock-nut by a ring spanner.
- 11 Ensure that the adjusting screw does not turn while tightening the locking nut.
- 12 Check again the adjustment by sliding the feeler gauge leaf in the gap and turning the push rod.
- 13 Repeat the above steps to adjust the tappet clearance for other valves bringing the respective positions on TDC of compression stroke according to firing order.
- 14 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.

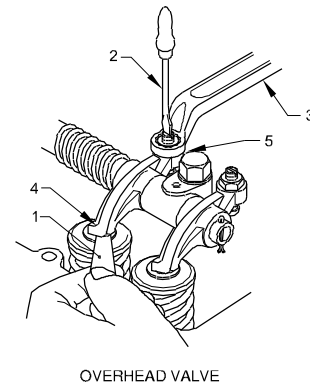
- Adjust No.1 valve when No.8 is lifted.
 - Adjust No.2 valve when No.7 is lifted.
 - Adjust No.3 valve when No.6 is lifted.
 - Adjust No.4 valve when No.5 is lifted.
 - Adjust No.5 valve when No.4 is lifted.
 - Adjust No.6 valve when No.3 is lifted.
 - Adjust No.7 valve when No.2 is lifted.
 - Adjust No.8 valve when No.1 is lifted.
- 15 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.

16 Start the engine and leave it in idle speed

17 Check the tappet noise, if found noise adjust and rectify the noise.

Fig 3



MDN2271J3

Overhauling the piston and connecting rod assembly.

Objectives: At the end of this exercise you shall be able to

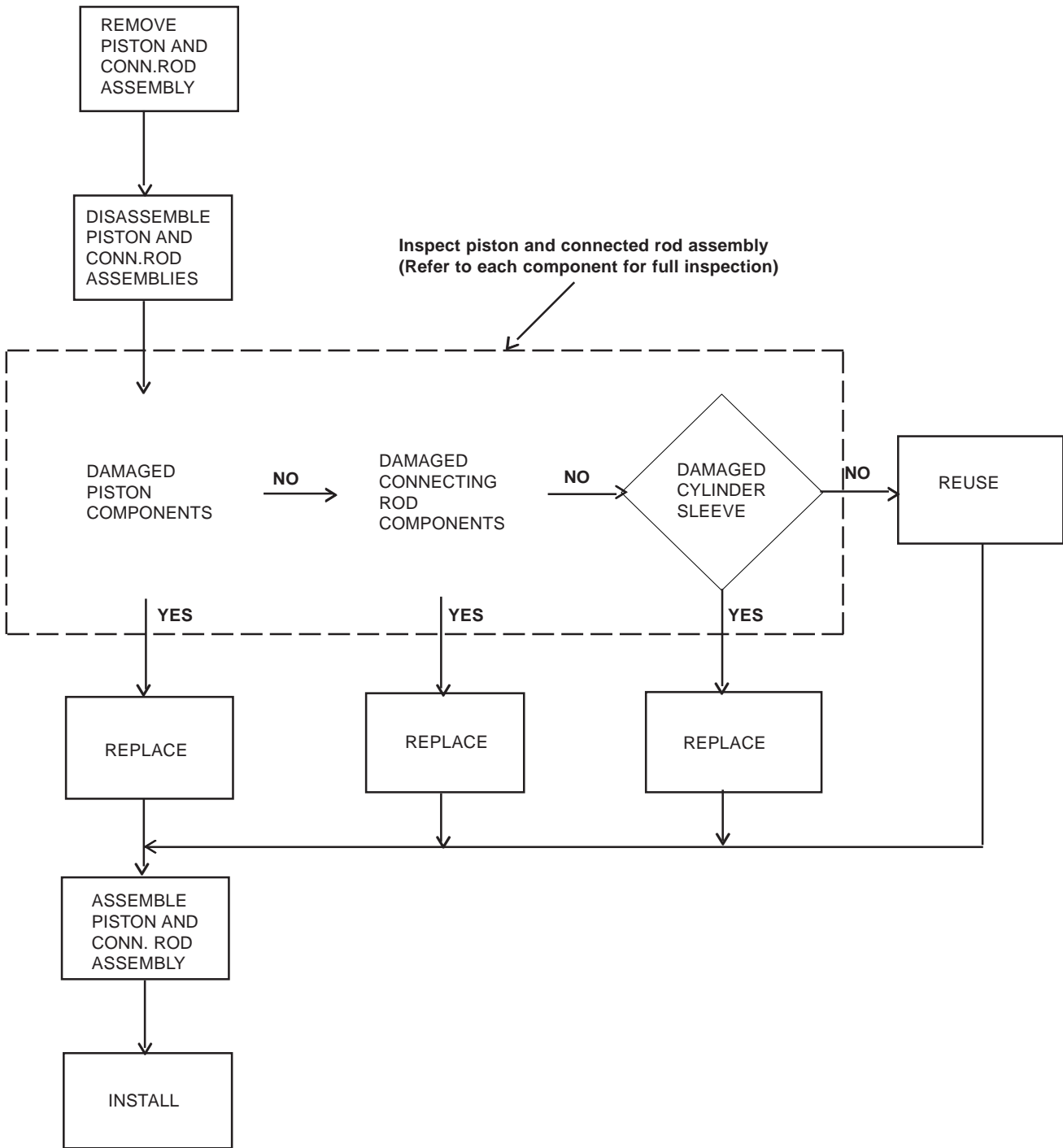
- **remove the piston and connecting rod assembly**
- **use service manual for clearance**
- **assemble the piston assembly.**

Requirements			
Tools / Instruments		Equipments	
• Trainee's tool kit	- 1 No.	• Air compressor	- 1 No.
• Socket spanner set	- 1 Set	• Petrol engine	- 1 No.
• Torque wrench	- 1 Set	• Arbor press	- 1 No.
• Piston Ring expander	- 1 Set		
• Drift	- 1 Set	Materials	
• Mallet	- 1 Set	• Soap oil	- as reqd.
• Ball pein hammer	- 1 No.	• Kerosene	- as reqd.
• Ring groove cleaner	- 1 No.	• Banian cloth	- as reqd.
• Internal circlip plier	- 1 No.	• Lube oil	- as reqd.
• Feeler gauge	- 1 No.	• Emery sheet	- as reqd.
• Bench vice	- 1 No.	• Piston ring	- as reqd.

PROCEDURE

- | | |
|---|--|
| <ol style="list-style-type: none"> 1 Drain the engine coolant. 2 Drain the engine oil and remove the oil pan. 3 Remove the cylinder head. 4 use emery cloth remove any carbon deposits from the upper surface of the cylinder liner. 5 Remove the bearing cap from the connecting rod. 6 Push the piston and connecting rod assembly upward. 7 Protect the crank shaft journal. 8 Push the piston and connecting rod assembly out through the top of the cylinder block. 9 Place the piston assembly on the work bench. 10 Using the snap ring pliers, remove the circlip/ snap rings from the piston skirt. 11 Slide out the piston pin and remove the connecting rod from the piston. 12 Remove the piston rings from the piston 13 Remove the carbon deposit from the piston head, skirt, oil holes and grooves. 14 Remove the dirt deposit from the piston pin boss. 15 Clean the oil hole of connecting rod and piston parts. 16 Discard the used piston pin, bolts/circlips and replace with new one. 17 For other parameters on reusing piston assembly components compare with service manual. | <p>(Care in handling and cleanliness of piston dome bearings and piston pin)</p> <ol style="list-style-type: none"> 18 Fix the piston with connecting rod small end. 19 Position the piston ring gap on the piston at 90° intervals. 20 Push the piston and connecting rod assembly into the liner until the piston is free of the ring compressor. 21 Push the piston assembly in firmly seated on the crank shaft journal.(Crankpin) 22 Install the bearing cap (as per number marked) on the same side. 23 Torque the connecting rod bolts alternately. 24 Check the connecting rod side clearance on the crank pin and compare with the service manual. 25 Install the cylinder head with new gasket. 26 Fit the rocker arm assembly and adjust tappets. 27 Install oil pump with strainer. 28 Install oil pan. 29 Refill the recommended oil to the proper level. 30 Close the drain cocks and fill the recommended coolant. |
|---|--|

Draw chart



CONN. ROD = Connecting ROD

Practice on removing oil sump and oil pump

Objectives: At the end of this exercise you shall be able to

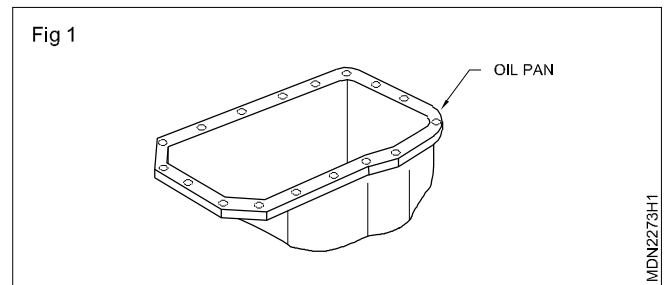
- remove the oil sump from the engine
- remove the oil pump from the engine.

Requirements			
Tools/Instruments		Materials/Components	
• Trainees tool kit	- 1 No.	• Tray	- 1 No.
• Box spanner set	- 1 Set.	• Cotton cloth	- as reqd.
• Feeler gauge	- 1 No	• Kerosene	- as reqd.
• Straight edge	- 1 No	• Soap oil	- as reqd.
Equipments/Machineries		• Lube oil	- as reqd.
• Multi cylinder diesel engine	- 1 No		

PROCEDURE

TASK 1 : Removing oil sump. (Fig 1)

- 1 Loosen the engine oil sump drain plug
- 2 Place the tray under the sump
- 3 Remove the drain plug and ensure the complete oil is drained from the oil sump
- 4 Crank the engine to drain remain oil from the engine
- 5 Fix the oil sump drain plug
- 6 Loosen the oil sump mounting bolt
- 7 Remove the all mounting bolts of oil sump
- 8 Remove the oil sump and place it on the work bench.
- 9 Remove the gasket from the sump

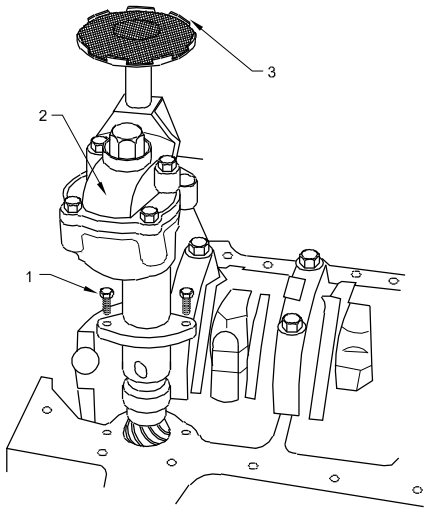


- 10 Clean the surface of the gasket fitting
- 11 Clean the sump with kerosene
- 12 Clean the dust particles deposited in drain plug
- 13 Inspect the oil sump for any damages and cracks , if found any crack, repair it.

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

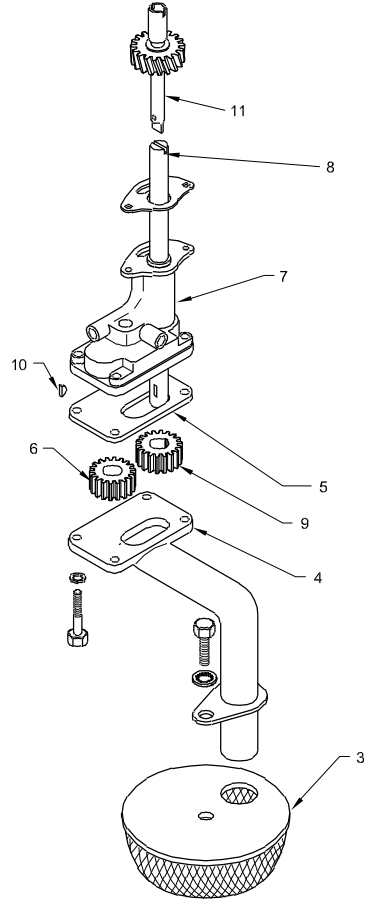
- | | |
|---|--|
| <ol style="list-style-type: none"> 1 Locate the oil pump mountings 2 Select the suitable tools to remove the oil pump mountings 3 Loosen the oil pump mountings (Fig 1) 4 Remove the oil pump along with strainer. 5 Place the oil pump on tray for cleaning and inspection. | <ol style="list-style-type: none"> 6 Dismantle the oil pump parts and clean it (Fig 2) 7 Inspect the dismantled parts, if any damages, replace the defective parts. 8 Assemble the all parts in sequence 9 Check the pressure test of the oil pump with your instructor's guide line |
|---|--|

Fig 1



MDN2273.1

Fig 2



MDN2273.2



Practice on removing piston with connecting rod assembly

Objectives: At the end of this exercise you shall be able to

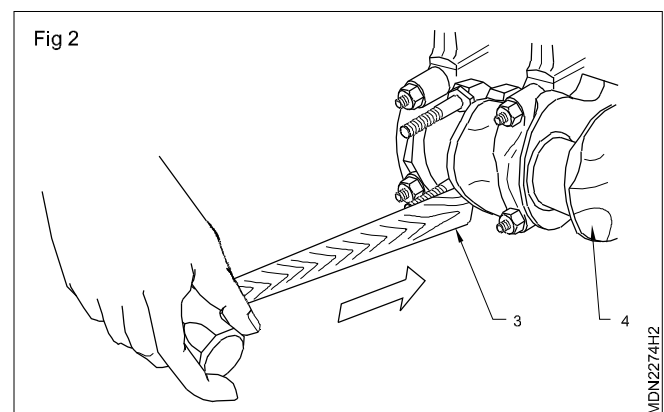
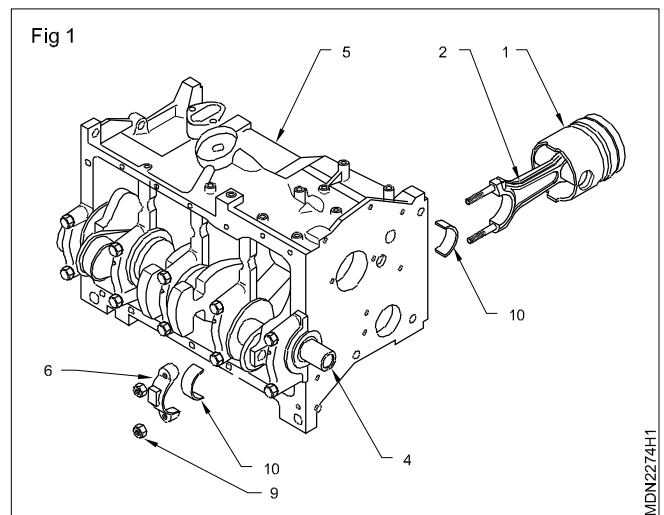
- remove the big end bearing from the connecting rod
- remove the piston with connecting rod.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Torque wrench, Ring expander	- 1 No each.	• Cotton cloth	- as reqd.
• Mallet, Drift punch	- 1 No.	• Kerosene	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Lube oil	- as reqd.
		• Wooden block	- as reqd.

PROCEDURE

TASK 1 : Remove piston

- 1 Remove the oil sump.
- 2 Disconnect the oil pipe from the oil pump and remove the oil strainer.
- 3 Remove the oil pump.
- 4 Tilt the engine block.
- 5 Clean and check for ridge formation of all cylinders.
- 6 Turn the crankshaft (4) till the piston (1) comes at B.D.C.
- 7 Remove the bolts/nuts (9) of the connecting rod (2).
- 8 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.
- 9 Turn the crankshaft (4) till the piston (1) comes at T.D.C. Tap the connecting rod (2) with a wooden block (3).
- 10 Note down the connecting rod cap matching number stamped on it to avoid mismatching while reassembling.
- 11 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)
- 12 Repeat the relevant steps to remove all the pistons. (Fig 2)
- 13 Clean the connecting rod and pistons



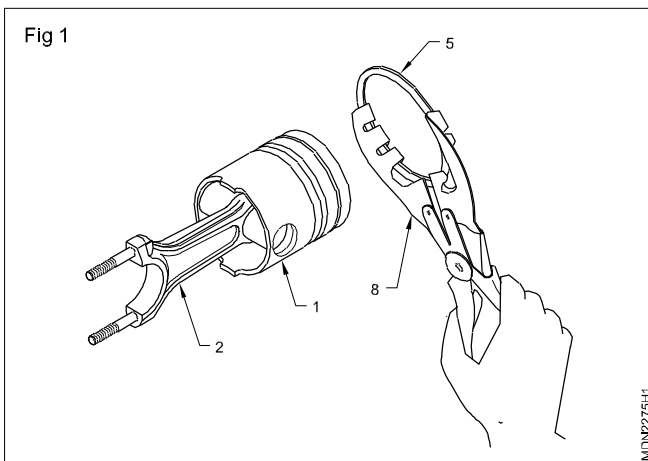
Practice on removing and measuring the piston

- 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.

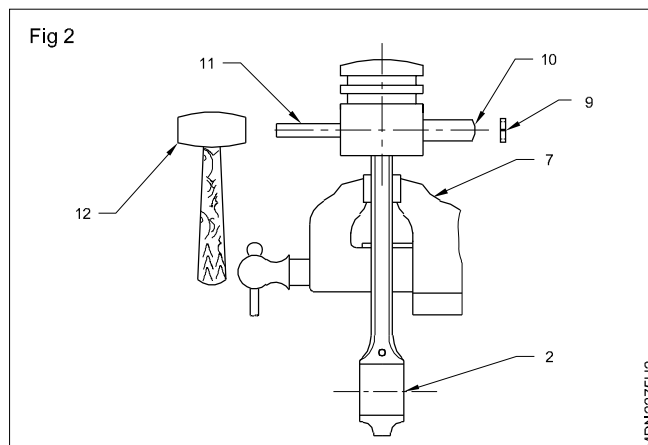
Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Cotton waste	- as reqd.
• Feeler gauge	- 1 No.	• Kerosene	- as reqd.
• Outside micrometer	- 1 No.	• Piston rings	- as reqd.
• Plastic of a gauge	- 1 No.		

PROCEDURE

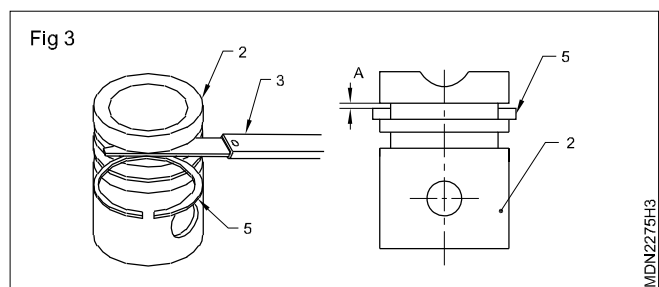
- 1 Remove the piston ring (5) with help of piston ring (8) expander as shown in (Fig1).



- 2 Remove the circlip (9) of the piston pin (10), using a circlip plier.
- 3 Remove the piston pin (10) with the help of a drift (11) and hammer(12). Repeat the steps to all the pistons. (Fig 2)

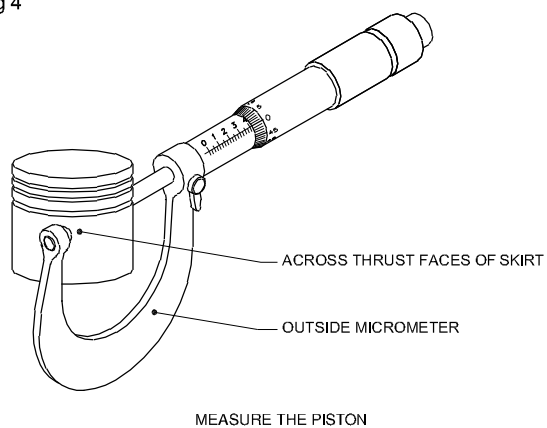


- 4 Remove connecting rod from piston.
- 5 Clean the piston, piston pin, piston rings grooves, oil ring holes.
- 6 Remove the carbon deposits from the piston ring grooves.
- 7 Clean the piston rings and the connecting rod by using kerosene.
- 8 Check the piston skirt and crown for scuffing, crack, scoring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



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

Fig 4



MDN2275H4

Measure the clearance of piston, ring and big end bearings

Objectives: At the end of this exercise you shall be able to

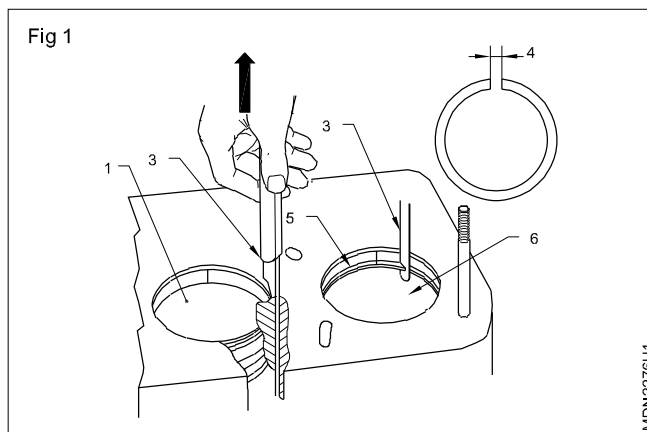
- check the piston ring close gap
- check the clearance between the piston and cylinder wall
- check the clearance between crank pin and big end bearing.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Cotton cloth	- 1 No.
• Feeler gauge	- 1 No.	• Soap oil	- as reqd.
• Torque wrench	- 1 No.	• Piston ring	- as reqd.
		• Big end bearing	- as reqd.
Equipments/Machineries			
• Multi cylinder diesel engine	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

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

- 1 Clean the cylinder bore with banyan cloth
- 2 Clean the selected piston ring for measure
- 3 Insert the piston ring inside of the cylinder bore
- 4 Ensure the piston ring placed in spaced level in side of cylinder bore (push the ring in the cylinder by piston head without rings)
- 5 Measure the piston ring, close gap by feeler gauge
- 6 Note the feeler gauge leaf reading and compare with service manual specification.



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

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

TASK : 3 Measure the clearance between the crankpin and connecting rod big end bearing

- 1 Clean the big end bearing and crank pin
- 2 Install the shell bearing in connecting rod and lower cap of big end
- 3 Place the piece of gauging plastic to full width of crank pin as contacted by bearing. (avoid oil hole).
- 4 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 tighten torque
- 5 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.
- 6 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
- 7 Same method followed to other crank pin and connecting rod bearings.

[Note : Never place plastic gauge above oil holes]

Check connecting rod for bend and twist.

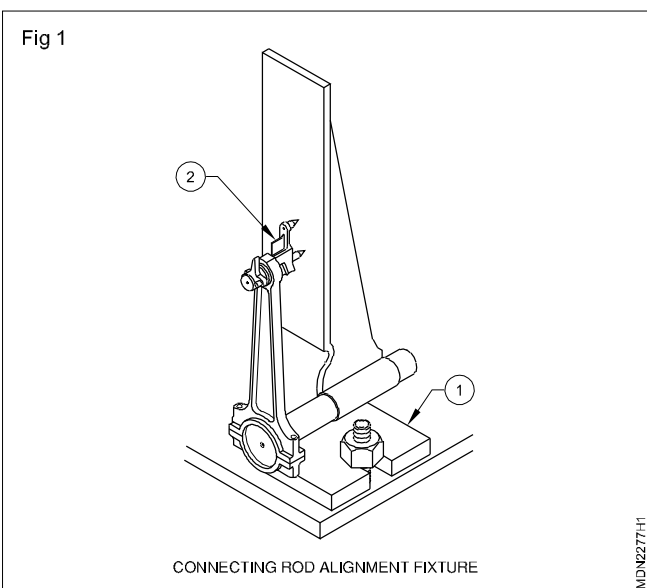
Objectives: At the end of this exercise you shall be able to

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

Requirements	
Tools/Instruments	Materials/Components
<ul style="list-style-type: none"> • Trainee's tool kit - 1 No each. • 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 each. 	<ul style="list-style-type: none"> • Tray - 1 No. • Cotton cloth - as reqd. • Kerosene - as reqd. • Soap oil - as reqd. • Lube oil - as reqd.
Equipments/Machineries	
<ul style="list-style-type: none"> • Multi cylinder diesel engine - 1 No. 	

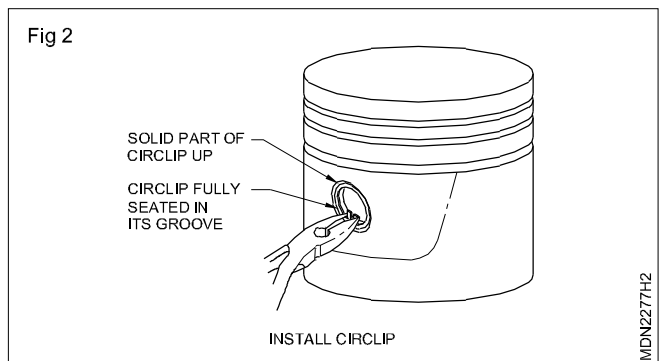
PROCEDURE

- 1 Place the connecting rod assembly on the work bench and remove the piston from the connecting rod
2. Clean the dismantled piston and connecting rod.
- 3 Check the connecting rod's small end bush bearing for wear and scoring.
- 4 Check the connecting rod's alignment for bend and twist.
- 5 Check the gudgeon pin surface for any injury.
- 6 Place the connecting rod on the alignment fixture (1). (Fig 1)

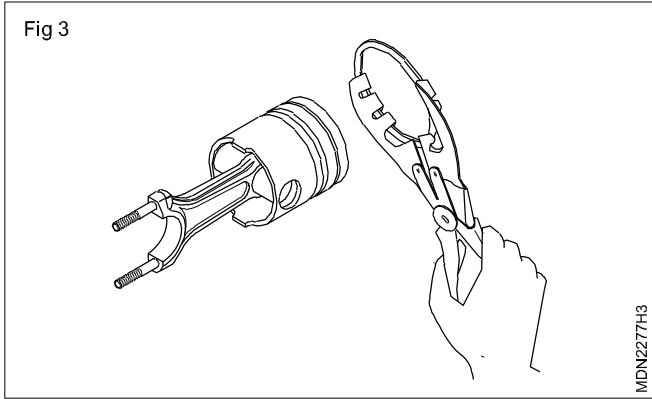


- 7 Insert the gudgeon pin in the small end bore.
- 8 With a square edge (2) check the square seating of the gudgeon pin. If the connecting rod is bent or twisted, the gudgeon pin will not sit squarely in the bore. Replace the connecting rod if found bent or twisted.

- 9 Fit one circlip in the groove of the piston. (Fig 2)



- 10 Align the connecting rod's small end bore and the gudgeon pin bore of the piston.
- 11 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.
- 12 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)
- 13 Place the upper and lower bearing shells in all the connecting rods and caps and keep them in proper order for reassembling purpose.



Overhauling of crankshaft

Objectives: At the end of this exercise you shall be able to

- use of service manual
- check the clearance of crank shaft.

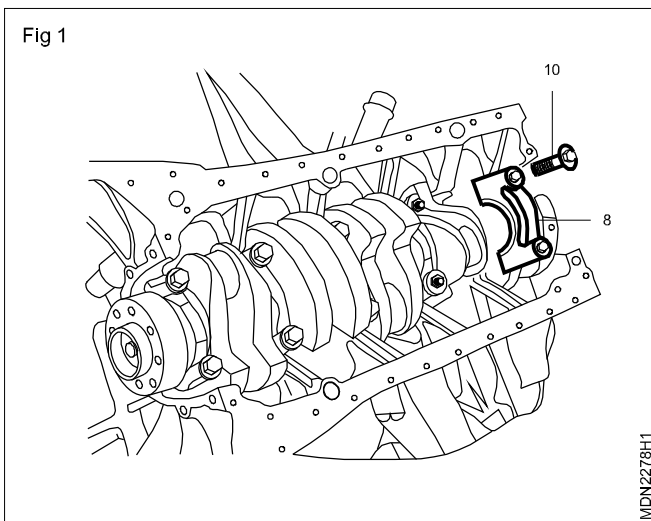
Requirements			
Tools/Instruments		Equipments/Machineries	
• Trainee's tools kit	- 1 No.	• Work bench	- 1 No.
• Engine manual book	- 1 No.	• Multi cylinder engine	- 1 No.
• soft harmer - plastic	- 1 No.		
• Pry bar	- 1 No.	Materials/Components	
• Feeler gauge	- 1 No.	• Tray	- 1 No.
• Plastic gauge	- 1 No.	• Banian cloth	- as reqd.
• Torque wrench	- 1 No.	• Soap oil	- as reqd.
• Dial gauge	- 1 No.	• Lube oil	- as reqd.
• Inside micro meter	- 1 No.	• Shell bearing	- as reqd.

PROCEDURE

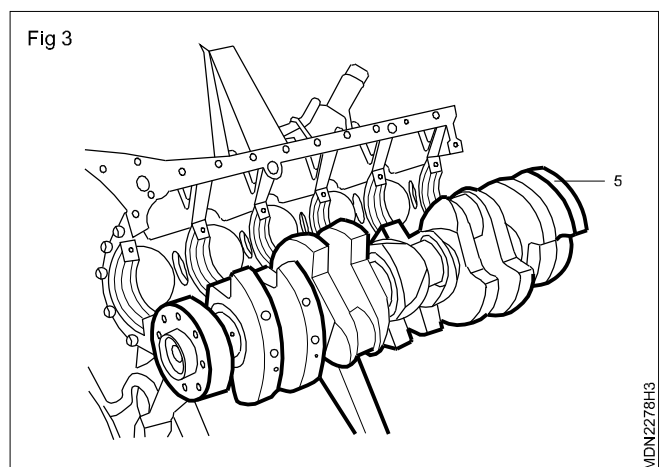
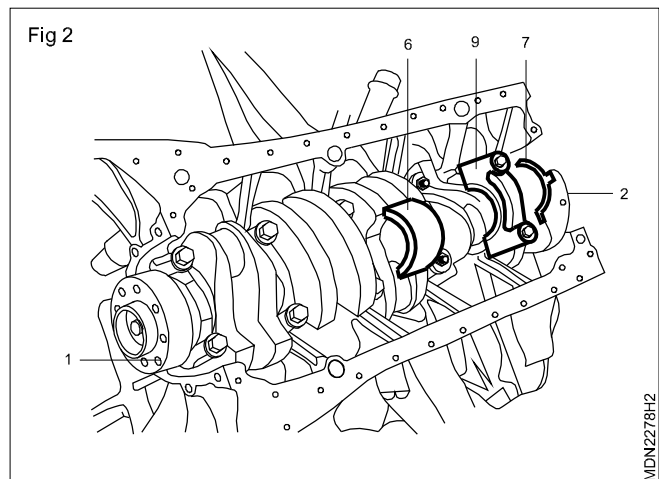
1. Remove the bearing cap bolt (10). (Fig 1)
2. Remove the bearing caps (8).

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

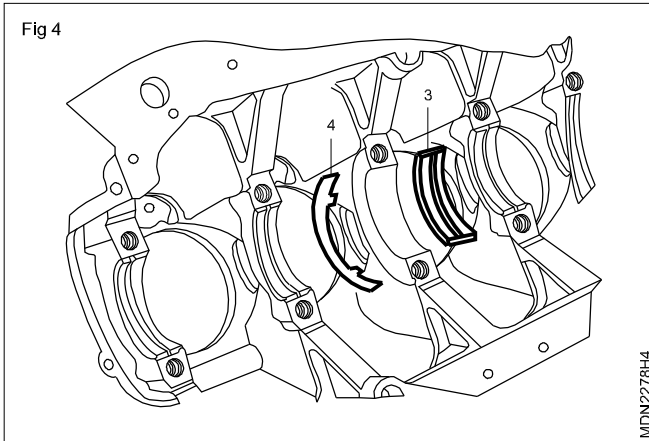
3. Remove the crankshaft bearing caps (9) and lower thrust bearings (7).



4. Remove the lower bearing shell (6) from the bearing cap (9).(Fig 2)
5. Remove the crankshaft (5).(Fig 3)
6. Remove the upper thrust bearings (4).(Fig 4)
7. Remove the upper bearings shells (3) from crankcase.
8. Thoroughly clean the oil gallery.



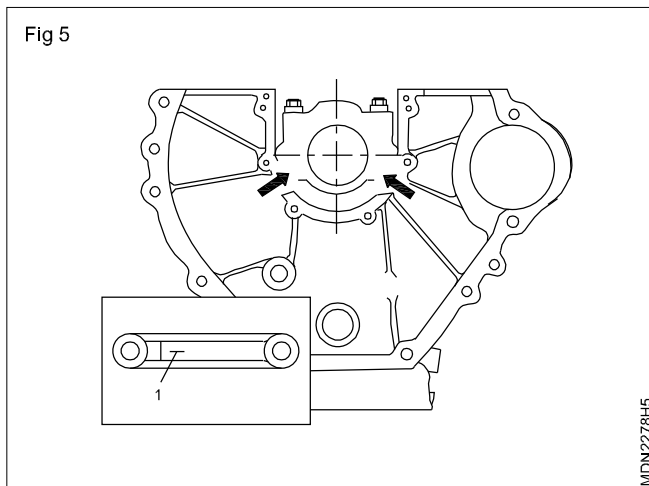
9. Select a proper new bearing shells with references to table.



10 Coat the new bearing shells with oil and insert into the crankcase and into the crankshaft bearing caps.

Notice: Do not mix up upper and lower crankshaft bearing shells

11. 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°
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No. 1 is vibration damper side. (Fig 2)

12 Measure crankshaft bearing diameters (E) using the dial gauge 00 and extension. (Fig 6)

13 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)

14 Measure crankshaft bearing journal diameter (F). (Fig 8)

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

15 Measure radial clearance of crankshaft bearing (G).

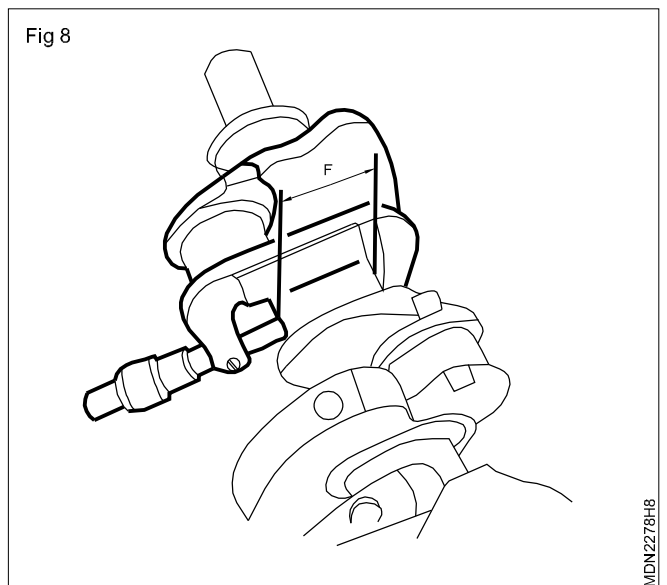
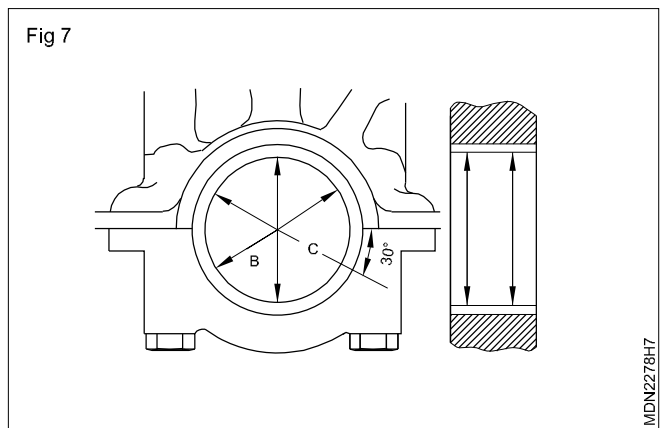
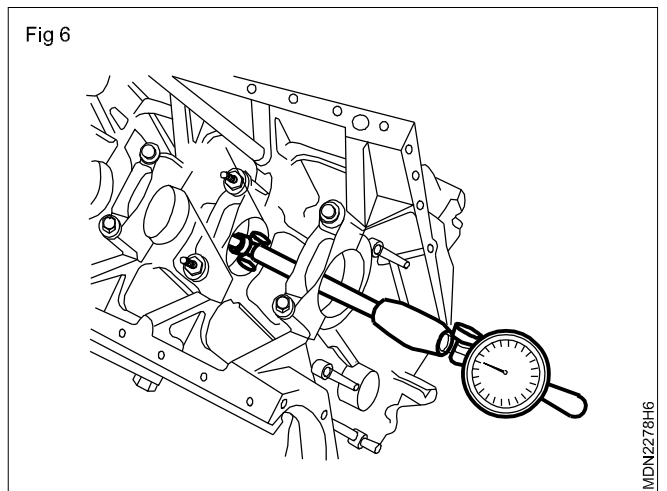
Clearance 'G'	0.027-0.051 mm
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Note: Compare final radial clearance figure of crank shaft bearing to the service manual

(Example) Measured value 'E' = 57.700 mm

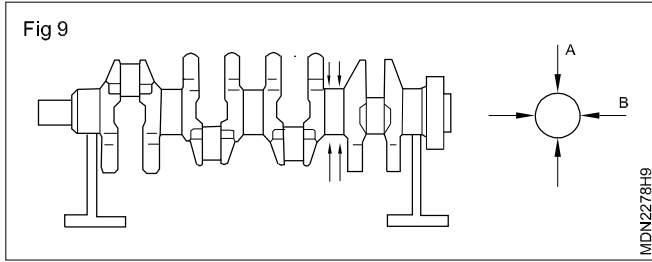
Measured value 'F' = 57.659 mm

Clearance 'G' = 0.041 mm

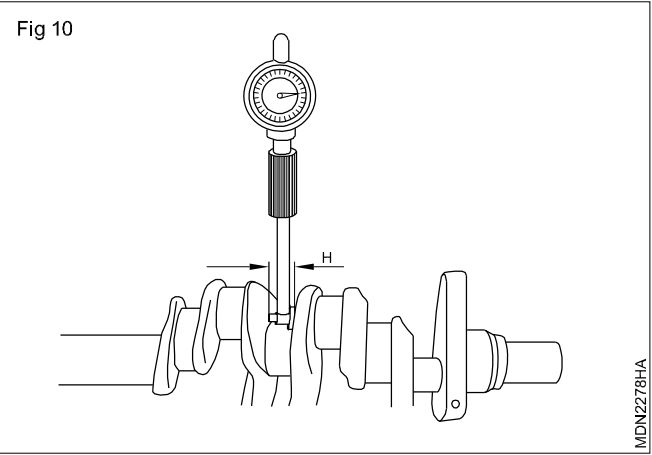


16 Remove the crankshaft bearing cap.

17 Measure width of trust bearing journal (H) and adjust with proper thrust bearings. (Fig 10)



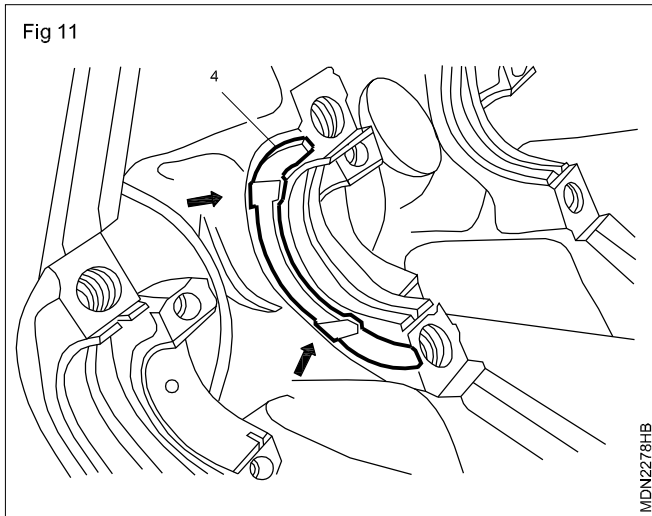
MDN2278H9



MDN2278HA

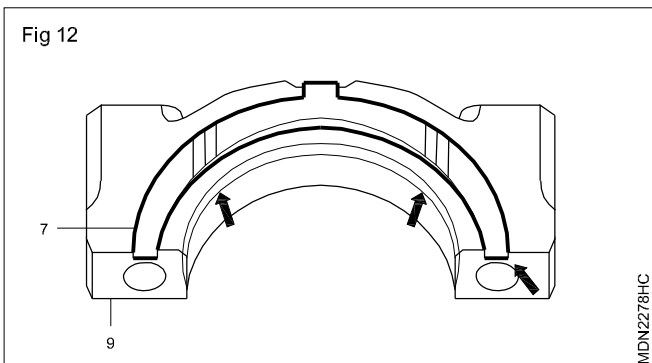
Notice: The same thickness of thrust washers should be installed on both sides of the thrust bearing.

18 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)



MDN2278HB

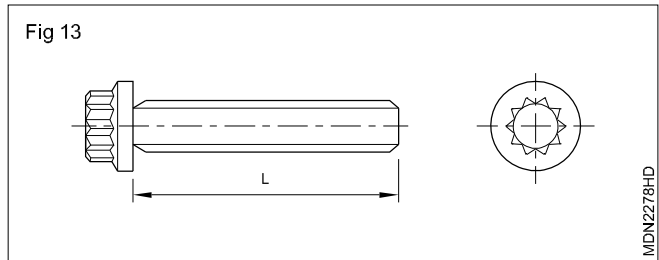
19 Coat the lower thrust bearing (7) with oil and insert into the crankshaft bearing cap so that the oil grooves are facing the crank webs (arrow). (Fig 12)



MDN2278HC

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

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



MDN2278HD

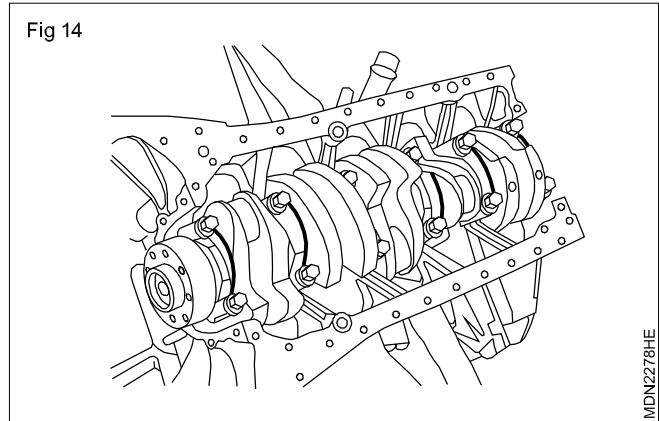
20 Coat the new crankshaft with engine oil and place it on the crankcase.

21 Install the crankshaft bearing caps according to marking and tighten the bolts.

Installation Notice

Tightening Torque	55 N*m (41 lb-ft) + 90°
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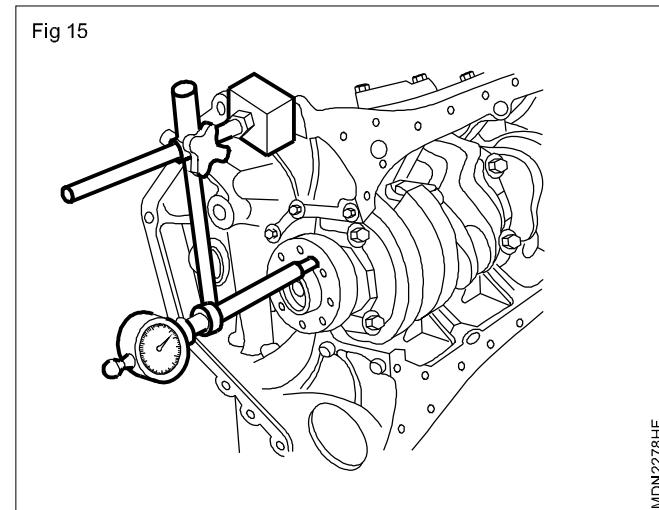
Install from No. 1 cap.



MDN2278HE

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

23 Measure crankshaft bearing axial clearance or thrust clearance dial gauge and dial gauge holder.(Fig 15)



MDN2278HF

Clearance	0.100 - 0.245 mm
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Notice: Compare your thrust clearance figure to the service manual

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

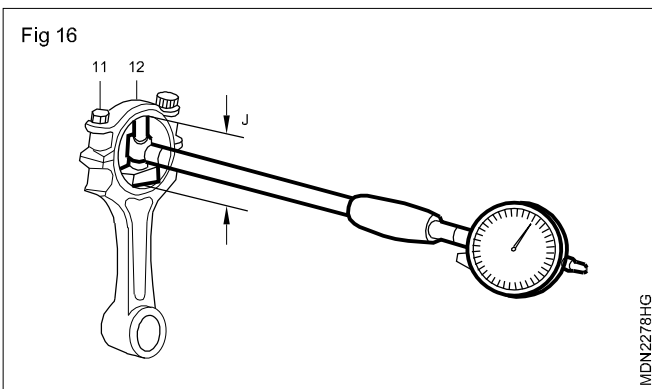
Notice: If the clearance is out of standard, adjust the axial clearance of crankshaft bearing by replacing the thrust washers.

24 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°
-------------------	-------------------------

25 Measure inner diameter of connecting rod bearing. (Fig 6)



26 Measure connecting rod bearing journal diameter (k).

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

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

(Example) Measured value 'E' = 47.700 mm

Measured value 'F' = 47.653 mm

Clearance 'G' = 0.047 mm

Radial Clearance 'L'	0.026 - 0.068 mm
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Note : Compare your radial clearance of the connecting rod bearing to the service manual

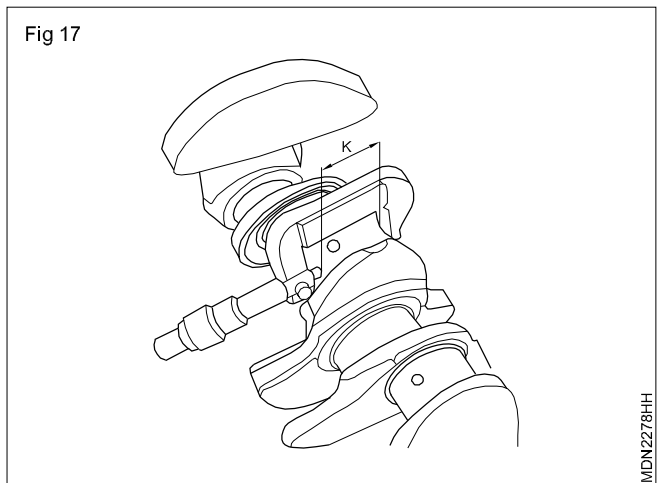
Notice: if the clearance is out of standard, adjust the radial clearances of connecting rod bearing by replacing the connecting rod bearing shells.

28 Remove the connecting rod bearing cap.

29 Install the piston.

30 Rotate the crankshaft by hand and check whether it rotates smoothly.

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



Remove the crankshaft from the engine

Objectives: At the end of this exercise you shall be able to

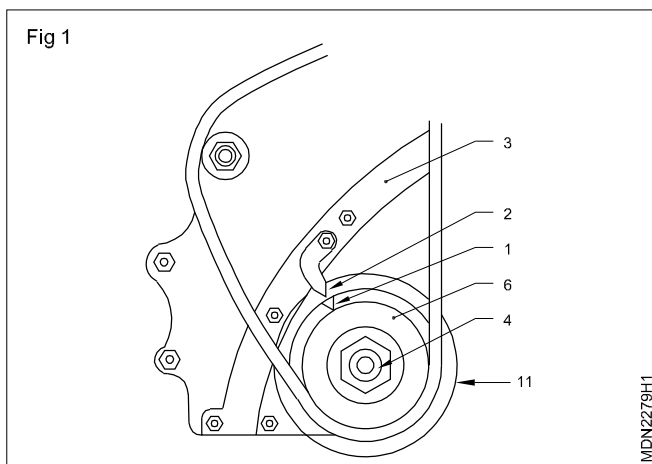
- remove the damper pulley
- remove the timing gear/timing chain
- remove the flywheel from the engine
- remove the crankshaft assembly from the engine.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Torque wrench	- 1 No.	• Cotton cloth	- as reqd.
• Mallet, Drift punch	- 1 No.	• Kerosene	- as reqd.
		• Soap oil	- as reqd.
		• Lube oil	- as reqd.
Equipments/Machineries			
• Multi cylinder diesel engine	- 1 No.		

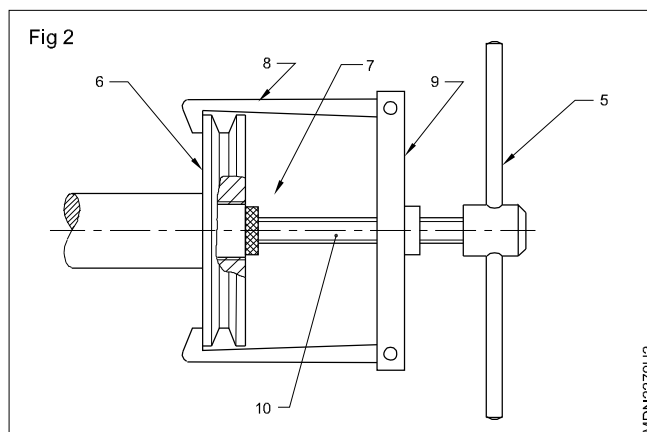
PROCEDURE

TASK 1 : Removal of damper pulley

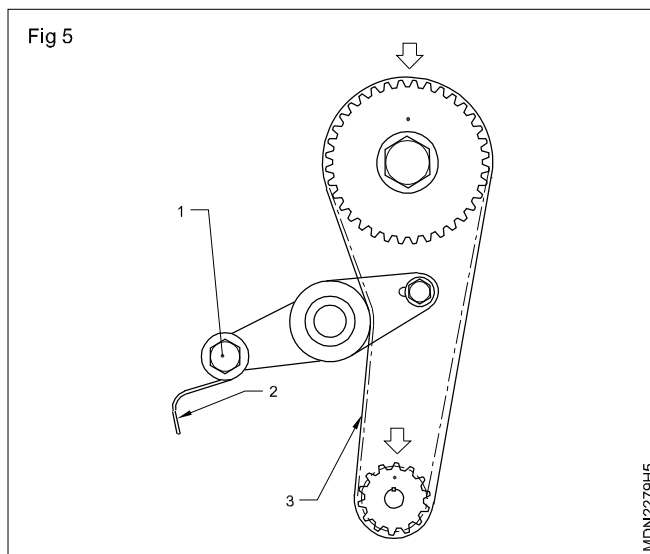
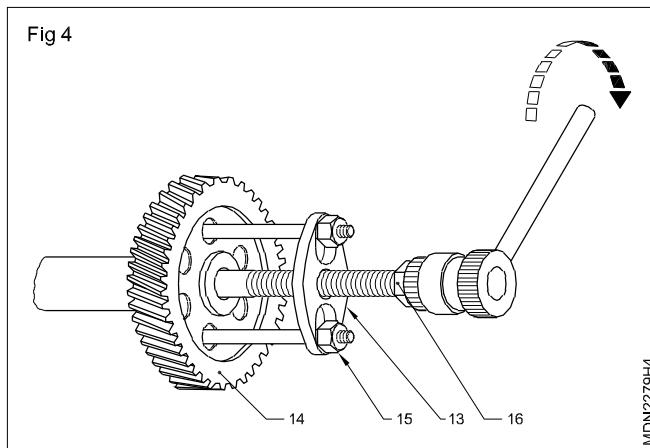
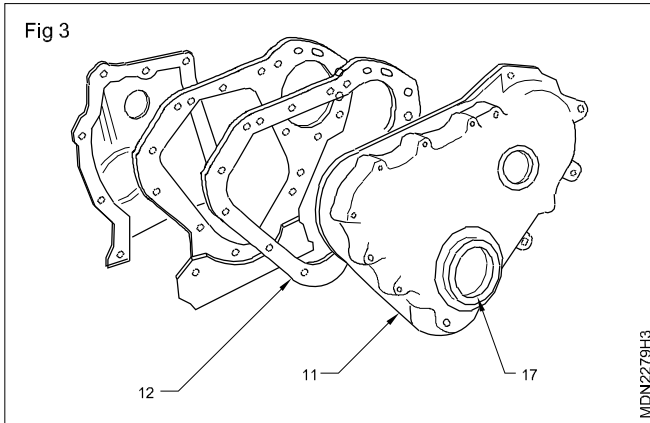
- 1 Rotate the engine and coincide the timing marks (1) with the timing pointer (2). (Fig 1)



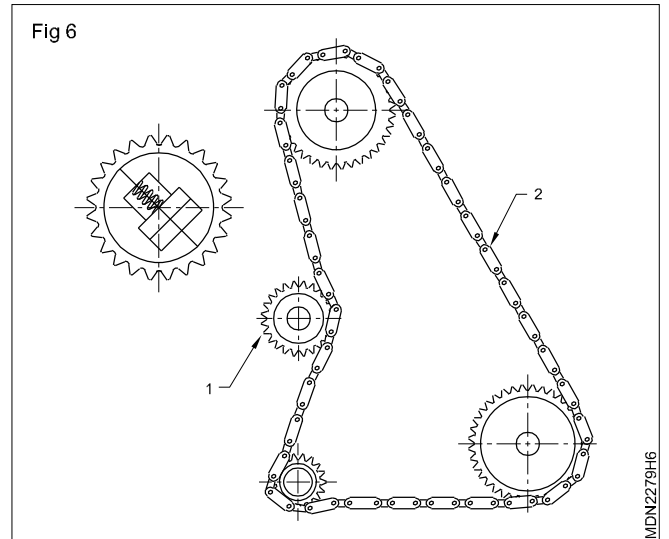
- 2 Mark the position of the pointer (2) with respect to the timing cover(3).
- 3 Place a wooden piece in between the flywheel ring gear and crankcase to prevent rotation of the flywheel.
- 4 Remove the crankshaft pulley nut(4).
- 5 Place the puller (5) on the crankshaft pulley (6). Ensure the distance piece (7) does not sit inside the crankshaft threads.
- 6 Place the puller legs (8) in such a way that the puller's flange (9) is parallel to the pulley (6). (Fig 2)



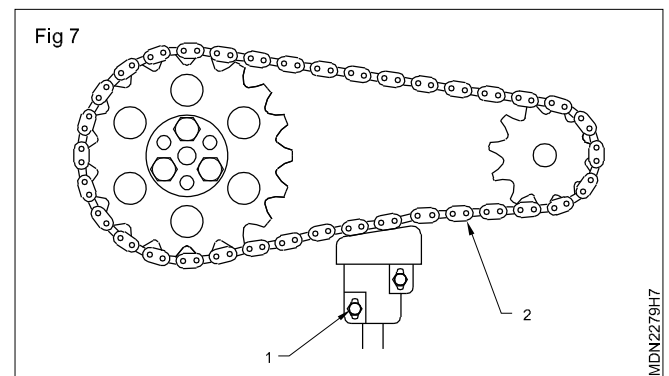
- 7 Tighten the centre bolt (10) till the pulley (6) comes out of the crankshaft.
- 8 Remove the damper pulley (11) with the help of puller. Remove the timing cover (11) loosening the mounting screws diagonally opposite.
- 9 Remove the gasket (12) and oil seal (17). (Fig 3)
- 10 Unscrew the mounting bolts of the timing gear.
- 11 Place the puller (13) on the camshaft timing gear (14).
- 12 Tighten the puller bolt (15) in such a way that the puller flange (13) is parallel to the timing gear (14). (Fig 4)
- 13 Tighten the centre bolt (16) till the timing gear (14) comes out of the camshaft. (Fig 5)
- 14 Remove the woodruff key.
- 15 Remove the chain/belt from the gear/sprocket.



- 16 Remove the chain/belt having the tensioner.
- 17 Loosen the water pump bolt (1) till the spring's (2) tension is reduced.
- 18 Loosen and remove the belt (3) from the pulley.
- 19 Loosen the timing chain tensioner (1) and remove the tensioner from the tensioner contact and take out the chain (2) from the gear. (Fig 6)

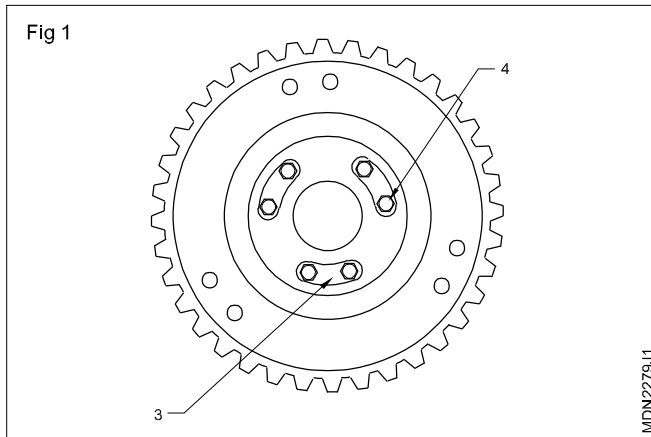


- 20 Loosen the chain tensioner mounting bolt (1). (Fig 7)
- 21 Remove the bolt.
- 22 Remove the spring.
- 23 Remove the tensioner pad.
- 24 Take out the chain (2) from the chain sprocket.

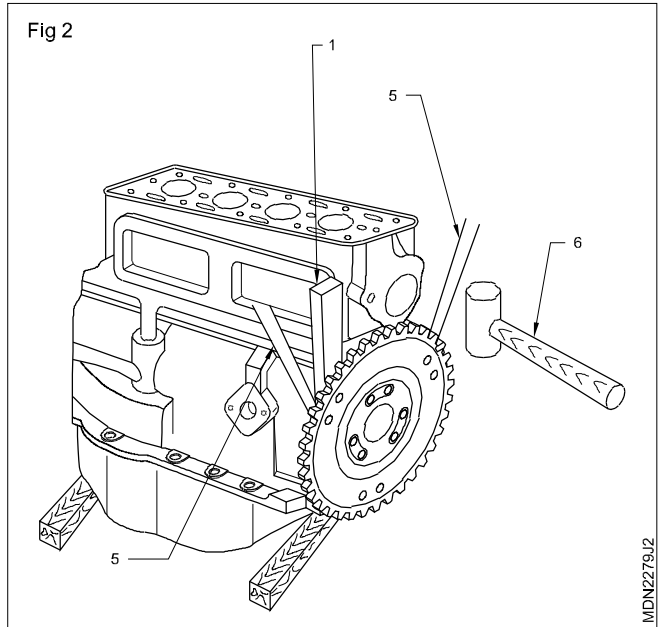


TASK 2 : Removal of flywheel

- 1 Lock the flywheel by placing a wooden piece (1) between the flywheel and crankshaft or use a special tool to lock the flywheel rotation.
- 2 Unlock the lock plates (3)/locking wire from the flywheel mounting bolts (4). (Fig 1)



- 3 Unscrew the fastening bolts from the flywheel.
- 4 Use a pry bar (5) between the flywheel and the back of the engine or plastic mallet (6) for loosening the flywheel. Ensure that the flywheel does not fall on the ground. (Fig 2)
- 5 Remove the flywheel and keep it on the inspection table.



TASK 3 : Removal of crankshaft

- 1 Turn the engine upside down and keep the engine on wooden blocks.
- 2 Mark the main bearing caps (2) with respect to the crankcase (3).
- 3 Unscrew the bolts/nuts of the main bearing caps (2).
- 4 Tap the main bearing caps (2) with a plastic mallet.
- 5 Lift the bearing caps (2) along with the bearing shell evenly. Ensure that dowels do not bend. A bent dowel may cause misalignment of the caps resulting in bearing wear/ crankshaft seizure. (Fig 1)
- 6 Lift the crankshaft (4) with the help of another person/ lifting the hook (5) by holding each end, and place it on the inspection stand. (Fig 2)
- 7 Put the bearing caps at their respective places with the same bolts.

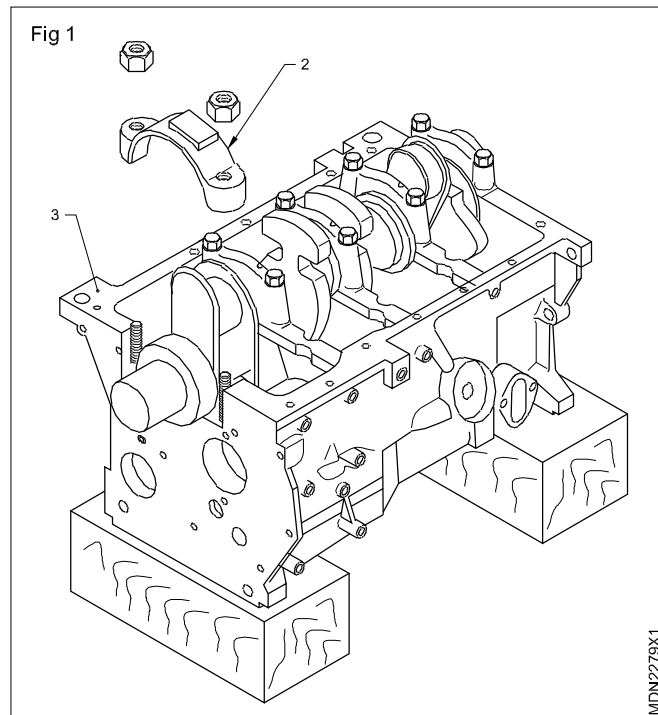
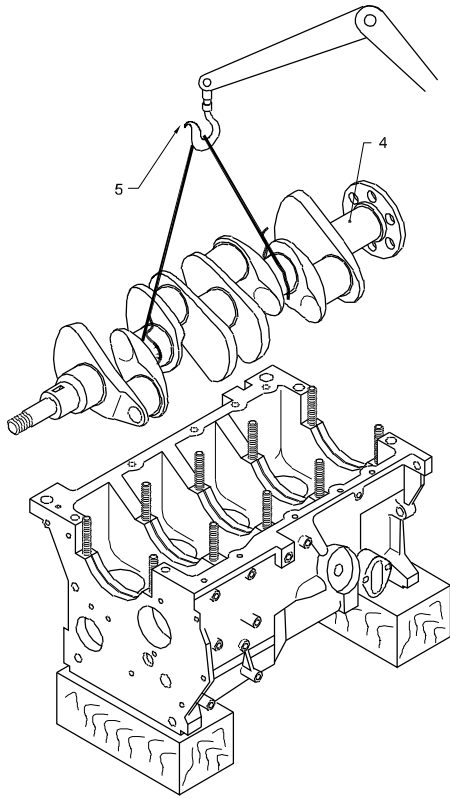


Fig 2



MDN2279X2

Inspecting oil retainer and thrust washer

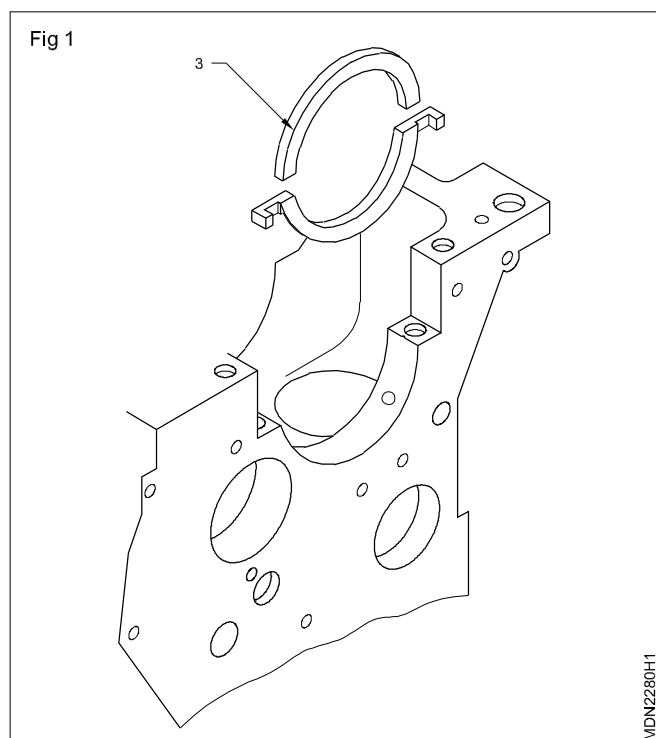
Objectives: At the end of this exercise you shall be able to

- check the wear of thrust surfaces of crank shaft
- inspect the oil retainer of crank shaft.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Dial indicator	- 1 No.	• Cotton cloth	- as reqd.
• 'V' block	- 1 No.	• Kerosene	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Lube oil	- as reqd.
• Work bench	- 1 No.	• Oil retainer	- as reqd.
• Surface table	- 1 No.		

PROCEDURE

- Remove the crank pulley
- Disconnect and remove the all connecting rods caps
- Loosen the mounting of crank shaft
- Remove the crankshaft from the engine
- Place the crankshaft in tray on the work bench
- Clean the crank shaft
- Clean the thrust half washers and oil retainers (Fig 1)
- Check the thrust washers for wear and damages
- Check the crankshaft oil retainers (1) for damages
- Place the crankshaft on the 'V' blocks and ensure crankshaft in freely rotate
- Set the dial indicator for check the thrust surfaces and rotate the crank shaft and measure the wearness
- Refer the wearness reading with service manual reading
- If thrust surface wear is more than the specified limit recommend for regrinding
- If any damage in thrust half washers and oil retainers replace it.



Measuring the crankshaft taper and ovality

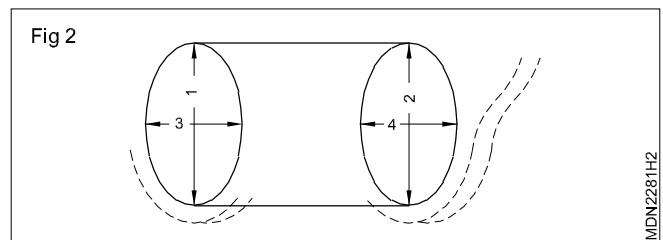
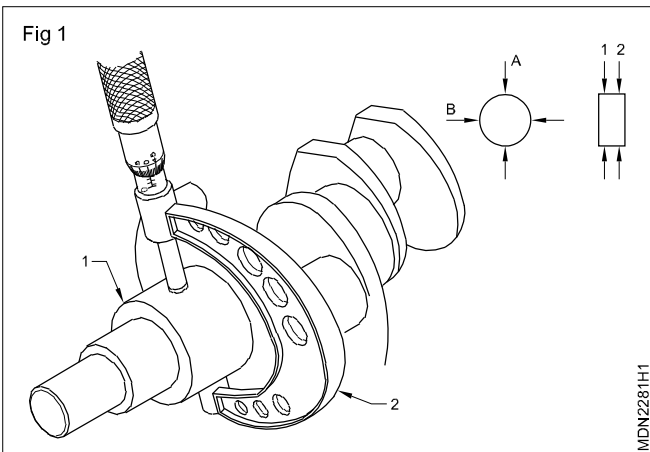
Objectives: At the end of this exercise you shall be able to

- check the crankshaft journal wear
- measure the crankshaft journal wear, taper and ovality.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Outside micrometer	- 1 No.	• Cotton cloth	- as reqd.
• 'V' block	- 2 No.	• Kerosene	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Lube oil	- as reqd.
• Surface table	- 1 No.		

PROCEDURE

- 1 Remove the crankshaft from the engine block
- 2 Clean the crankshaft assembly with cleaning solvent
- 3 Clean the crankshaft with compressed air and banyan cloth
- 4 Check the crankshaft visually for cracks and damages
- 5 With the help of a outside micrometer measure the journal diameter at '1' '2' '3' & '4'. The difference in reading between '1' & '3' and '2' & '4' will give the ovality and '1' & '2' will give taper. (Fig 1 & Fig 2)
- 6 If the taper and ovality is more than the given specified limit, then the crankshaft should be reground for undersize.
- 4 Measure the oil clearance between the crankshaft main journal and the bearing shell.



Inspect the crankshaft

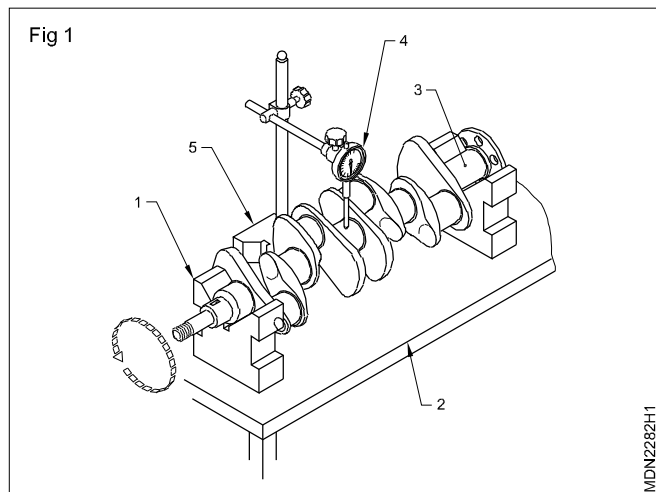
Objectives: At the end of this exercise you shall be able to

- check bend & twist of the crankshaft
- check fillet radii of the crankshaft.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• 'V' block	- 2 No.	• Cotton cloth	- as reqd.
• Dial gauge with magnetic base	- 2 No.	• Kerosene	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Lube oil	- as reqd.
• Surface table	- 1 No.		

PROCEDURE

- 1 Place two 'V' blocks (1) on the surface table (2).
- 2 Place the crank shaft (3) on the 'V' blocks and adjust the distance between the 'V' blocks in such a way that on either side of the 'V' block the shaft does not overhang more than 1/10th of its total length.
- 3 Place the dial indicator with the magnetic base (5) on the surface table. (Fig 1)

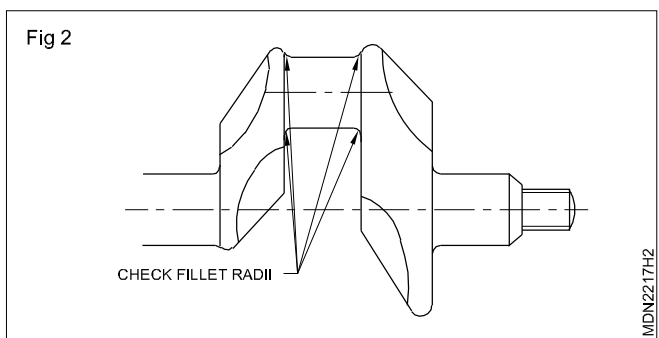


- 4 Bring the dial indicator (4) at the centre of the shaft (3).
- 5 Push the dial indicator's (4) needle on the shaft so that the needle shows some deflection.
- 6 Adjust the indicator's needle to 'O' position by rotating the dial.

- 7 Rotate the shaft (3) by hand and note down the deflection of the needle. This will give the bend of the shaft at the centre.
- 8 Repeat the above steps at three places, so as to cover the complete length of the shaft (3).
- 9 Check fillet radii of the main and connecting rod journals (Fig 2)

Note down the maximum bend at all the places.

Removal of bend/replacement of shaft recommended, if the maximum bend at any one or more places is found more than the limit specified by the manufacturer.



Inspect the flywheel and spigot bearing

Objectives: At the end of this exercise you shall be able to

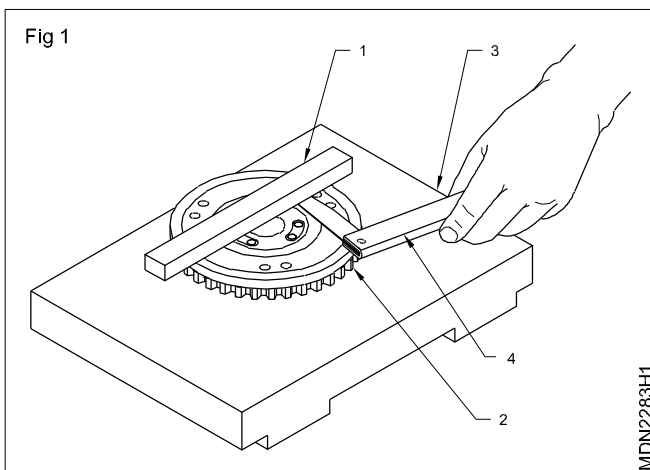
- inspect the flywheel and mounting flange
- inspect the spigot bearing.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Torque wrench	- 1 No.	• Cotton cloth	- as reqd.
• Box spanner kit	- 2 No.	• Kerosene	- as reqd.
• Bearing puller	- 1 No.		
Equipments/Machineries			
• Multi cylinder diesel engine	- 1 No.		

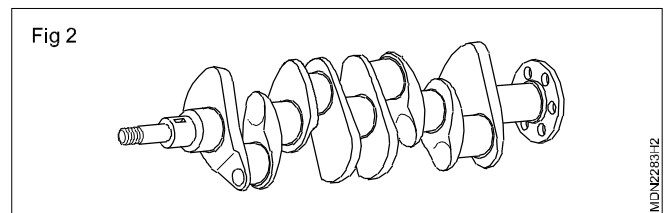
PROCEDURE

Inspecting flywheel and mounting flange

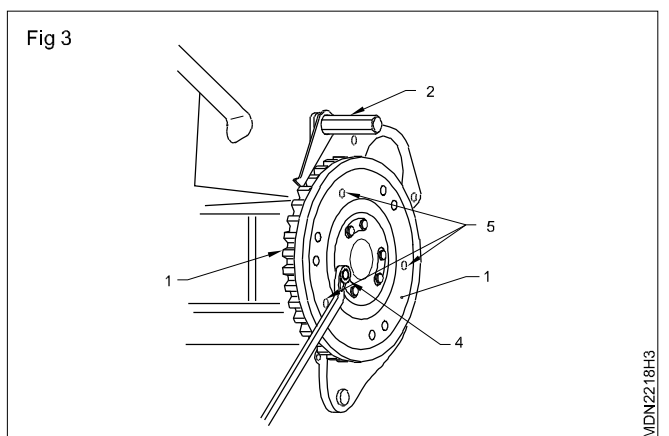
- 1 Clean the surface of flywheel
- 2 Visually check the flywheel (Fig 1) friction surface by using a straight edge (1) and feeler gauge (4)
- 3 Flywheel warpage is more than the specified limit by the manufacturer, then recommend for machining
- 4 Ensure that flywheel thickness after machining it has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



- 6 Visually check the flywheel mounting flange (Fig 2) for damage and cracks
- 7 Fix the flange bolts on the crankshaft
- 8 Remove the spigot bearing from rear end of the crankshaft/flywheel
- 9 Clean and inspect the bearing clearance and noise
[If wornout replace with new bearing]



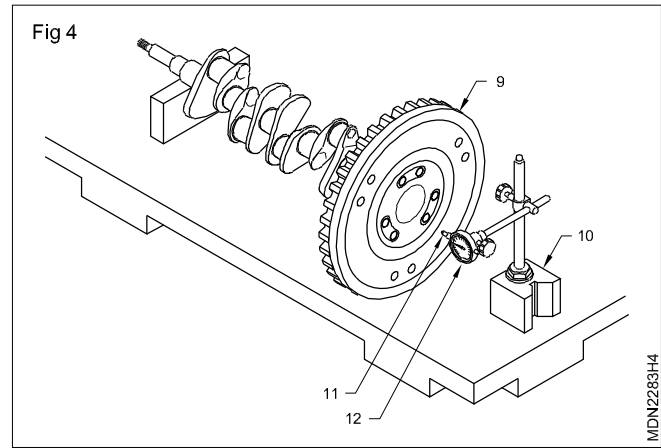
- 10 Fit the spigot bearing in the socket of crankshaft rear end.
- 12 Align the bearing with the help of dummy shaft.
- 13 Align the flywheel holes and flange bolts/dowel pins (5) (look for timing mark alignment with 1st cylinder (Fig 3)



- 14 Install the flywheel (1) on the crankshaft flange.
- 15 Lock the flywheel from rotation (by using the special tool) (2).
- 16 Tighten the flywheel mounting bolts/nuts (4) diagonally and evenly to the specified torque.
- 17 Use positive locking device avoid failure

18 Check the face run out of the flywheel (Fig 4)

19 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.



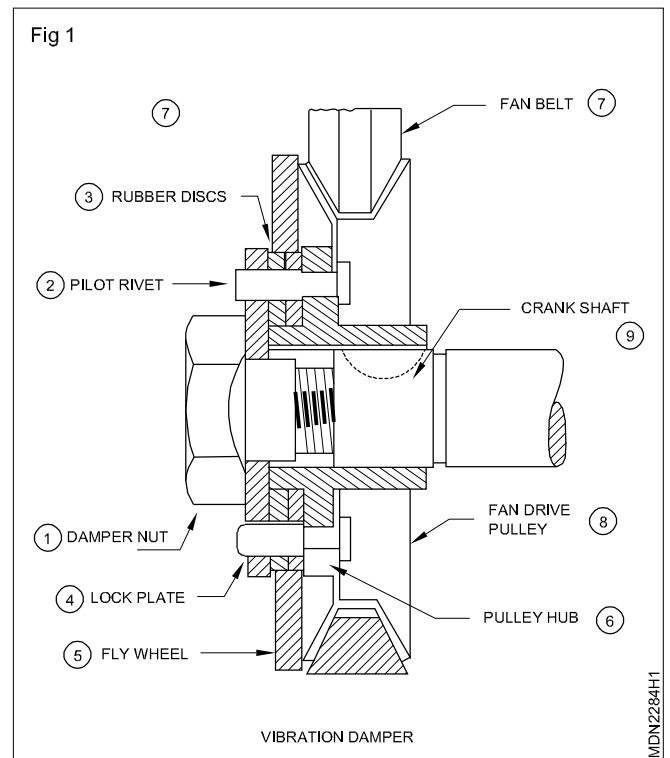
Check the vibration damper

Objective: At the end of this exercise you shall be able to
 • check the vibration damper defects.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Socket spanner for damper pulley	- 1 No.	• Cotton cloth	- as reqd.
• Pulley puller	- 1 No.	• Kerosene	- as reqd.
		• Vibration damper accessories	- as reqd.

PROCEDURE

- 1 Remove the fan belt (7) (Fig 1) from the fan drive pulley
- 2 Loose the damper nut (1) with help of socket spanner and remove the damper nut
- 3 Fix the puller on fan drive pully (8) and remove it
- 4 Place the fan drive pulley on the tray
- 5 Clean the vibration damper and fan drive pulley
- 6 Visually check the rubber discs (3), pilot rivet (2) and lock plate (4) of vibration damper.
- 7 Dismantle the vibration damper
- 8 Plate the vibration damper, pilot rivet discs, pulley hub, fandrive pully, lock plate, damper nut on the work bench in tray.
- 9 Clean all dismantle parts of the vibration damper
- 10 Inspect the dismantled parts for wear and damages
- 11 Select the damaged/ wearing parts and replace it with new parts.
- 12 Assemble the all dismantled parts of vibration damper.
- 13 Fit the vaibration damper on the crank shaft.
- 14 Ensure the vibration damper is properly installed with the fan drive pulley.



MDN2284H1

Removing and checking the cam shaft

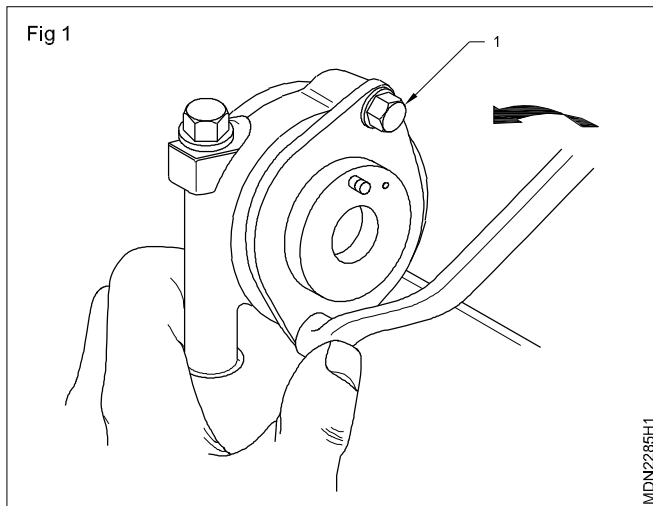
Objectives: At the end of this exercise you shall be able to

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

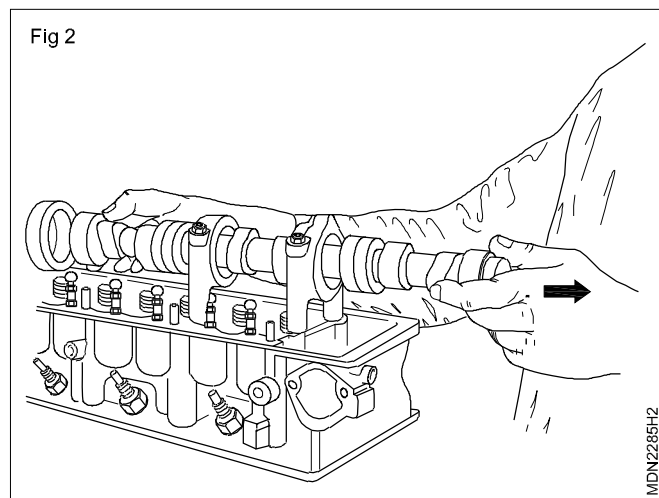
Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Mallet	- 1 No.	• Cotton cloth	- as reqd.
• Feeler gauge,	- 1 No.	• Kerosene	- as reqd.
• Outside micrometer	- 1 No.	• Soap oil	- as reqd.
• Dial test indicator	- 1 No.	• Lube oil	- as reqd.
• 'V' block	- 2 No.		
Equipments/Machineries			
• Multi cylinder diesel engine	- 1 No.		
• Surface table	- 1 No.		

PROCEDURE

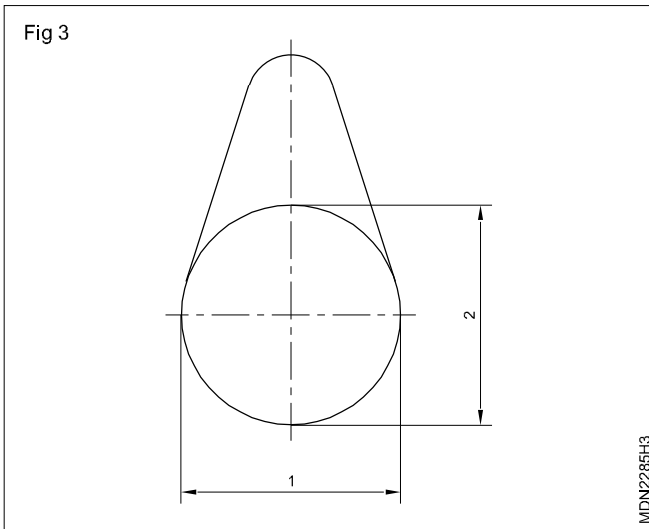
- 1 Remove the bolts (1) retaining the camshaft thrust plate and remove thrust plate (Fig 1)



- 2 Support the camshaft and carefully slide the journals through each bearing. Avoid contact of the surface with cam lobe and pull the camshaft. (Fig 2)
- 3 Clean the camshaft thoroughly.
- 4 Inspect the camshaft journals for scratches, grooves and pitting marks.
- 5 Measure each journal for ovality, taper and wear.
- 6 Check camshaft for bend and twist with dial test indicator



- 7 Check cam lobes surface for wear. (Fig 3) Measure diameter of the base circle (1) of camshaft with a micrometer.
- 8 Measure height (2) of cam lobe with micrometer.
- 9 Difference between cam lobe height (2) and base circle diameter (1) is cam lift.



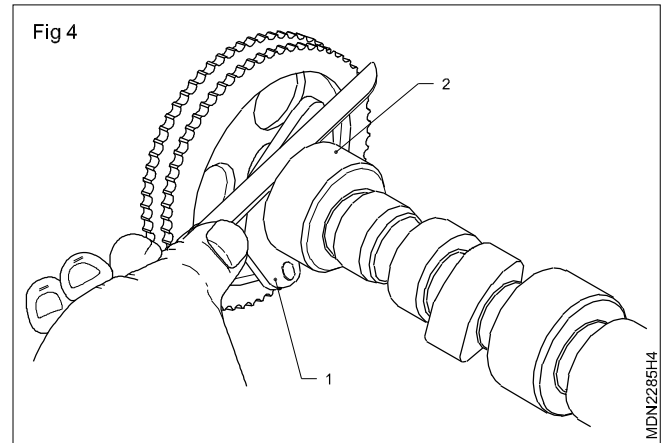
10 Check oil pump drive gear for pitting, wear and damage.

11 Check eccentricity for driving fuel pump.

12 Check the cam shaft bearings. If any damages, replace the bearing.

13 Measure clearance between thrust washer (1) and camshaft's first journal (2). (Fig 4)

14 Change thrust washer if clearance is not as per manufacturer's recommendation.



Assembling the crank shaft, piston and connecting rod assembly.

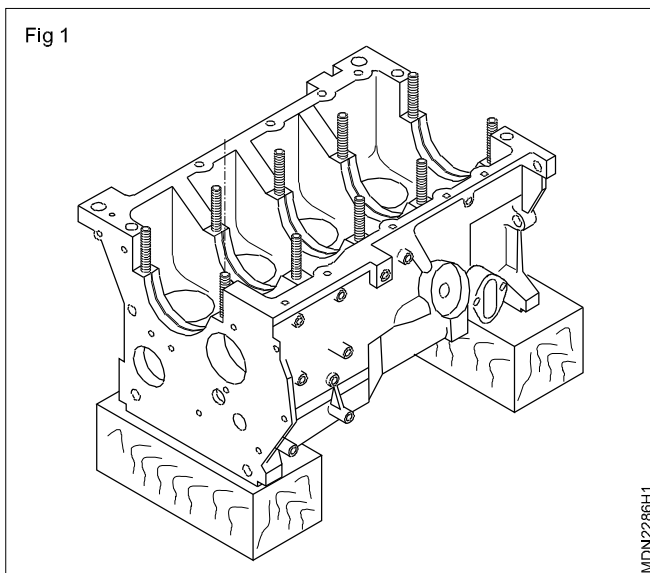
Objectives: At the end of this exercise you shall be able to

- 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	
<p>Tools/Instruments</p> <ul style="list-style-type: none"> • Magnetic base with dial gauge - 1 No. • Trainee tools kit - 1 No. • Heavy duty screw driver/bar - 1 No. • Torque wrench - 1 No. • Box spanner - 1 Set. • Piston ring compressor - 1 No. <p>Equipments/Machineries</p> <ul style="list-style-type: none"> • Multi cylinder diesel engine - 1 No. • Work bench - 1 No. • Wooden block - 2 Nos. • Oil can - 1 No. 	<p>Materials/Components</p> <ul style="list-style-type: none"> • Main journal bearing - 1 No. • Big end 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

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



- 2 Clean the parent bore of the main bearing in the cylinder block.
- 3 Clean the oil holes of the parent bore.
- 4 Place the main bearing shell into its respective parent bore. Ensure that the oil hole of the bearing shell and that of the parent bore align.

- 5 Install the crankshaft rear bearing seal (oil seal).

Insert the rubber packing (rubber rod) in the holes between the bearing cap and the cylinder block.

- 6 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.

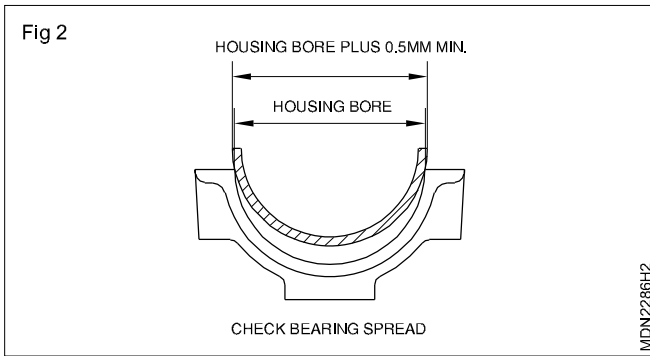
- 7 Install the thrust washers into the respective bearings. Lubricate all the bearing surfaces with clean engine oil.

Place the crankshaft in its position in the cylinder block.

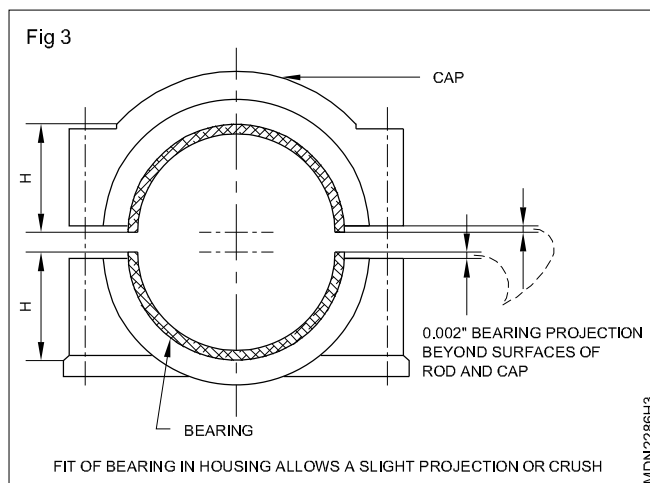
Place the shell bearings into their respective bearing caps.

Check the bearing shells for spread. The inserts should 'snap' into position in the housing and cap. (Fig 2)

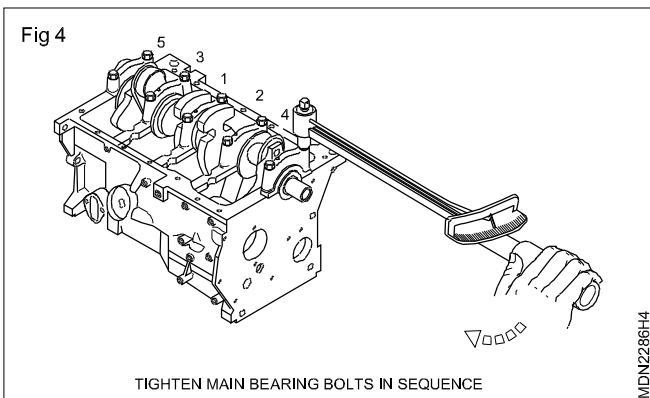
- 8 Lubricate and install the main bearing caps. Ensure that the bearing caps are fitted into their original positions.
- 9 Hand-tighten the main bearing cap bolts.
- 10 Tighten the middle bearing cap to the specified torque and check the crankshaft for free rotation.
- 11 Loosen the main bearing caps and bolts on one side.



12 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)



13 Tighten the bolts of the main bearing caps on either side of the centre bearing, one by one to the specified torque. (Fig 4)



14 Check the crankshaft for its free rotation after tightening each bearing cap's bolts.

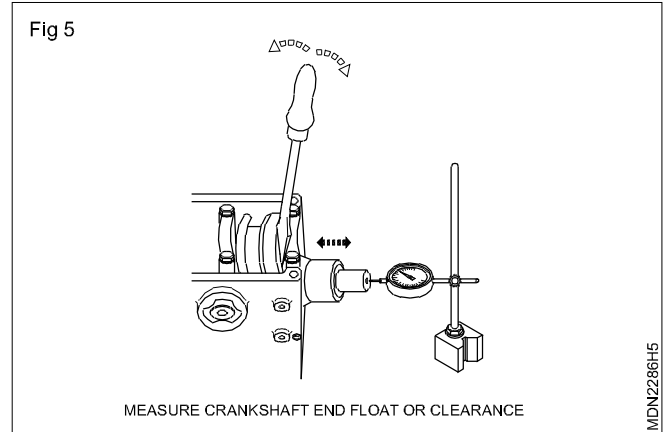
15 Check the crankshaft end play. (Fig 5)

16 To increase the end play use a thinner thrust washer and to reduce the end play use a thicker thrust washer.

17 Clear the cylinder block surface.

18 Keep the cylinder block in a tilted position and support it on wooden blocks.

19 Stagger the piston rings as specified by the manufacturer.

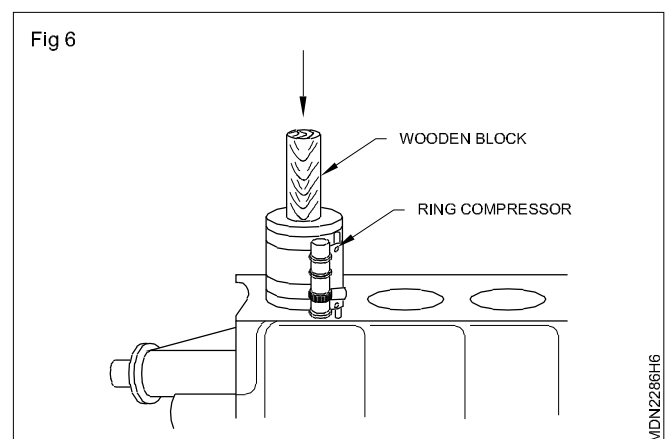


20 Lubricate the cylinder walls, piston and rings, big end bearing shells and crankpins with engine oil.

21 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.

22 Bring the respective crankpin to T.D.C.

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.



24 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 crankshaft while rotating the crankshaft. (Fig 7)

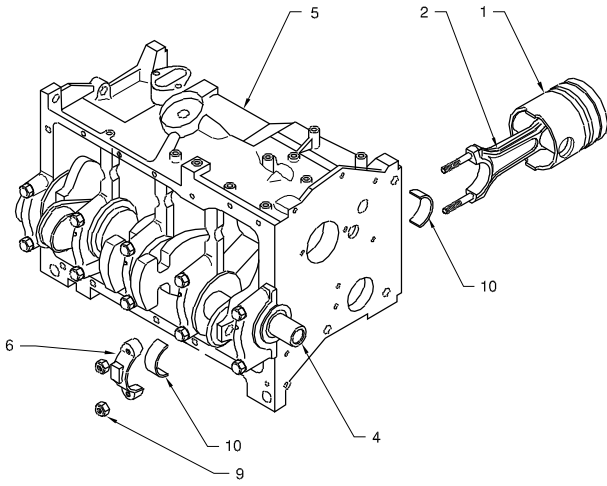
25 Fit the connecting rod bearing cap, along with the lower bearing shell.

26 Tighten the bearing cap bolts/nuts to the recommended torque.

27 Rotate the crankshaft and check for free rotation.

Repeat the above steps for fitting all the remaining pistons and connecting rod assemblies.

Fig 7



MDN2286H7

Practice on cleaning and checking the cylinder blocks

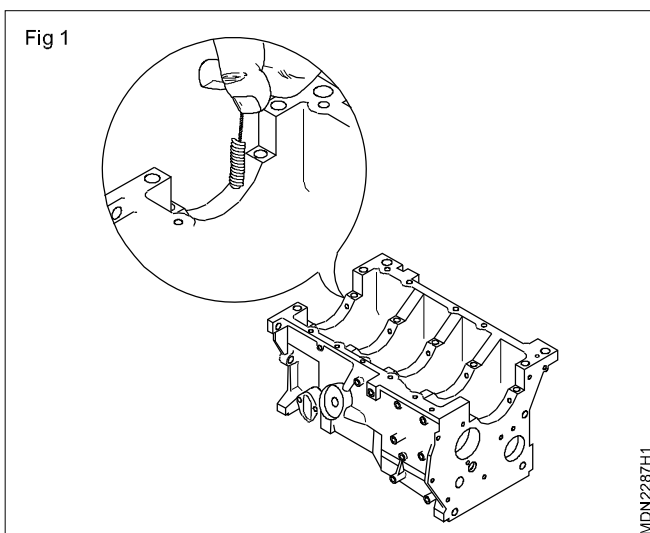
Objectives: At the end of this exercise you shall be able to

- clean the cylinder block
- check the cylinder block.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Scraper	- 1 No.	• Cotton cloth	- as reqd.
Equipments/Machineries		• Kerosene	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Soap oil	- as reqd.
• Air compressor, Water washer	- 1 No.	• Lube oil	- as reqd.

PROCEDURE

TASK 1: Cleaning



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 scapper to remove hard carbon deposits and take care with out damage the highly finished sur faces
7. Clean the cylinder block by using compressed air blast
8. Visually check the cylinder block for crecks and dam-ages
9. Replace the cylinder block if any damage is found.

Measure the cylinder bore taper, ovality and flatness.

Objectives: At the end of this exercise you shall be able to

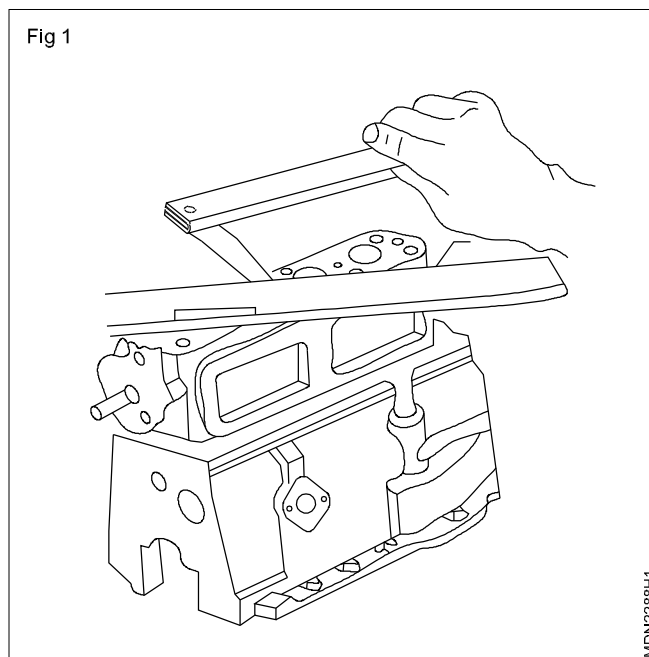
- check cracks and flatness of cylinder block
- check taper and ovality of cylinder bore and clean oil passages.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Straight edge, Feeler gauge	- 1 No.	• Banian cloth	- as reqd.
• Bore dial gauge	- 1 No.	• Kerosene	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Engine cylinder block	- 1 No.	• Lube oil	- as reqd.
• Air compressor, Water washer	- 1 No.		

PROCEDURE

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

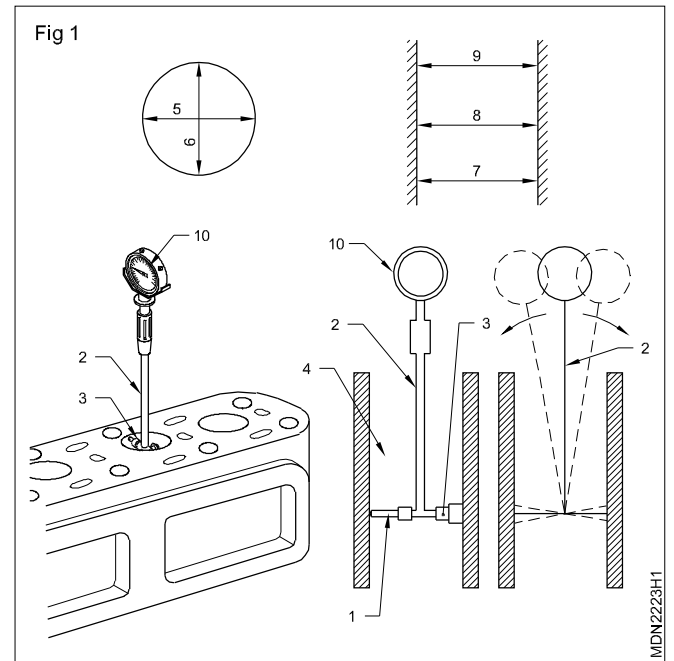
- 1 Place the cylinder block on the plain two wooden block
- 2 Clean the top plain surface of the cylinder block
- 3 wipe the plain surface with clean banian cloth to be required part of the cylinder block.
- 4 Keep the straight edge on the surface of the cylinder block and press the straight edge at the centre with your left hand.
- 5 Insert the feeler gauge leaves between the straight edge and the surface of the cylinder block (Fig 1).
- 6 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.
- 7 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.
- 8 Recommend for replacing or resurfacing of cylinder block in maximum face out is more than the specified limit by the manufacture.



TASK 1: taper, ovality and clean oil passages

- 1 Clean cylinder bore with a piece of cloth.
- 2 Measure inside diameter of the bore with an inside micro meter (80 mm)
- 3 Select the correct size of extension rod (1) which is more than measuring range (80.8 mm).
- 4 Assemble the extension rod on the stem of the dial test indicator (2).
- 5 Press the spring loaded plunger end (3) as it enters inside the bore.
- 6 Keep the bore gauge parallel to the cylinder wall by slightly rotating the gauge (2).

- 7 Set the needle at 'O' in dial indicator (10).
- 8 Take measurement at (6) with the bore gauge and note down the reading.
- 9 Take another reading (5) at right angles to the first reading.
- 10 Repeat above at three places (7,8 and 9).
- 11 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.
- 12 Note down maximum ovality and taper. If any one of them is more than the specified limit, recommend for re boring/ replacement of liner. (Fig 1)
- 13 Clean the oil main gallery with help of wire brush
- 14 Clean the oil pipe line by air pressure



Descaling water passages of cylinder block

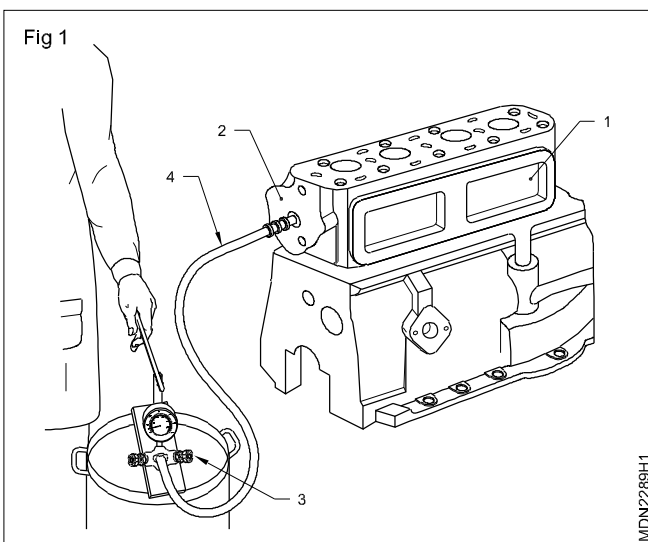
Objectives: At the end of this exercise you shall be able to

- descale the cylinder block water passages
- check the leakage of cylinder block.

Requirements	
Tools/Instruments	Materials/Components
<ul style="list-style-type: none">• Trainee's tool kit - 1 No.• Wire brush, scrapper - 1 No.• vaccum gauge - 1 No.	<ul style="list-style-type: none">• Steel plate with rubber pads - 1 No.• Cleaning solvent - as reqd.• Hot water - as reqd.
Equipments/Machineries	
<ul style="list-style-type: none">• Multi cylinder diesel engine - 1 No.• Air compressor, Water high pressure machine with rubber hose - 1 No.	

PROCEDURE

- 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 70°C to 80°C 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.



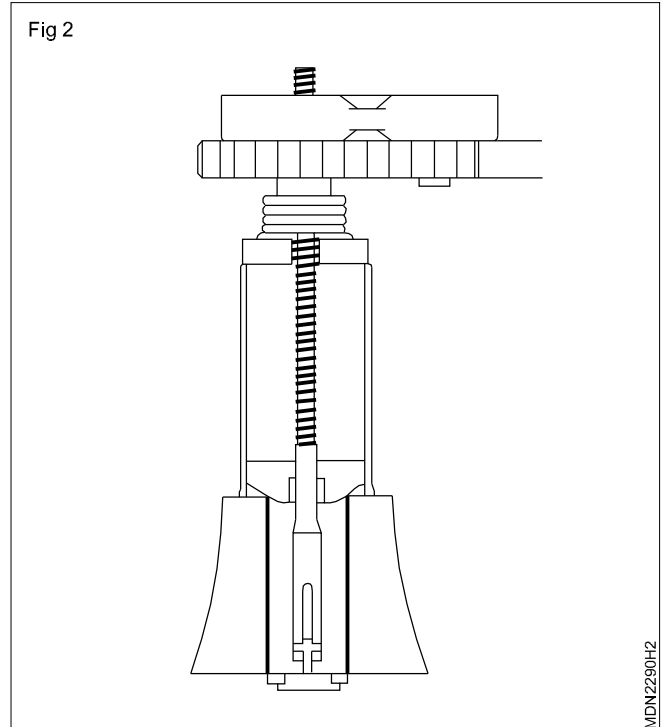
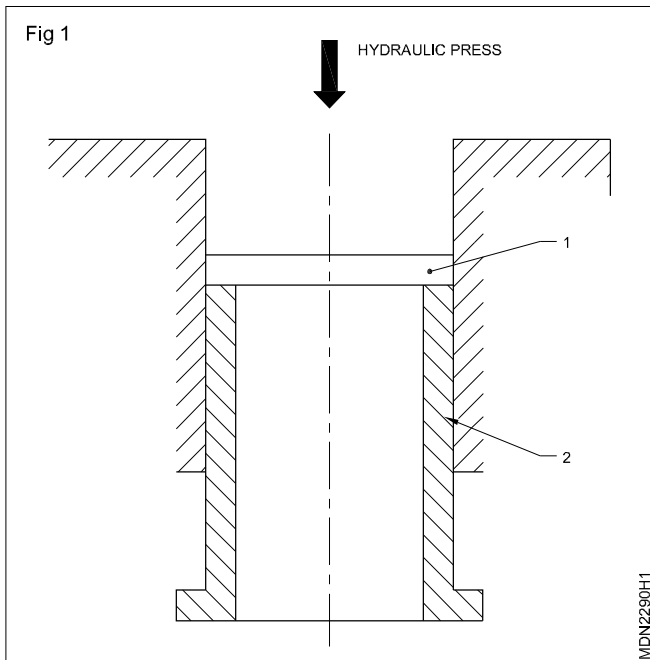
Removing the cylinder liner

Objective: At the end of this exercise you shall be able to
 • **remove cylinder liners from the cylinder bore.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Scraper	- 1 No.	• Cotton cloth	- as reqd.
Equipments/Machineries		• Kerosene	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Soap oil	- as reqd.
• Hydraulic press	- 1 No.	• Lube oil	- as reqd.

PROCEDURE

- 1 Clean the cylinder block with soap oil
- 2 Dry the cylinder block with compressed air pressure
- 3 Keep the cylinder block upside down on the hydraulic press bed
- 4 Ensure sufficient space is available for the liner come out properly on hydraulic machine bed
- 5 Place the drift (1) on liner and ensure that the drift, is seating properly on bottom base of liner (2)
- 6 Use suitable distance piece between the bore and the drift
- 7 Press out liner, individually and keep the liners on work bench
- 8 Clean the parent bores in the cylinder block thoroughly
- 9 Scrape out all the deposits of rust, scale, carbon, etc., from the block bore.
- 10 Scrape all the deposits, from the block counter bore for flanged type liner (Fig 2)



Refitting cylinder liner

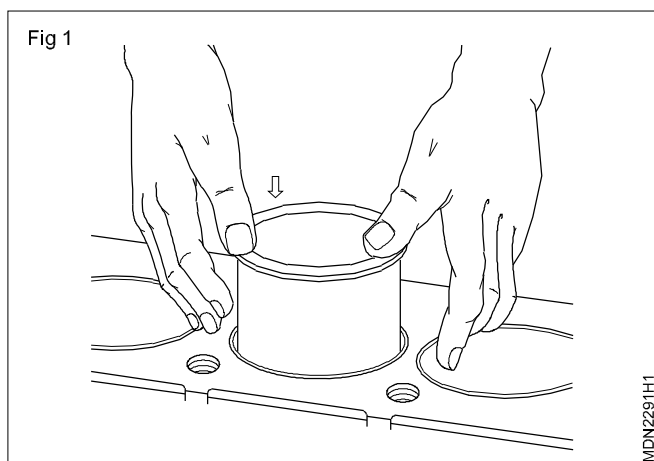
Objective: At the end of this exercise you shall be able to
 • Refit the wet liners on the cylinder bore.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Liners	- as reqd..
• Bore dial gauge	- 1 No.	• Cotton cloth	- as reqd.
• Drift liner	- 1 No.	• Soap oil/cleaning solvent	- as reqd.
• Tray	- 1 No.	• Lube oil	- as reqd.
Equipments/Machineries		• Liner sealing ring	- as reqd.
• Multi cylinder diesel engine	- 1 No.		
• Work bench	- 1 No.		

PROCEDURE

- 1 Clean the cylinder block liner's scaling
- 2 Select the new liner's
- 3 Visually inspect the liners
- 4 Measure the liner's out of roundness and thickness
- 5 Measure the liners diameter at one point and then moving 180° and measuring the diameter again with dial bore gauge
- 6 Confirm the liners specification with maker's recommendations.
- 7 Ensure the liner is fit for the cylinder bore
- 8 Clean wet liner sealing ring grooves and install the and bottom ('O' rings)

- 9 Liners protrusion can be checked at before used to installed with 'O' rings
- 10 Ensure 'O' rings are not twisted and properly sealed on liner grooves
- 11 After fix the liner 'O' rings inserts the small screw under the 'O' rings and drawn the around the entire grooves to allow the 'O' rings to align itself in the grooves on the sleeve.
- 12 Lubricate the 'O' ring and lower packing are of the block with lubricant recommended by the engine manuals
- 13 Insert the liner into block carefully and wind damage 'O' rings by sharp ridges on top of the block
- 14 Allow the liner to set into block on its own weight and ensure that 'O' rings are setting on the lower packing ring chamfer
- 15 Don't use excessive force when pushing liner
- 16 If the liner does not seated in the chamfer, bounce back up after pressure is smoked
- 17 In this condition remove the liner and replace the install the liner into cylinder block.
- 18 Finally ensure the liner is properly seated into block space
- 19 Liner it is advisable to use suitable bolts and washers to hold the liner it place



Reassembling the diesel engine parts

Objectives: At the end of this exercise you shall be able to

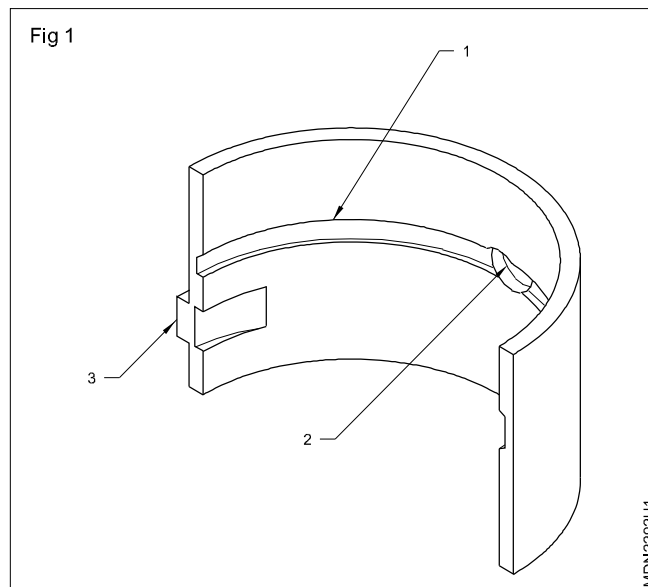
- assemble the crankshaft and camshaft
- assemble the piston in cylinder bore
- assemble the cylinder head assembly on cylinder block
- assemble fuel, water and electrical components
- adjust tappet clearance
- adjust fuel injection timing
- bleed the fuel system.

Requirements			
Tools/Instruments		Materials/Components	
<ul style="list-style-type: none"> • Trainee's tool kit • Torque wrench, Ring expander • Box spanner set • Feeler gauge 	<ul style="list-style-type: none"> - 1 No. - 1 No. - 1 No. - 1 No. 	<ul style="list-style-type: none"> • Tray • Cotton cloth • Kerosene • Soap oil • Lube oil 	<ul style="list-style-type: none"> - 1 No. - as reqd. - as reqd. - as reqd. - as reqd.
Equipments/Machineries			
<ul style="list-style-type: none"> • Multi cylinder diesel engine • Zib crane/engine hoist 			

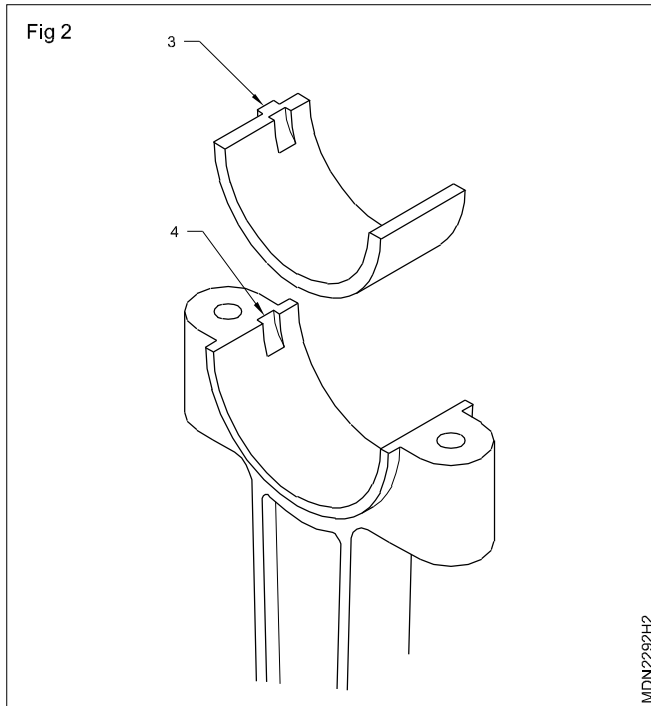
PROCEDURE

TASK 1 : Assembling crankshaft and camshaft

- 1 Clean main oil gallery in the cylinder block.
- 2 Place cylinder block in inverted position on stand.
- 3 Clean the water jackets if necessary.
- 4 Fit main bearing shells in the parent bore of the cylinder block and also in the bearing caps. Ensure that the bearing notches (3 & 4) sit in position and oil holes (2) of bearing shells and cylinder block are aligned. (Fig 1 & Fig 2)
- 5 Apply lub oil on the bearing shells.
- 6 Place the crank shaft.
- 7 Place the thrust washer in its position.
- 8 Fit the bearing caps ensure that the marks are matched, and tighten the caps at the recommended torque in given sequence.
- 9 Check free rotation of crank shaft after tightening each cap.
- 10 Check the end play of crankshaft, If it is not within limits replace the thrust washer to get recommended end play and lock the cap bolts.
- 11 Fit the timing back plate and lock the bolts.

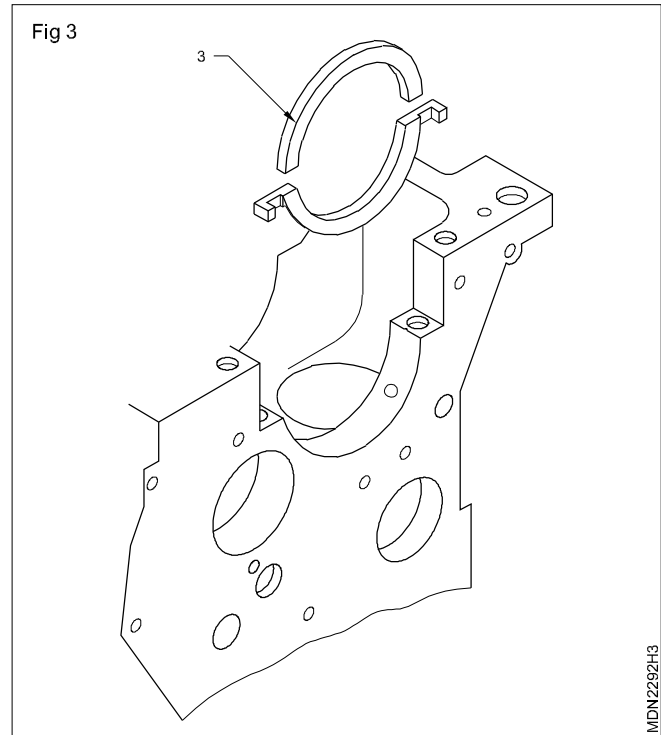


- 12 Fit the camshaft bushes. Ensure that the oil hole in block and bush is aligned.
- 13 Insert camshaft in its position.
- 14 Tighten camshaft thrust plate bolt.
- 15 Check camshaft end play and adjust with shims and lock it. Increasing shims will reduce the end play.
- 16 Fit the flywheel housing and tighten the bolts and lock them.



17 Press rear oil seal (3) into retainer and fit the same over the crank shaft. (Fig 3)

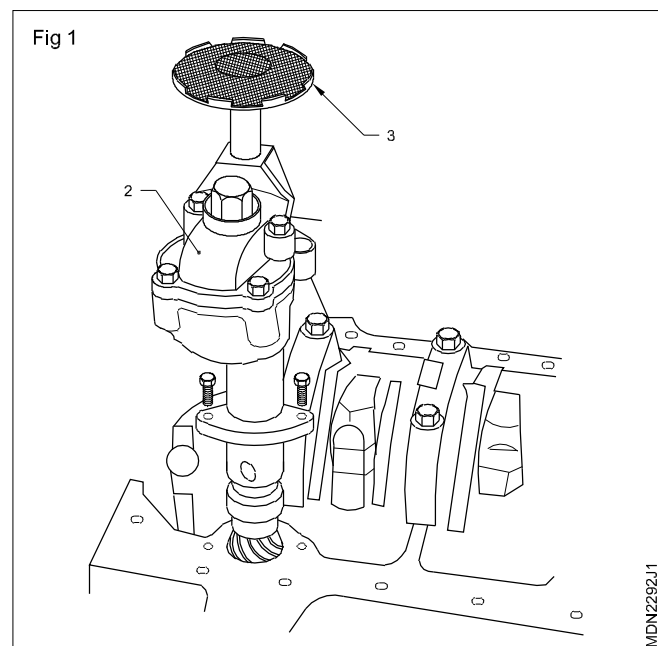
18 Check for free rotation of crankshaft.



19 Fix the flywheel in its position and tighten mounting bolts at the recommended torque.

TASK 2 : Assembling piston and connecting rod assembly in engine

- 1 Tilt the engine block and lubricate cylinder bore.
- 2 Stagger piston rings as specified by the manufacturer. Place the piston in the cylinder till the bottom ring touches the cylinder block's top. Ensure that the piston is placed in the cylinder in the same direction, as specified by manufacturer.
- 3 Bring respective crank pin to TDC.
- 4 Compress piston rings by a ring compressor.
- 5 Push the piston with a wooden block till connecting rod sits on the crankpin. Push the piston and simultaneously rotate the crankshaft till it comes to B.D.C. Ensure that the connecting rod does not dislodge from the crankshaft while rotating crank shaft.
- 6 Fit the connecting rod bearing cap along with the lower bearing shell. Tighten bearing cap bolts/ nuts at the recommended torque.
- 7 Rotate the crankshaft and check for free rotation. Repeat the above steps for fitting all the remaining pistons.
- 8 Fit oil pump (2) and check free rotation of oil pump shaft with the camshaft. (Fig 1)
- 9 Connect strainer (3) with oil pump and fix the oil sump with packing.
- 10 Place the engine vertically mount the engine on the stand properly.



11 Fit camshaft gear and coincide its timing mark with mark/ pointer on timing back plate. Coincide flywheel's TDC mark (1/6 or 1/4) with flywheel housing's pointer.

12 Fit idler gear and tighten its bolt.

13 In some engines timing chain/ belt is provided instead of idler gear to drive camshaft. Follow manufacturer's procedure. (Consult your instructor)

- 14 Replace timing case's oil seal and fit timing case.
- 15 Lock flywheel with wooden block or special tool.

- 16 Fit damper pulley and tighten damper pulley bolt at recommended torque.



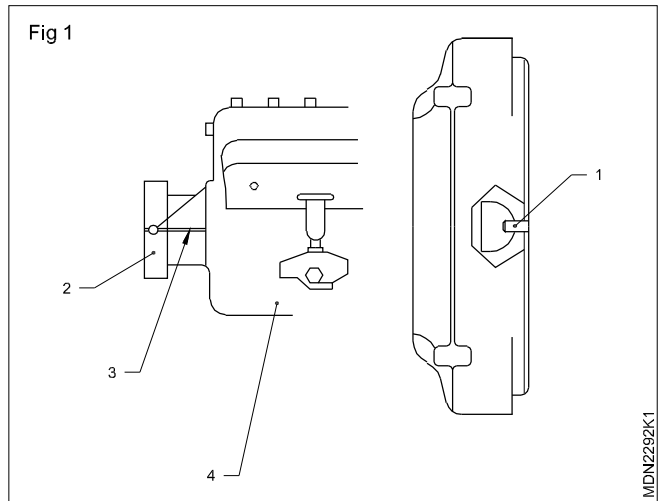
TASK 3 : Fitting cylinder head assembly, rocker arm assembly

- | | |
|--|--|
| <ol style="list-style-type: none"> 1 Check the tightness of the cylinder head studs and if found loose, tighten these at recommended torque. 2 Clean the cylinder head surface and engine block surface. 3 Place the cylinder head gasket on cylinder block. 4 Ensure that 'Top' marked on the gasket faces upwards. 5 Lower the cylinder head carefully on cylinder block. 6 Ensure that the studs are not damaged. 7 Tighten the cylinder head nuts in the given sequence at recommended torque. 8 Place tappets in tappet bore. | <ol style="list-style-type: none"> 9 Place push rods in push rod holes. 10 Place the rocker arm assembly on cylinder head. Ensure that the rocker shaft brackets do not hit the studs. 11 Loosen the ball pins of rocker levers. 12 Tighten rocker shaft mounting bolts at recommended torque. 13 Place new injector washers. 14 Fit the injectors and tighten at recommended torque. 15 Place the new gaskets on inlet and exhaust flanges. 16 Fit the inlet and exhaust manifolds and tighten the mounting nuts at recommended torque. |
|--|--|



TASK 4 : Fitting fuel injection pump, fuel filter assembly, oil filter, water pump, air cleaner, starter motor, dynamo/alternator

- 1 Turn flywheel and coincide its T.D.C. 1/4 or 1/6 marks with flywheel housing's pointer (1). Confirm that 1st cylinder is in compression stroke by rotating both the push rods of 1st cylinder by hand. In the compression stroke both the push rods will rotate. If both the push rods do not rotate turn flywheel one full round and again coincide 1/6 or 1/4 mark with flywheel housing. (Fig 1)
- 2 Rotate the FIP camshaft until the mark on its flywheel (2) is in line with pointer (3) on the pump body (4).
- 3 Install the pump on the bracket at the same time pump flange should go inside the drive flange and mount the radiator with proper mountings.
- 4 Ensure that the timing mark is not disturbed.
- 5 Fix bolts and tighten.
- 6 Fit fuel filter assembly and connect fuel lines to feed pump and FIP.
- 7 Connect high pressure lines and fix the clamp.
- 8 Fit overflow lines.
- 9 Fit oil filter assembly and connect the oil pipes.
- 10 Fix the gasket on the water pump body.



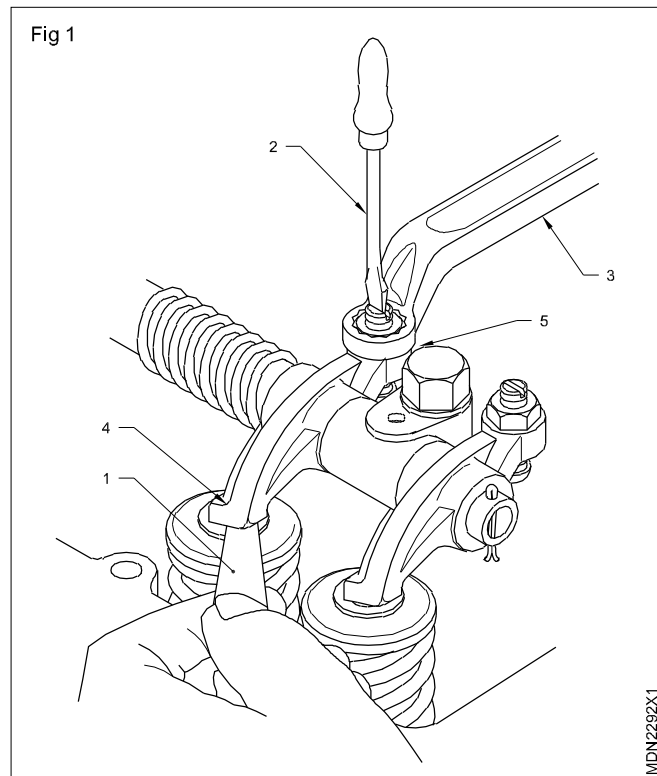
- 11 Fit the water pump and fix the fan leaf and mount the radiator with proper mounting
- 12 Fit self starter motor.
- 13 Fit dynamo/alternator.
- 14 Fit fan belt.
- 15 Fit the air cleaner assembly.



TASK 5 : Adjusting tappet clearance

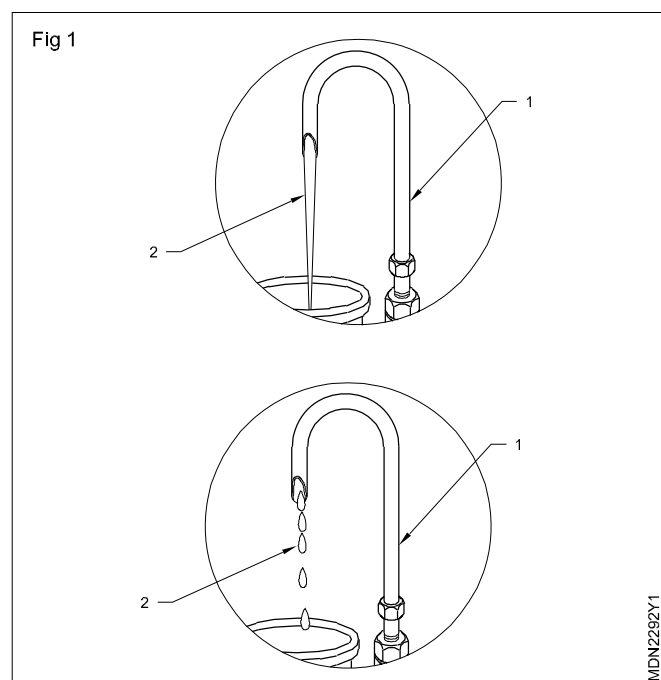
- | | |
|---|--|
| <ol style="list-style-type: none"> 1 Turn crankshaft in clockwise direction and coincide flywheel's TDC 1/6 or 1/4 mark with flywheel housing's pointer. Confirm that 1st cylinder is in compression stroke. | <ol style="list-style-type: none"> 2 Place ring spanner (3) on the lock nut (5). (Fig 1) 3 Place the specified thickness feeler gauge (1) between the valve stem and the rocker tip (4). |
|---|--|

- 4 Tighten the adjusting screw by a screw driver and at the same time move feeler gauge to and fro.
- 5 Stop tightening of the adjusting screw when it moves with the load, but it should not be jammed.
- 6 Rotate the push rod, it should also rotate with a slight load; but it should not be jammed.
- 7 Hold the adjusting screw with the screw driver firmly and tighten lock nut by a ring spanner (3).
- 8 Ensure that the adjusting screw (5) does not rotate while tightening the locking nut.
- 9 Check again the movement of the feeler gauge leaf (1) and push rod.
- 10 Repeat the above steps to adjust the tappet clearance for remaining cylinder according to firing order.
- 11 Rotate engine flywheel in clockwise direction to coincide INJ mark on flywheel with flywheel housing pointer.
- 12 Rotate FIP camshaft until the mark on its flywheel is in line with pointer on the FIP flange.
- 13 Tighten the FIP flange bolts.



TASK 6 : Checking injection timing by spill cut off method

- 1 Loosen F.I.P. flange's bolt.
- 2 Remove 1st delivery valve holder and remove valve peg and spring.
- 3 Fit delivery valve holder.
- 4 Fit swan neck pipe (1) on 1st delivery valve holder. (Fig 1)
- 5 Connect fuel gallery of F.I.P to fuel container placed at a higher level.
- 6 Move F.I.P. towards engine till fuel (2) starts flowing freely through swan neck pipe.
- 7 Now move the FIP away from engine till fuel flow cuts-off completely.
- 8 Again move F.I.P. towards engine and stop. When the fuel flow regulates in such a way that there is a flow of each drop between 15 and 20 seconds, at that time tighten the bolts of the F.I.P. flange without varying the flow of drop.
- 9 Remove swan neck pipe (1) and delivery valve holder and replace peg and spring and fit the delivery valve holder.
- 10 Connect the pressure pipes between injectors and fuel injection pump.
- 11 Place the valve door gasket over the cylinder head.
- 12 Fix the valve door cover and tighten bolts.

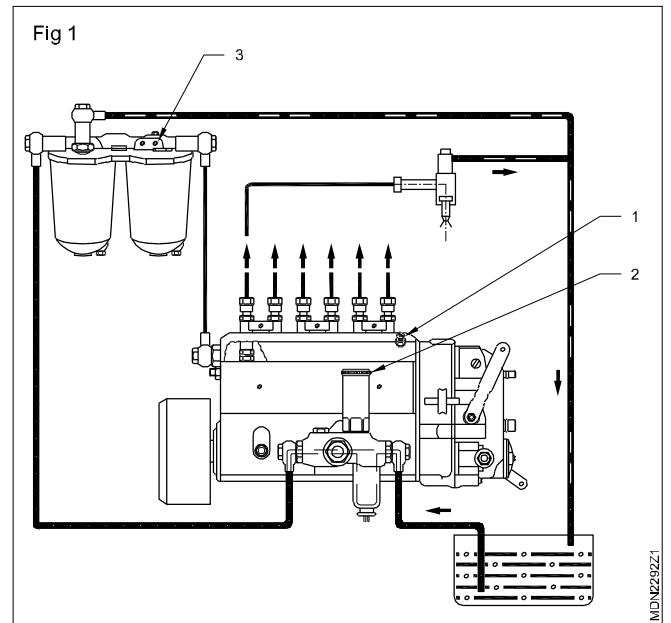


13 Open the oil filling cap/flap and fill the correct grade of engine oil slowly. While filling intermittently check the oil level. This avoids over filling of oil.

14 Close the filling cap/flap.

TASK 7 : Bleed the fuel system

- 1 Loosen bleeding screw (3) of filter one or two turns.
- 2 Pump fuel by hand primer (2) till fuel comes without air through bleeding screw. Tighten bleeding screw. (Fig 1)
- 3 Repeat the above procedure to bleed air from F.I.P. through bleeding screw (1).
- 4 Start and test the engine. (Consult your instructor)



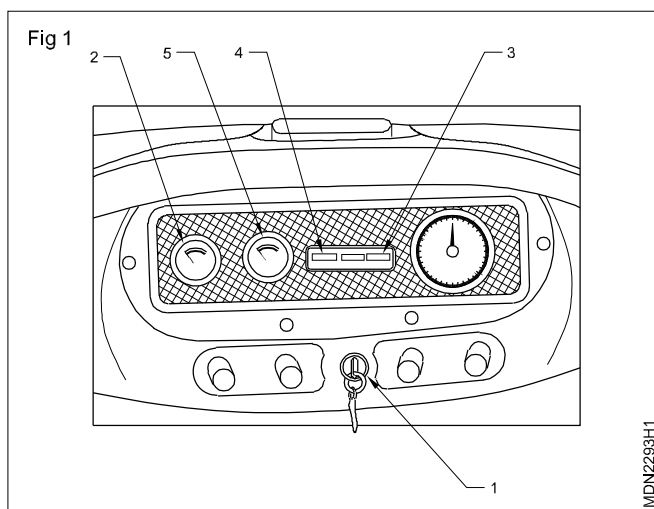
Test the cylinder compression of an engine

Objectives: At the end of this exercise you shall be able to
 • check the compression pressure.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Compression gauge	- 1 No.	• Cotton cloth	- as reqd.
Equipments/Machineries		• Kerosene	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Soap oil	- as reqd.
		• Lube oil	- as reqd.
		• Diesel	- as reqd.

PROCEDURE

- 1 Check the water level in the radiator and top up if needed.
- 2 Check the engine oil level and top up, if needed.
- 3 Check the electrolyte level in the battery and top up with distilled water if needed.
- 4 Insert the key in the main switch (1) and press fully in and turn the key to the 'ON' position. (Fig 1)



- 5 Observe the ammeter (2) on the instrument panel. 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.
- 6 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.
- 7 Depress the accelerator lever fully.
- 8 Press the starter 'button' or turn the ignition key further and crank the engine.

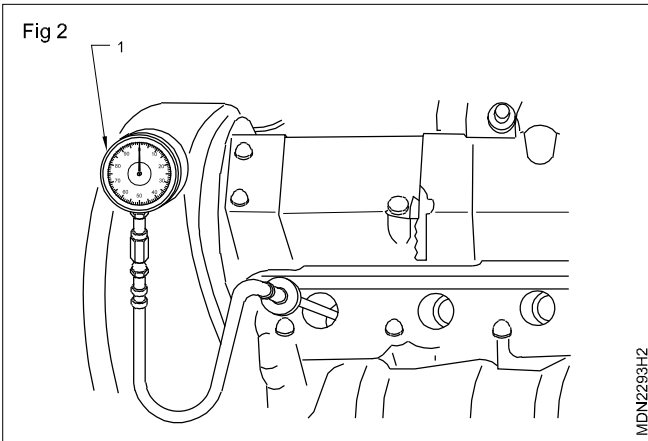
- 9 Release the starter button /key as soon as the engine has started.

Once the engine starts do not touch the starter switch.

- 10 If 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 ring and pinion will get damaged or the self-starter motor will get damaged.
- 11 Raise the engine r.p.m. steadily and allow the engine to warm up.
- 12 Observe the ammeter. The indicator on the positive side shows charging of the battery.
- 13 Observe the oil pressure indicator.
- 14 Note down the temperature of the water on the temperature gauge.
- 15 Note down the oil pressure at full throttle.
- 16 Compare the observations made with the manufacturer's specification.
- 17 Depress the accelerator steadily to full throttle, and observe the exhaust smoke.
- 18 Note down the colour of the smoke as black/white/blue.
- 19 Run it at idle speed for a few minutes to bring it to operating temperature.
- 20 Loosen the injector one or two turns and crank the engine to blow off the carbon and dust around the injectors.
- 21 Remove all the injectors.

Dry test

- 22 Install the compression gauge '1' on the first cylinder.
- 23 Press the accelerator lever.
- 24 Crank the engine with the starter motor and read the highest pressure on the compression gauge.
- 25 Note the reading and release the pressure from the compression gauge. (Fig 2)



- 26 Repeat the procedure for all the remaining cylinders and note down the reading.

Wet test

- 27 Put 10 ml of engine oil in the first cylinder.
- 28 Crank the engine to circulate the oil around the piston and piston rings.
- 29 Repeat the procedure to take the compression pressure reading as given in the above steps.
- 30 Take the reading for all cylinders by pouring oil in each cylinder.
- 31 Note down the difference of the readings in the dry and wet tests.
- 32 Put back all the injectors and tighten at the recommended torque.
- 33 Fit the fuel pipe lines and bleed it.
- 34 Start the engine and check for leakage at the injectors.
- 35 Check vibration of engine in idle speed.
- 36 Overhaul the injectors to improve the performance of the engine. If needed.
- 37 Refit the injectors and connect the fuel lines and start the engine.
- 38 Adjust and set idle speed of the engine.

Removing and replacing timing and engine drive belt

Objectives: At the end of this exercise you shall be able to

- removing and replacing timing belt
- replacing the engine drive belt.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Torque wrench	- 1 No.	• Cotton cloth	- as reqd.
• Mallet, Drift punch	- 1 No.	• Kerosene	- as reqd.
• Puller	- 1 No.	• Soap oil	- as reqd.
		• Lube oil	- as reqd.
Equipments/Machineries		• Engine drive belt	- as reqd.
• Multi cylinder diesel engine		• Timing belt	- as reqd.

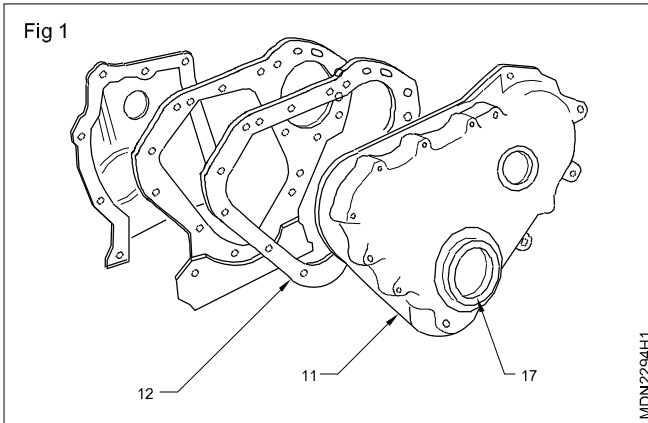
PROCEDURE

TASK 1: Removeing and replacing cam belt.

- | | |
|--|--|
| <ol style="list-style-type: none"> 1 Rotate the engine and coincide the timing marks (1) with the timing pointer (2). 2 Mark the position of the pointer (2) with respect to the timing cover(3). 3 Place a wooden piece in between the flywheel ring gear and crankcase to prevent rotation of the flywheel. 4 Remove the crankshaft pulley nut(4). 5 Place the puller (5) on the crankshaft pulley (6). Ensure the distance piece (7) does not sit inside the crankshaft threads. 6 Place the puller legs (8) in such a way that the puller's flange (9) is parallel to the pulley (6). 7 Tighten the centre bolt (10) till the pulley (6) comes out from the crankshaft. 8 Remove the timing cover (11) loosening the mounting screws diagonally opposite. 9 Remove the gasket (12) and oil seal (17). (Fig 3) 10 Loosen the mounting of timing belt tensioning pulley. 11 Remove the belt tensioning pulley | <ol style="list-style-type: none"> 12 Remove the timing belt from the timing pulley and crank pulley 13 Inspect the timing belt for defects. 14 Clean the timing pulley, crank pulley and belt tension pulley 15 Check oil seal of cam shaft and crank shaft 16 Ensure no oil leaks from cranshaft and crank shaft oil seals 17 Select the correct size of timing belt for your engine 18 Fix the timing pulley drive belt and coincide the timing marks on flywheel, vibration damper and camshaft timing pulley 19 Adjust the timing belt tension pulley for correct belt tension 20 Crank the engine and check timing belt tension 21 Apply the adhesive on the timing cover gasket and fix the gasket on the timing cover. 22 Fix the timing cover and mount the bolts for correct tightness 23 Mount the crank pulley and nut, tighten the nut as specified torque with help of torque wrench |
|--|--|

TASK 2 : Replcing and adjusting an engine drive belt

- 1 Disconnect the battery negative terminal
- 2 Loosen the alternators mounting
- 3 Loosen the nuts at the link bracket (Fig 1)



- 4 Inspect drive and driver pulley wheel
- 5 Check the side way movement and bearing free rotation.

- 6 Check the belt for excessive wear, and cracks
- 7 Select correct size and type of replacement belt
- 8 compare it with the new belt.

Note: old belt may have stretched in use

- 9 Install the new belt and ensure it is properly seated in the groove
- 10 Make sure width and squarely aligned in the puller groove (If it not correctly aligned the belt will be thrown off by pulley in heels)
- 11 Push the alternator away from the engine with a suitable lever until the correct tension is obtained
- 12 Check it with a tension gauge as per recommendation
- 13 Tighten the alternator mounting and bracket-nut or bolts
- 14 Connect the battery negative terminal
- 15 Start the engine and observe the belt the make sure that it is seated with proper the tension.
- 16 If necessary, readjust the engine drive belt tension.

Checking and replacing the radiator hoses

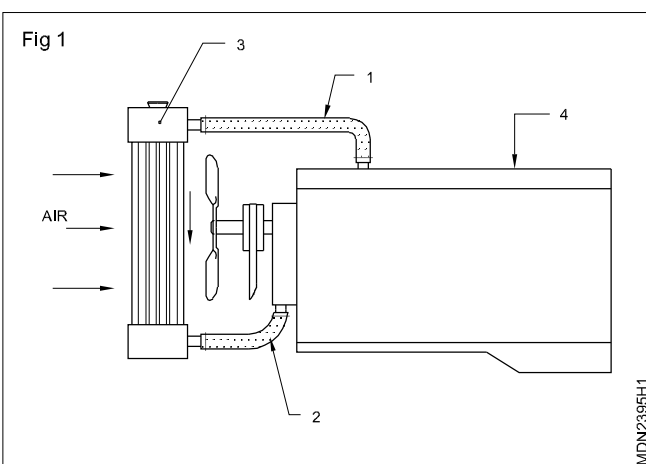
Objectives: At the end of this exercise you shall be able to

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

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Coolant	- as reqd.
• Tray	- 1 No.	• Cotton cloth	- as reqd.
Equipments/Machineries		• Radiator hose	- as reqd.
• Running diesel engine	- 1 No.	• Hose clamp	- as reqd.
		• Grease	- as reqd.
		• Soap oil	- as reqd.
		• Funnel	- as reqd.

PROCEDURE

- 1 Locate the top and bottom hoses between the radiator and engine. (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 cork of radiator and drain water completely
- 6 Close the drain cork.
- 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 correct length, diameter and shape)
- 11 Apply sealing compound inside of the new hoses.
- 12 Sliding the new hoses into the position on the fittings with new clamps.
- 13 Tightened the clamps (6m in 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 leaks.
- 17 Stop the engine and allow to cool
- 18 Open the radiator cap
- 19 Check the coolant level, if necessary top up.



Testing the leakage in cooling system

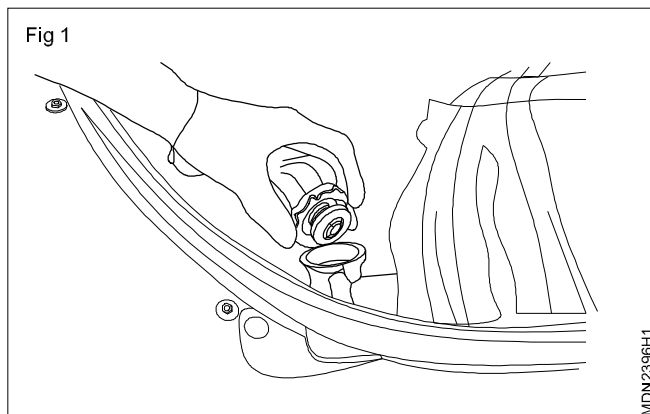
Objective: At the end of this exercise you shall be able to
 • **check pressure test cooling system.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Cotton cloth	- as reqd.
• Cap pressure test kit	- 1 No.	• Pressure cap	- as reqd.
Equipments/Machineries		• Coolant	- as reqd.
Multicylinder diesel engine	- 1 No.		

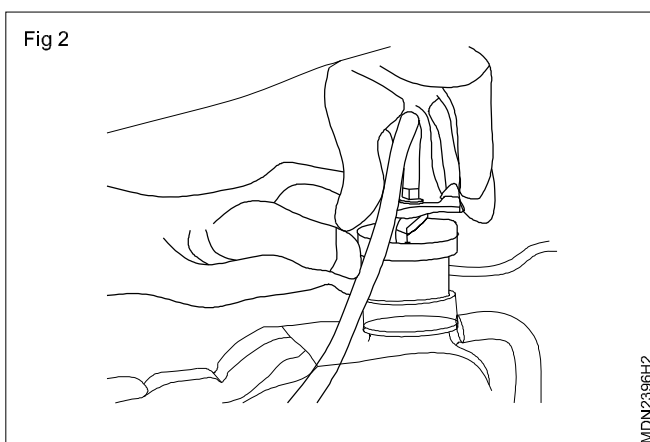
PROCEDURE

1 Remove the radiator cap

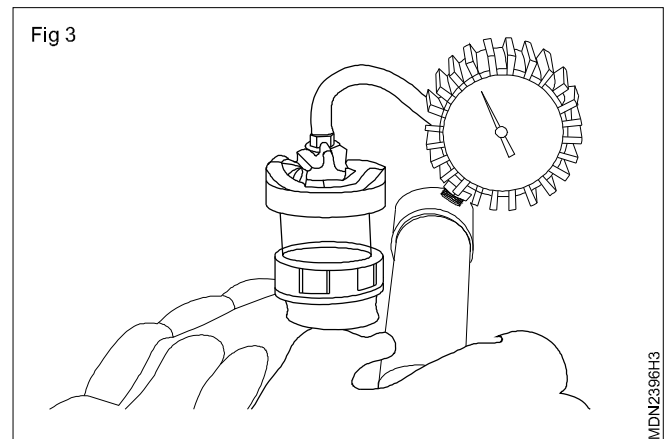
Before removing the radiator cap squeezing the upper radiator hose to check for pressure in the system. Determine no pressure inside, otherwise slowly remove (Fig 1)



2 Attach to the pressure tester filler neck of the radiator (Fig 2)



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



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, your cooling system in likely free of leaks or the presure slowly drops, leak somewhere or the pressure tester is not attached properly, recheck the tester connection. Listen out for the leaks or bubbling if escaping pressure and throughly go over the engine bay for any sign. If no sign leak is inside engine

5 Remove the nozzle or spark plug coolant raised in cylinder

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

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

8 Clean and reinsert the tester back into its care and store in cool dry place.

Overhauling of radiator and check the pressure cap

Objectives: At the end of this exercise you shall be able to

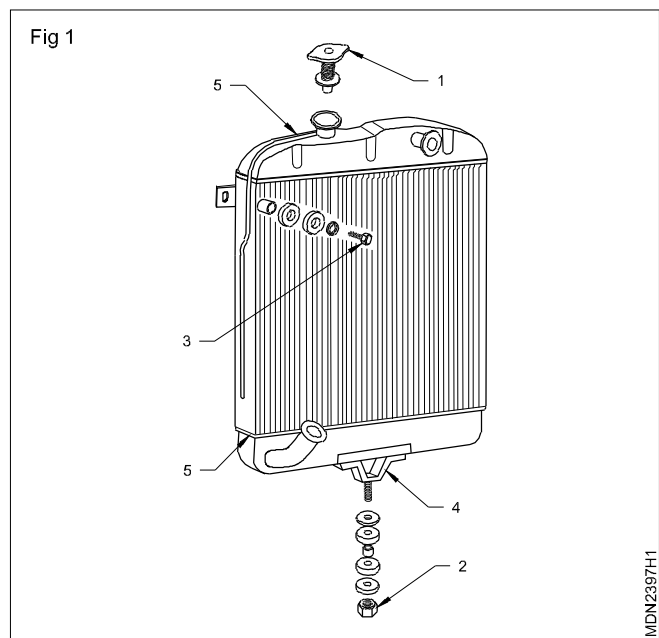
- remove the thermostat valve
- clean and refit the thermostat valve
- check the radiator cap
- remove the radiator from the frame
- clean the radiator
- assemble the radiator
- adjust fan belt tension.

Requirements			
Tools/Instruments		Materials/Components	
• Trainees tool kit	- 1 No.	• Tray	- 1 No.
• Box spanner set	- 1 Set.	• Cotton cloth	- as reqd.
Equipments/Machineries		• Kerosene	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Soap oil	- as reqd.
• Air compressor, Water washer	- 1 No each.	• 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.
- 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 filler 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.

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

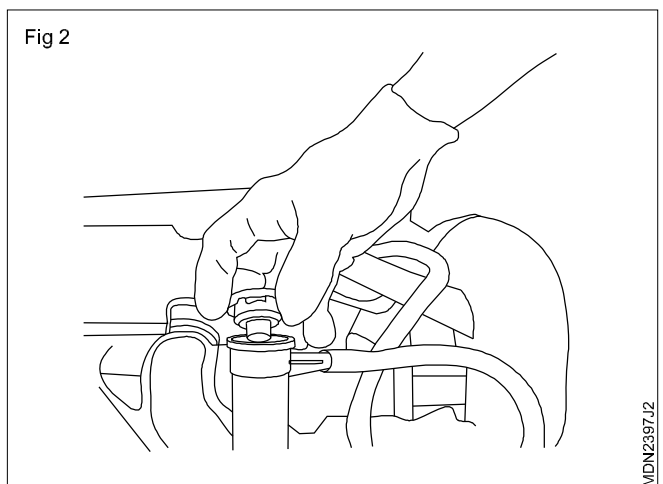
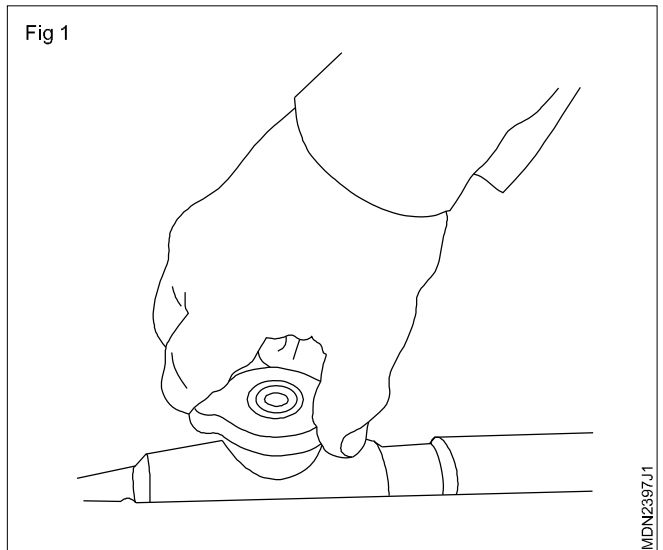
- Carefully touch the radiator hose and feel its hot.
- Make sure the cooling system is not in hot

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 filler 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 most of the max pressure for up to fine minutes. This take littel 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 found damage in radiator pressure cap valve or valve spring replace it.

NOTE: Too much pressure in the system can result damage

Testing the thermostat valve

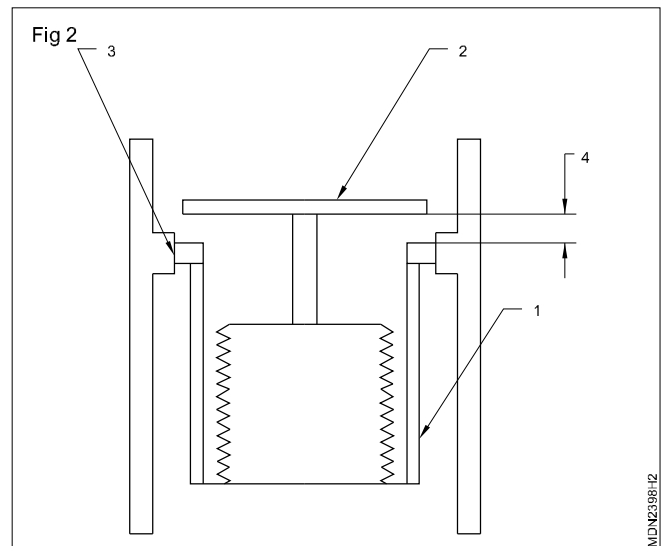
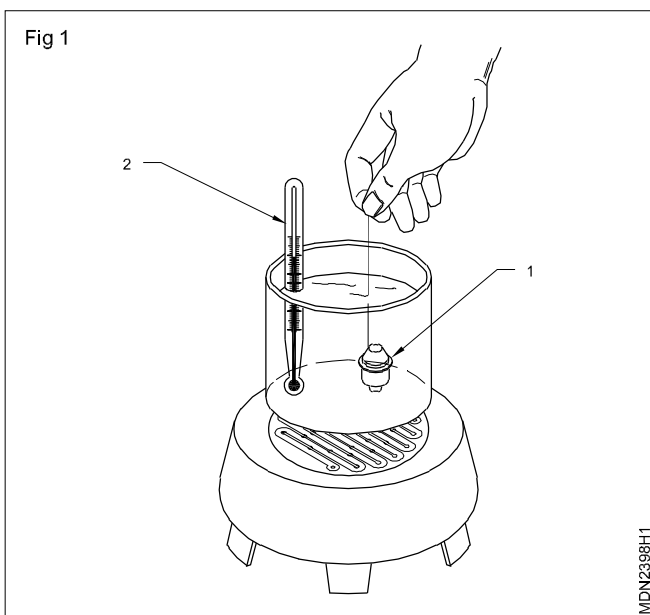
Objectives: At the end of this exercise you shall be able to

- remove the thermostat valve
- inspection and test the thermostat valve
- refit and test the thermostat

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Cotton cloth	- as reqd.
• Water jar	- 1 No.	• Kerosene	- as reqd.
• Thermometer	- 1 No.	• Soap oil	- as reqd.
• Heater		• Coolant	- as reqd.
Equipments/Machineries		• Gasket	- as reqd.
• Work bench	- 1 No.	• Thermostat valve	- 1 No.

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.
- 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).



- 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.

- 11 Fit the thermostat in the thermostat case.
- 12 Fit the thermostat cover in the thermostat case.

Practice on reverse flushing radiator

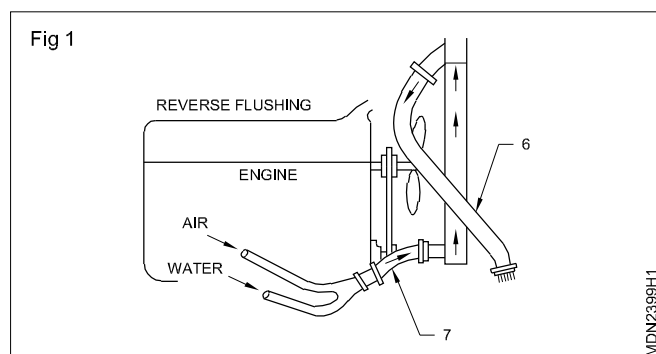
Objectives: At the end of this exercise you shall be able to

- clean and reverse flushing radiator.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Box spanner set	- 1 Set.	• Cotton cloth	- as reqd.
Equipments/Machineries		• Kerosene	- as reqd.
• Multi cylinder diesel engine		• Soap oil	- as reqd.
• Air compressor, water washer	- 1 No.	• 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.

Overhauling the water pump

Objectives: At the end of this exercise you shall be able to

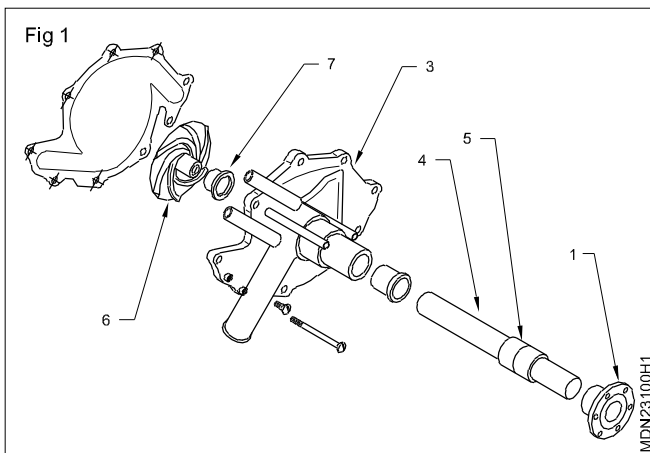
- **dismantle the water pump**
- **inspect the parts of a water pump**
- **assemble the water pump.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
• Box spanner set	- 1 No	• Cotton cloth	- as reqd.
• Puller, Circlip pliers	- 1 No each.	• Kerosene	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multi cylinder diesel engine	- 1 No.	• Coolant	- as reqd.
		• Grease	- as reqd.

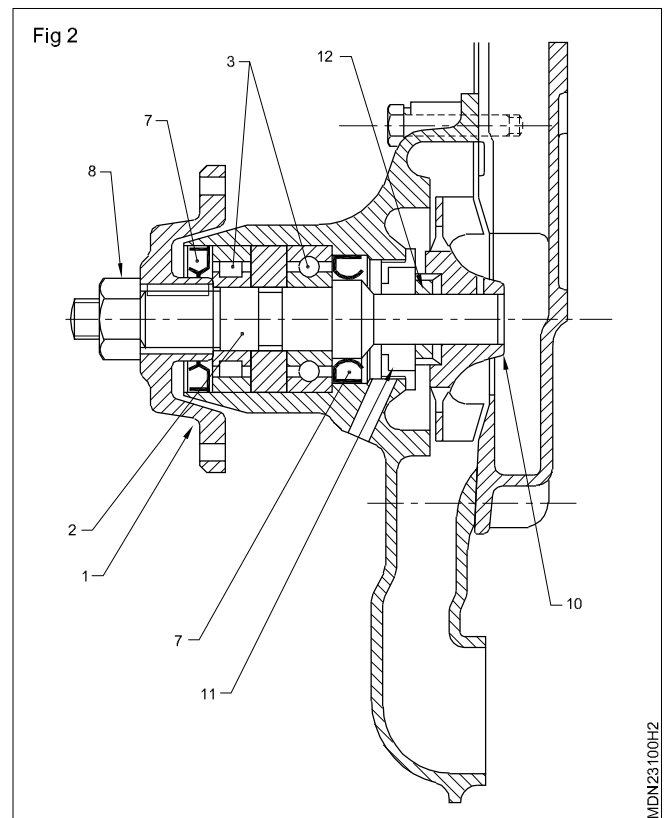
PROCEDURE

TASK 1: Dismantling

1 Lock the water pump's pulley hub (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.

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

Changing the engine oil

Objectives: At the end of this exercise you shall be able to

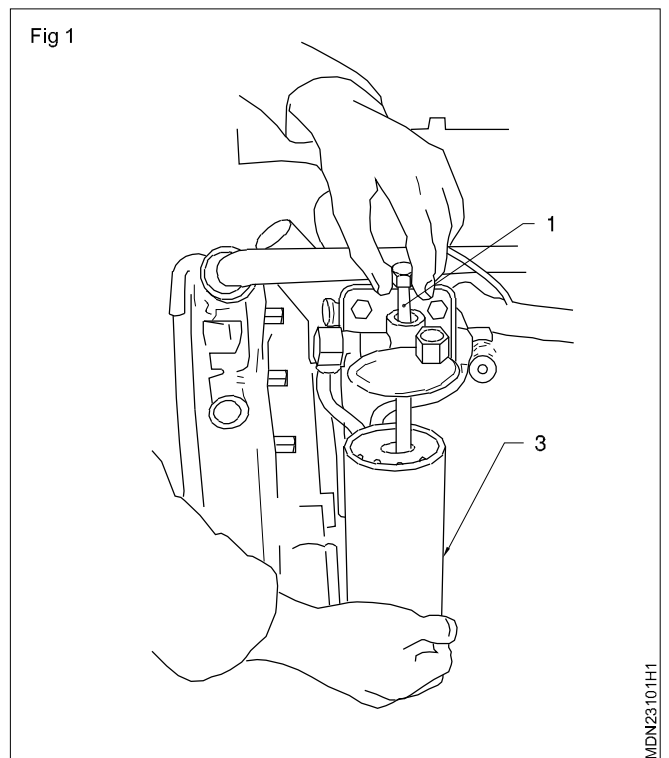
- drain the engine oil
- fill the engine oil to a specified level
- check the engine oil pressure at different r.p.m.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Tray	- 1 No.
Equipments/Machineries		• Cotton waste/Baniam cloth	- as reqd.
• Multi cylinder diesel engine		• 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 filling cap.
- 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.
- 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.

Fig 1



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

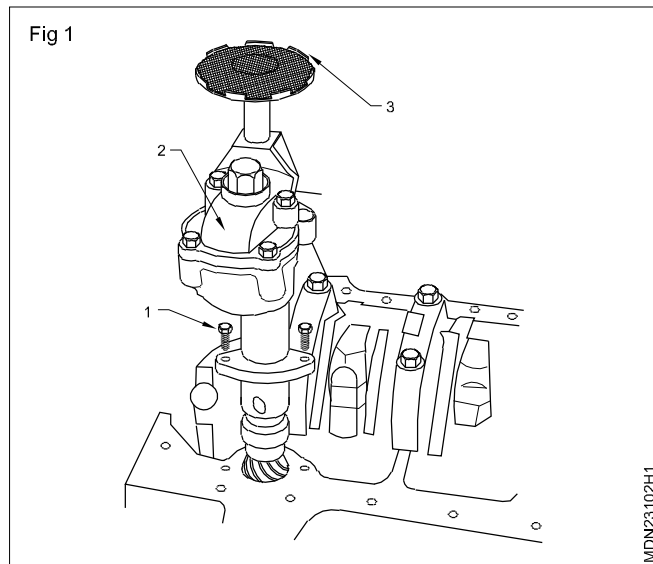
- **dismantle the oil pump**
- **check the clearances and endplay**
- **assemble the oil pump**
- **service oil cooler**
- **adjust oil pressure relief valve.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainees tool kit	- 1 No.	• Tray	- 1 No.
• Box spanner set	- 1 Set.	• Cotton cloth	- as reqd.
• Feeler gauge, Puller	- 1 No.	• Kerosene	- as reqd.
• Straight edge	- 1 No.	• Soap oil	- as reqd.
Equipments/Machineries		• Lube oil	- as reqd.
• Multi cylinder diesel engine		• Oil filter	- as reqd.
		• Air cleaner filter	- as reqd.

PROCEDURE

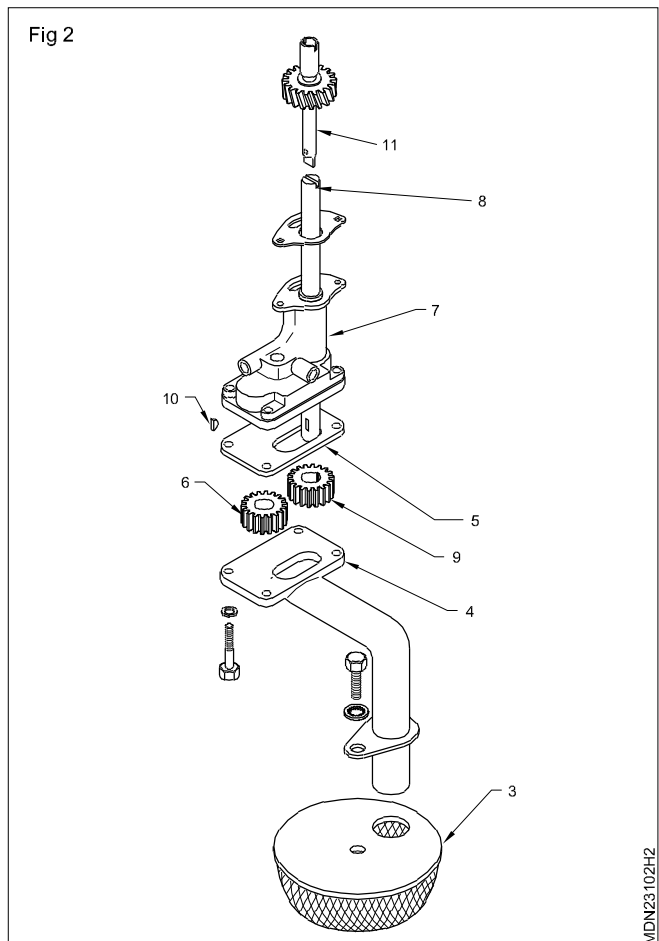
TASK 1: Dismantling

- 1 Remove the oil sump.
- 2 Remove the oil pump mounting bolts/nuts (1) (Fig 1).



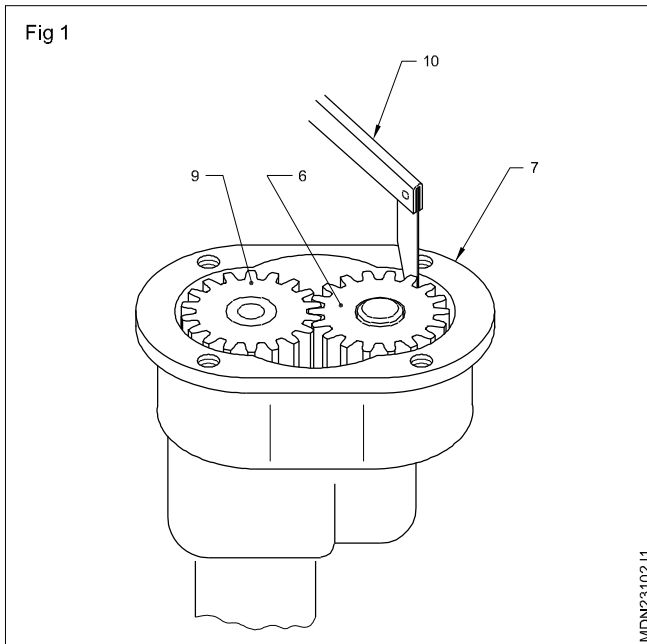
- 3 Take out the oil pump (2) along with the strainer (3).
- 4 Remove the strainer assembly (3) from the pump.
- 5 Remove the oil pump end cover (4) (Fig 2).
- 6 Remove the pump cover packing (5).
- 7 Remove the idler gear (6) from the oil pump housing(7).
- 8 Remove the driving gear (9) with the shaft (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.

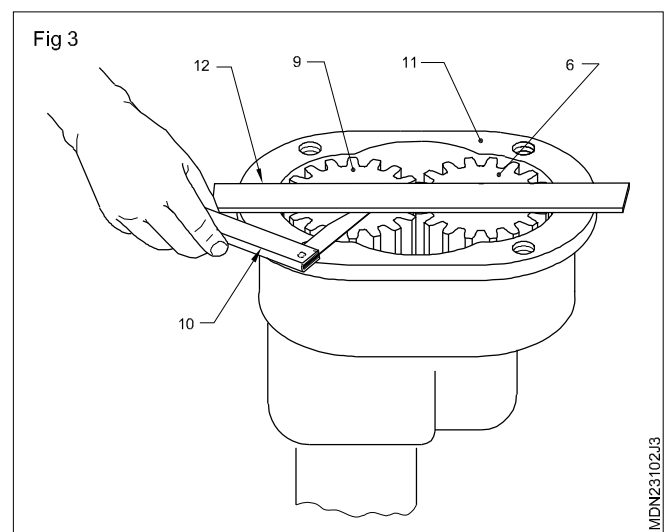
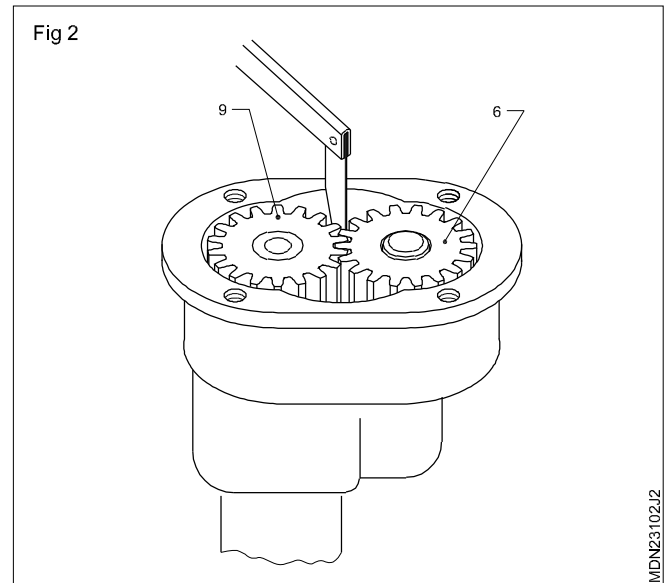


TASK 2: Cleaning and Inspection

- 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.



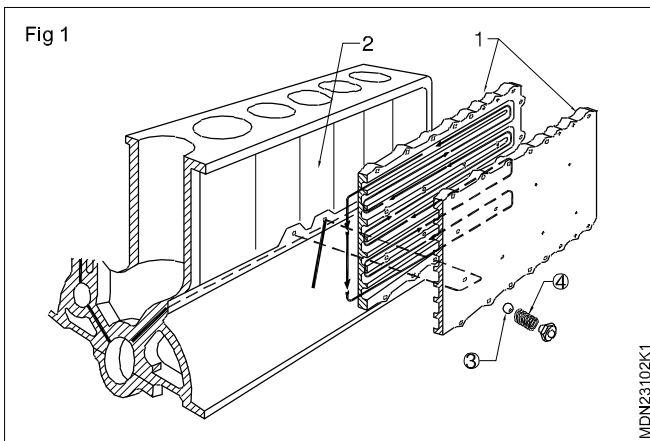
- 9 Check the suction pipe for cracks, damage and blockage and clean the blockage through air pressure.
- 10 If any damage/cracks in oil flow pipe and unions repair or replace it.

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.s and compare them with the manufacturer's specification.

TASK 4: Servicing of oil cooler

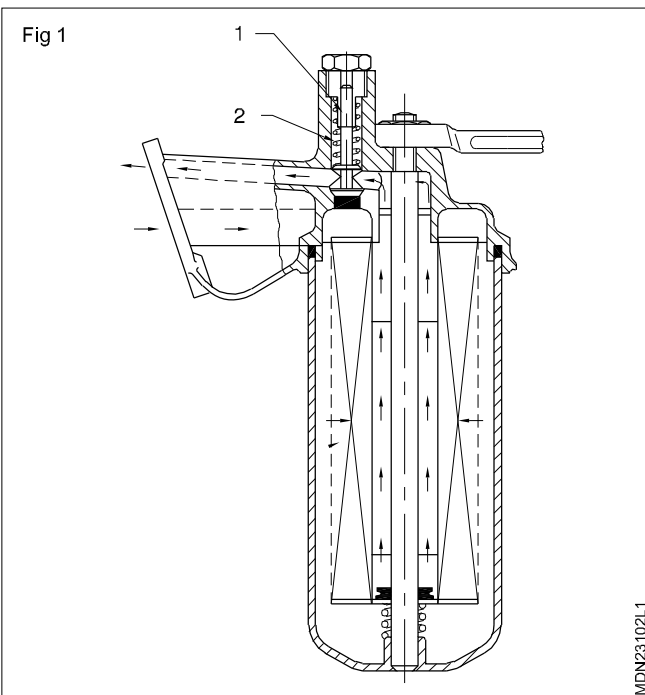
- 1 Remove the oil cooler (1) from the engine block (2) (Fig1).



- 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.
- 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.

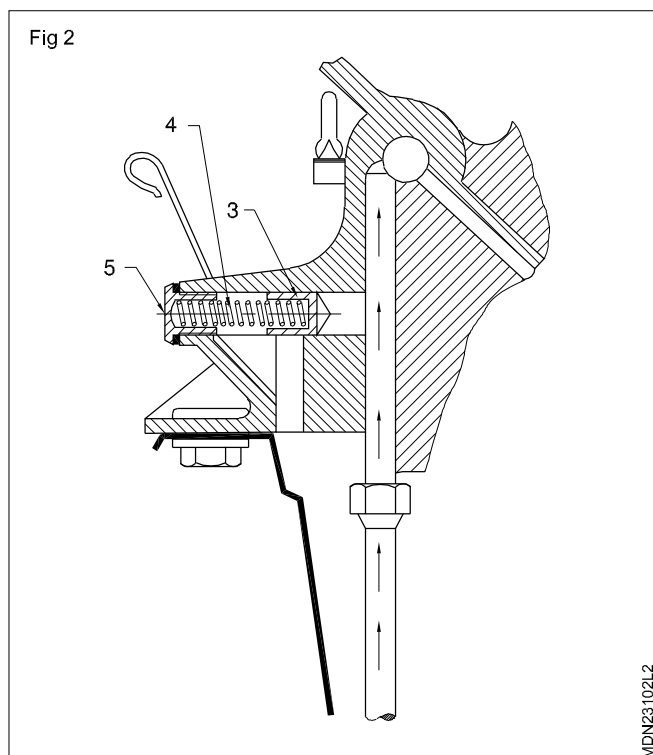
TASK 5: Adjust oil pressure relief valve

- 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).



- 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.



Servicing dry and wet air cleaner & charge air cooler

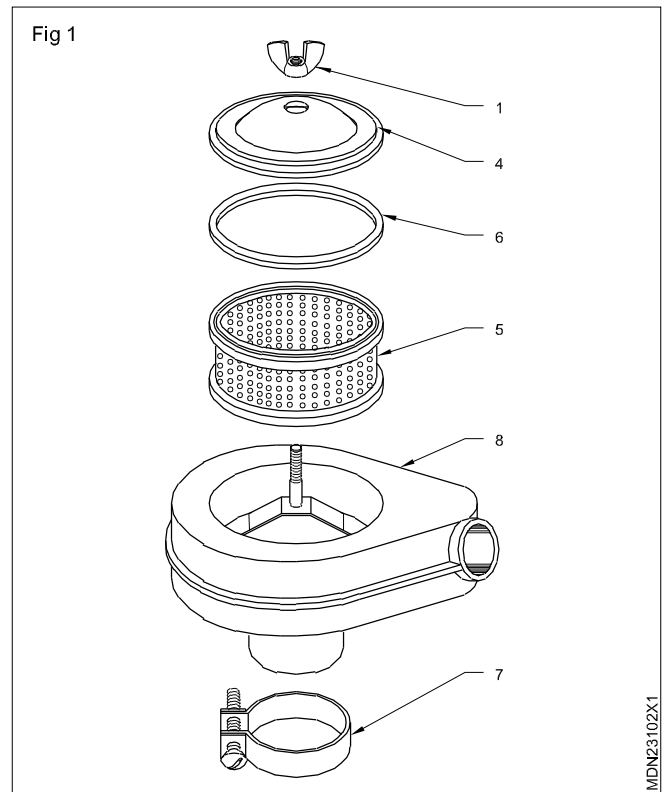
Objectives: At the end of this exercise you shall be able to

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

PROCEDURE

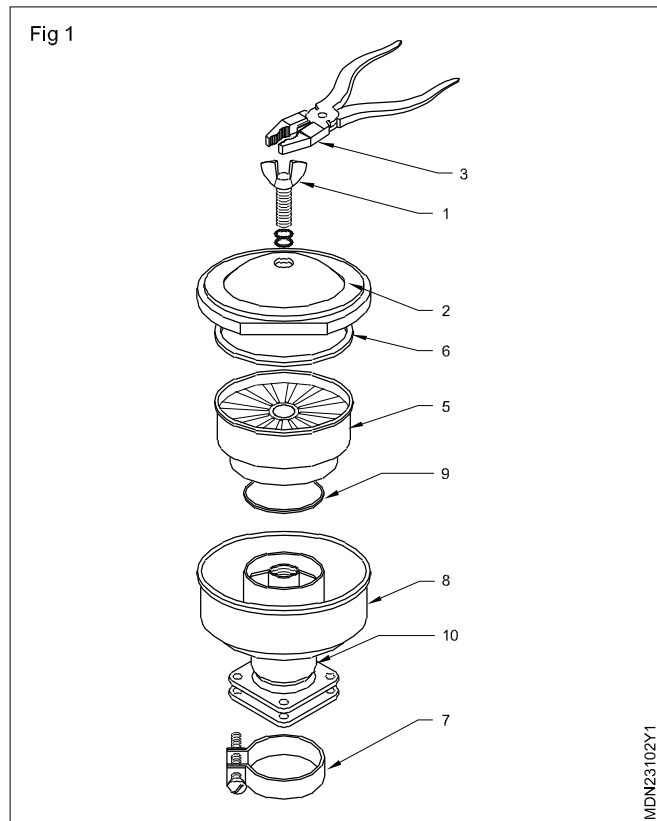
TASK 1 : Service air cleaner (Dry type)

- 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.



TASK 2: Service air cleaner (Oil bath type)

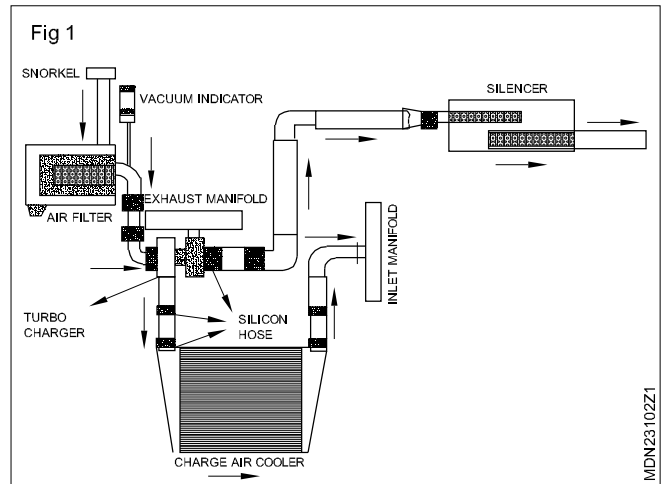
- 1 Open the bonnet of the vehicle.
- 2 Unscrew the bolt or wing-nut (1) on the top cover (2) by hand or plier (3) (Fig 1).
- 3 Remove the top cover (2) with the element (5) and gaskets (6 & 9).
- 4 Loosen the nuts/fixing clip (7) of the lower portion (10) of the air cleaner.
- 5 Remove the bowl (8) from the inlet manifold or carburettor.
- 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/carburettor 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 or on the carburettor 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.

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 pressurise 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.
- 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.

Overhauling the air compressor and exhauster

Objectives: At the end of this exercise you shall be able to

- **dismantle air compressor**
- **inspect parts of air compressor**
- **assemble air compressor**
- **dismantle air exhauster**
- **inspect parts of air exhauster**
- **assemble air exhauster.**

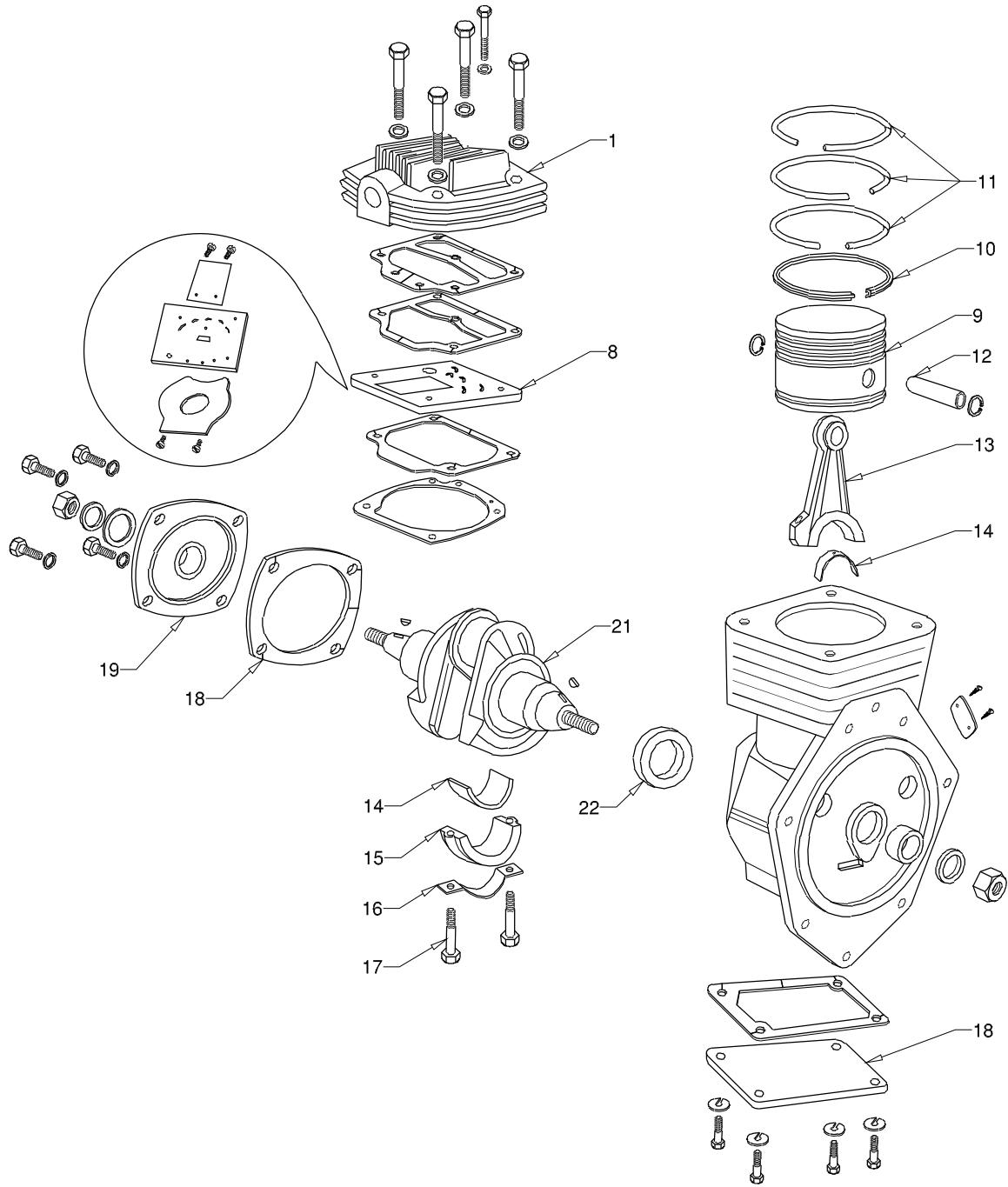
Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tools kit	- 1 No.	• Kerosene	- as reqd.
• Socket spanner set	- 1 No.	• Soap oil	- as reqd.
• Torque wrench	- 1 No.	• Lubricant Oil	- as reqd.
• Outside micrometer	- 1 No.	• Cleaning cloth	- as reqd.
• Cylinder bore gauge	- 1 No.	• Emery paper	- as reqd.
• Piston ring expander	- 1 No.	• Grease	- as reqd.
• piston ring compressor	- 1 No.	• Piston ring	- 1 Set
• Feeler gauge	- 1 No.	• Exhauster	- 1 No
Equipments/Machineries		• gasket material	- as reqd.
• Multicylinder diesel engine	- 1 No.		
• Air compressor	- 1 No.		

PROCEDURE

TASK 1: Dismantling (Fig 1)

- | | |
|---|--|
| <ol style="list-style-type: none"> 1 Release air from the system. 2 Remove oil and air lines. 3 Remove fasteners and take out air compressor from its position. 4 Clean air compressor unit externally. 5 Remove the drive connection. 6 Remove air compressor cylinder head (1) (Fig 1). 7 Remove reed valve assembly (8) with valve plate. 8 Remove inlet and delivery reed valves from the valve plate. 9 Remove base cover plate (23). | <ol style="list-style-type: none"> 10 Turn crankshaft and bring the piston to bottom position. 11 Unlock the lock plate (16) and loosen the connecting rod bolts (17) and take out the cap (15) alongwith bearing shell (14). 12 Remove piston assembly (9). 13 Remove piston oil ring (10) and compression rings (11). 14 Remove gudgeon pin (12) & connecting rod (13) from piston. 15 Remove end cover (19) alongwith gasket (18). 16 Take out crankshaft (21) and thrust washer (22). |
|---|--|

Fig 1



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TASK 2: Cleaning and inspection

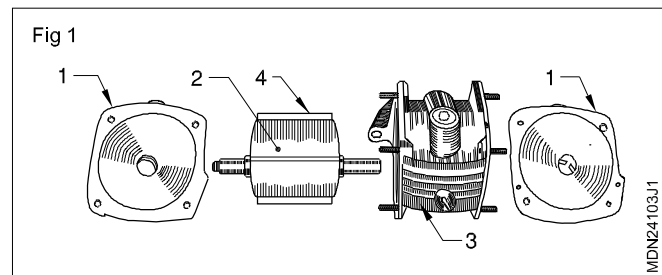
- | | |
|---|---|
| <p>1 Clean the air compressor parts.</p> <p>2 Clean oil passages in crank shaft and connecting rod and check for free flow of air.</p> <p>3 Inspect the cylinder bore for wear, taper and ovality. Recommend for reboring if required.</p> <p>4 Check ring clearance in piston groove.</p> <p>5 Inspect connecting rod for cracks damages</p> | <p>6 Inspect the crank shaft journal for wear/taper and ovality.</p> <p>7 Check clearance between crankshaft journals and bearings and if required replace the bearings.</p> <p>8 Inspect the inlet and delivery reed valve. If necessary replace them.</p> <p>9 Check crankshaft thrust washer for any damage.</p> <p>10 Check piston and cylinder head for crack, damage etc.</p> |
|---|---|

TASK 3: Assembling

- 1 Place the crankshaft (21) along with thrust washer (22) in correct position in the cylinder block.
- 2 Press new oil seal and position new gasket on the end cover.
- 3 Fit the end cover (19) on compressor body.
- 4 Tighten end cover screws with washers and check for free rotation of crank shaft.
- 5 Assemble the piston (9) and connecting rod (13) with gudgeon pin (12).
- 6 Fix piston rings (10) and (11) in piston grooves and stagger these as recommended by manufacturer.
- 7 Fix connecting rod upper bearing shell (14) in connecting rod.
- 8 Place ring guide on top of bore. Ensure that ring guide aligns with bore.
- 9 Insert piston and connecting rod assembly in ring guide and bore, with a wooden block.
- 10 Fix connecting rod cap (15) with bearing shell (14) and tighten connecting rod cap bolts (17) at recommended torque.
- 11 Fit the delivery reed valve on valve plate.
- 12 Reverse the valve plate and fit inlet reed valve.
- 13 Assemble cylinder head and valve plate using proper gasket. Ensure the gasket does not overlap the valves.
- 14 Apply grease/oil on the gasket.
- 15 Fit the cylinder head and fix fasteners and tighten at recommended torque.
- 16 Fit bottom cover on compressor body.
- 17 Fit air compressor on engine

TASK 4: Dismantling Exhauster (Fig 1)

- 1 Remove exhauster unit from the engine.
- 2 Remove drive connection.
- 3 Remove the end cover bolts.
- 4 Tighten puller bolts in threaded hole of end cover (1) to take out end cover (1) from exhauster body (3). In some exhausters fastening bolts of end cover are used as puller bolts otherwise use suitable bolts (Fig 1).
- 5 Take out rotor (2) along with the vanes (4).



- 6 Take out vanes.
- 7 Clean all parts by using the recommended solvent.

TASK 5: Inspection

- 1 Inspect visually vanes for any crack, damage etc.
- 2 Inspect visually the rotor slot, body for wear, crack etc.
- 3 Slide vanes in rotor slots and check for free movement of vanes in slot.

TASK 6: Assembling

- 1 Apply lubricants in the rotor slots.
 - 2 Fix the vanes inside the rotor's slots, keeping the chamfered edge outside.
 - 3 Insert the rotor inside the body (3).
 - 4 Fit the end covers (1) with new 'O' rings and joints.
 - 5 Fit the drive connection.
 - 6 Fit exhauster unit on engine.d
-

Overhauling the turbocharger

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.

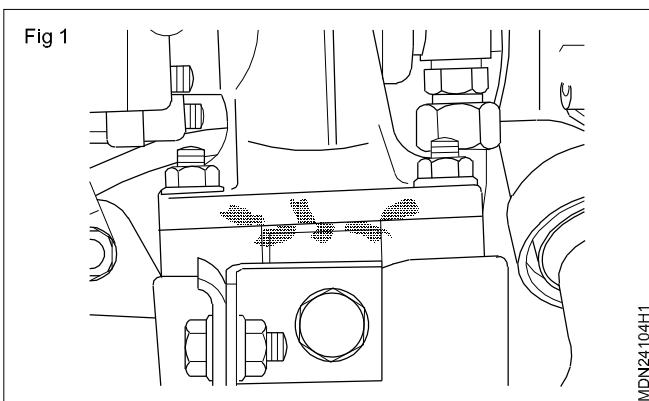
Requirements			
Tools/Instruments		Equipments/Machineries	
• Trainee's tool kit	- 1 No	• Work bench	- 1 No.
• Circlip plier	- 1 No	• Turbocharger	- 1 No.
• Box spanner	- 1 set	Materials/Components	
• Dial gauge	- 1 No	• Kerosene	- as reqd.
• Torque wrench	- 1 No	• Cotton cloth	- as reqd.
• Plastic mallet	- 1 No	• Anti corrosive solution	- as reqd.
		• Cleaning brush	- 1 No
		• Turbochager accessories	- as reqd.

PROCEDURE

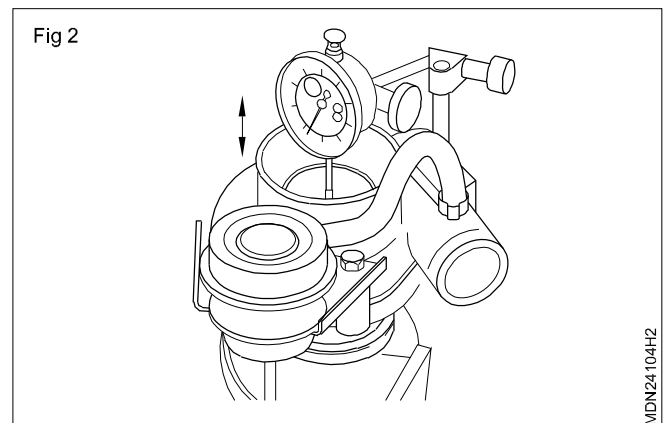
Removal

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

- 8 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)



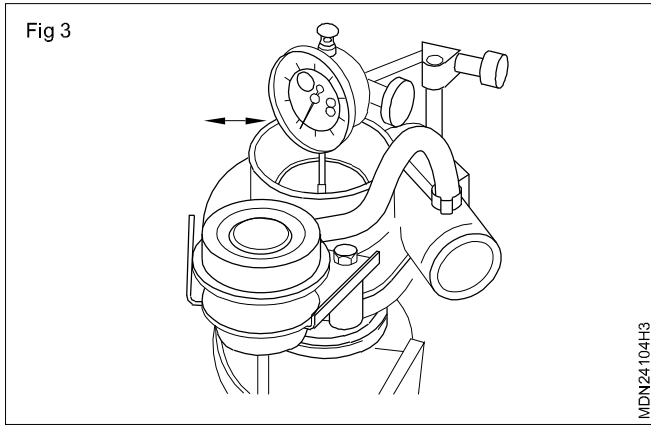
- 7 Check visually for cracked, bent or damaged compressor wheel blades.



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

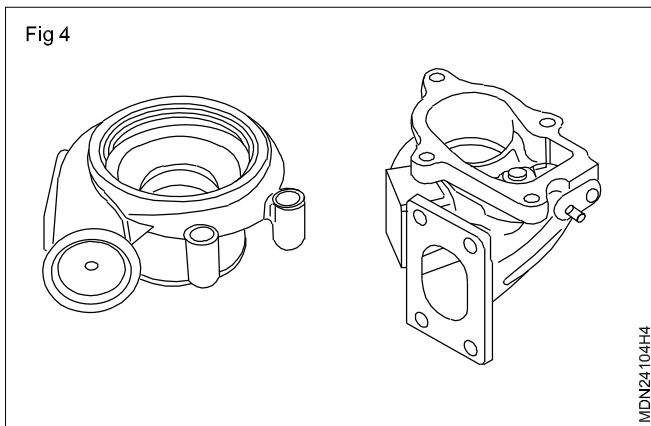
Ensure movement is within MIN/MAX TIR (Total Indicator Reading) values.

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

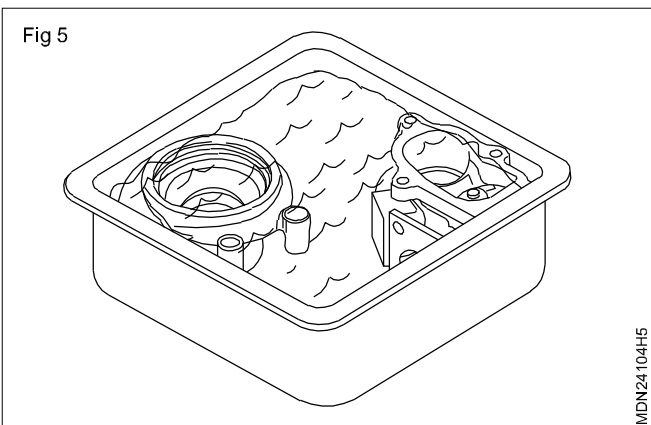


Dismantling/Cleaning

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

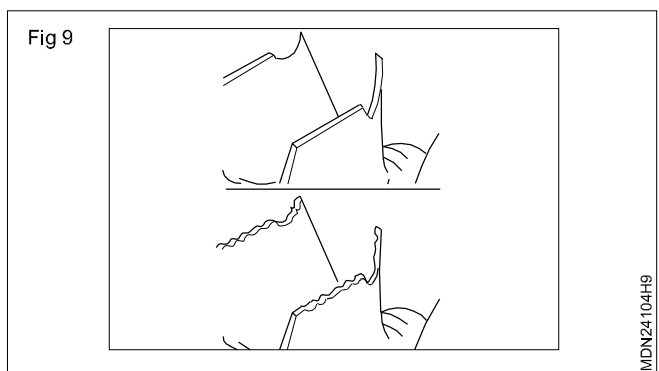
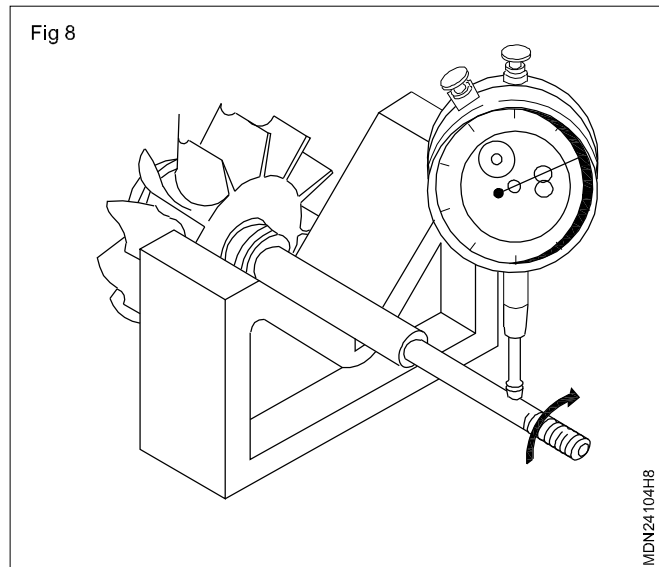
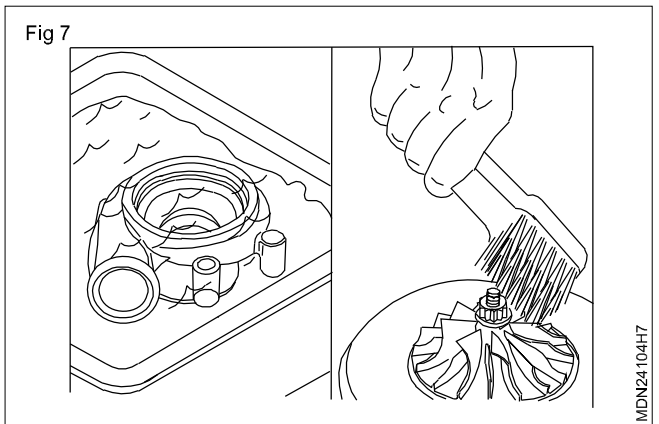
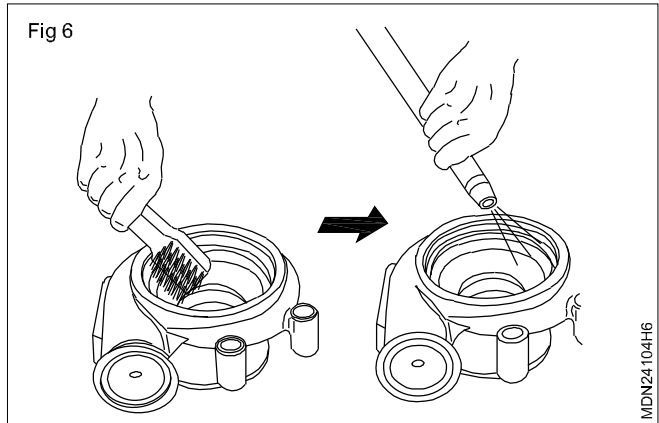


- 11 Remove actuator and placed in tray.
- 12 Remove 'V' band clamp and remove turbine body.
- 13 Remove circlip and remove the compressor body.
- 14 Remove the drive and driven impellor by loosening the impellor nuts (Fig 5 & Fig 6).
- 15 Remove both the impellors and place into tray (Fig 7).



- 16 Remove impellor shaft with bearing.
- 17 Remove "O" rings from both side of turbo charger body.
- 18 Remove thrust plate and "O" ring from turbo charger body.

19 Clean the above parts with kerosene except rubber parts (Fig 7, Fig 8 & Fig 9).



Inspection and repair

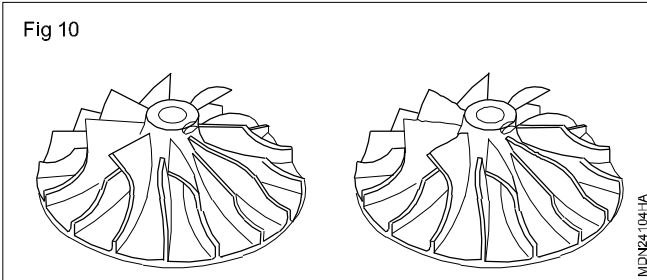
20 Inspect bearing and shaft free play. (Fig.8)

21 Check rubber "O" rings for crack or tear.

22 Check both impellers, shaft, thrust plate.(Fig 10)

23 If necessary replace faulty parts.

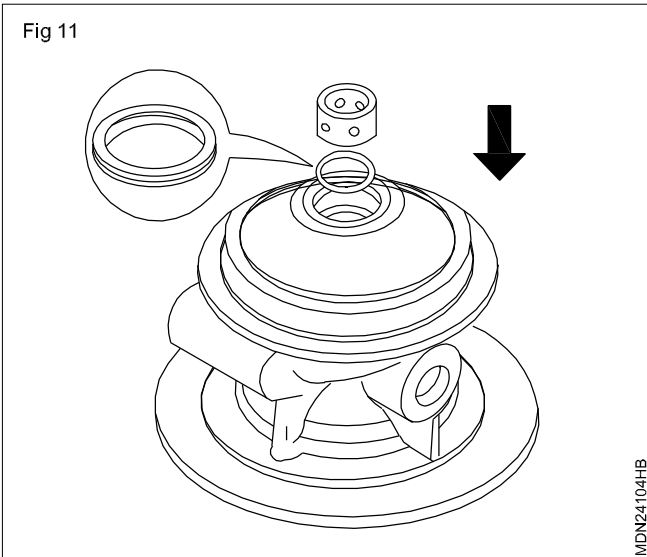
Fig 10



Assembling and testing (Fig.15)

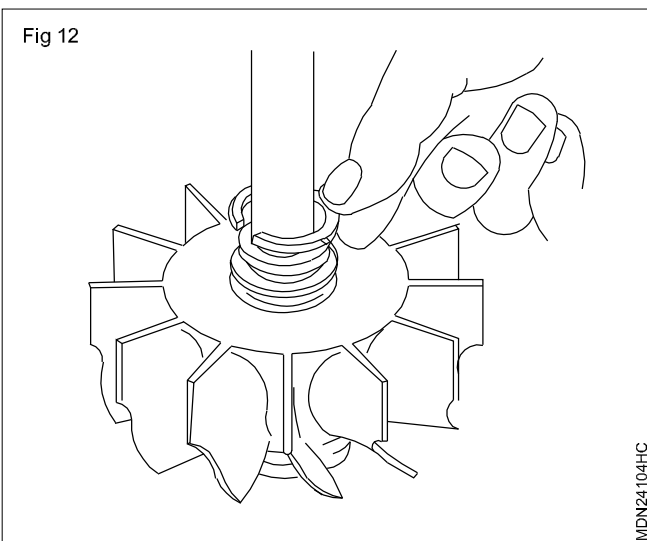
24 Assemble rubber "O" ring and thrust washer in turbo charger body (Fig 11).

Fig 11



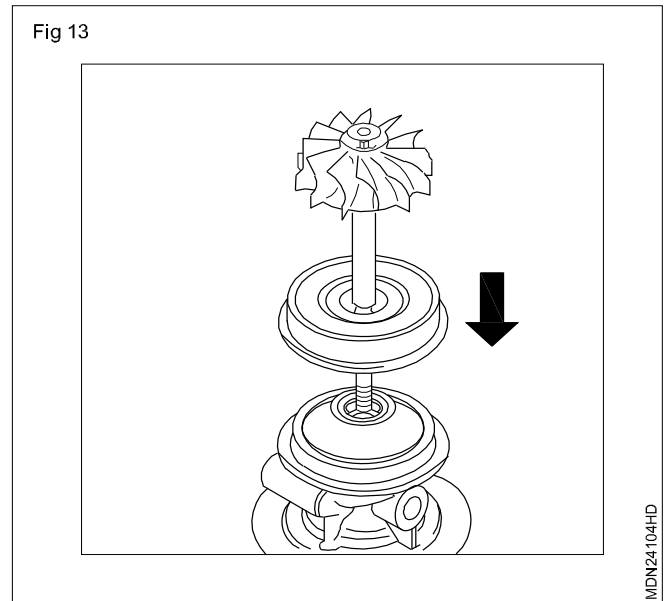
25 Fit external circlip of thrust washer and insert impeller shaft along with bearing (Fig 12).

Fig 12



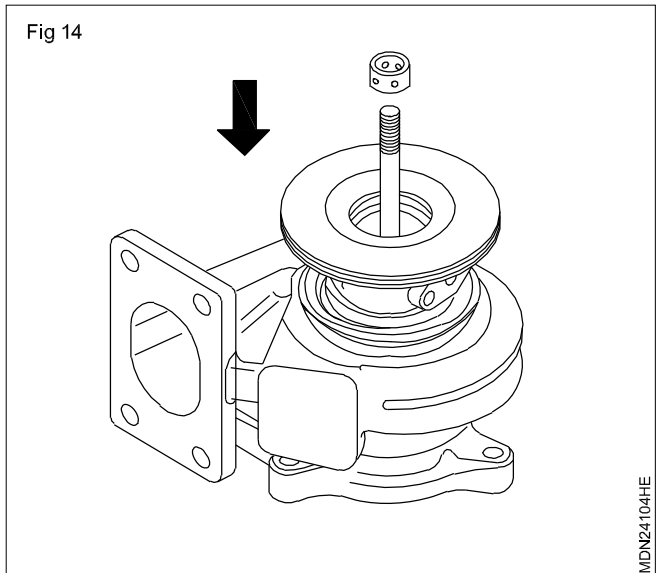
26 Fit both the impellers with impeller nuts (Fig 13).

Fig 13



27 Check impeller shaft free-play and end play and check impeller free movement (Fig 14).

Fig 14



28 Fit compressor and turbine flange with circlip and "V" band clamp respectively.

29 Refit actuator on turbo charger.

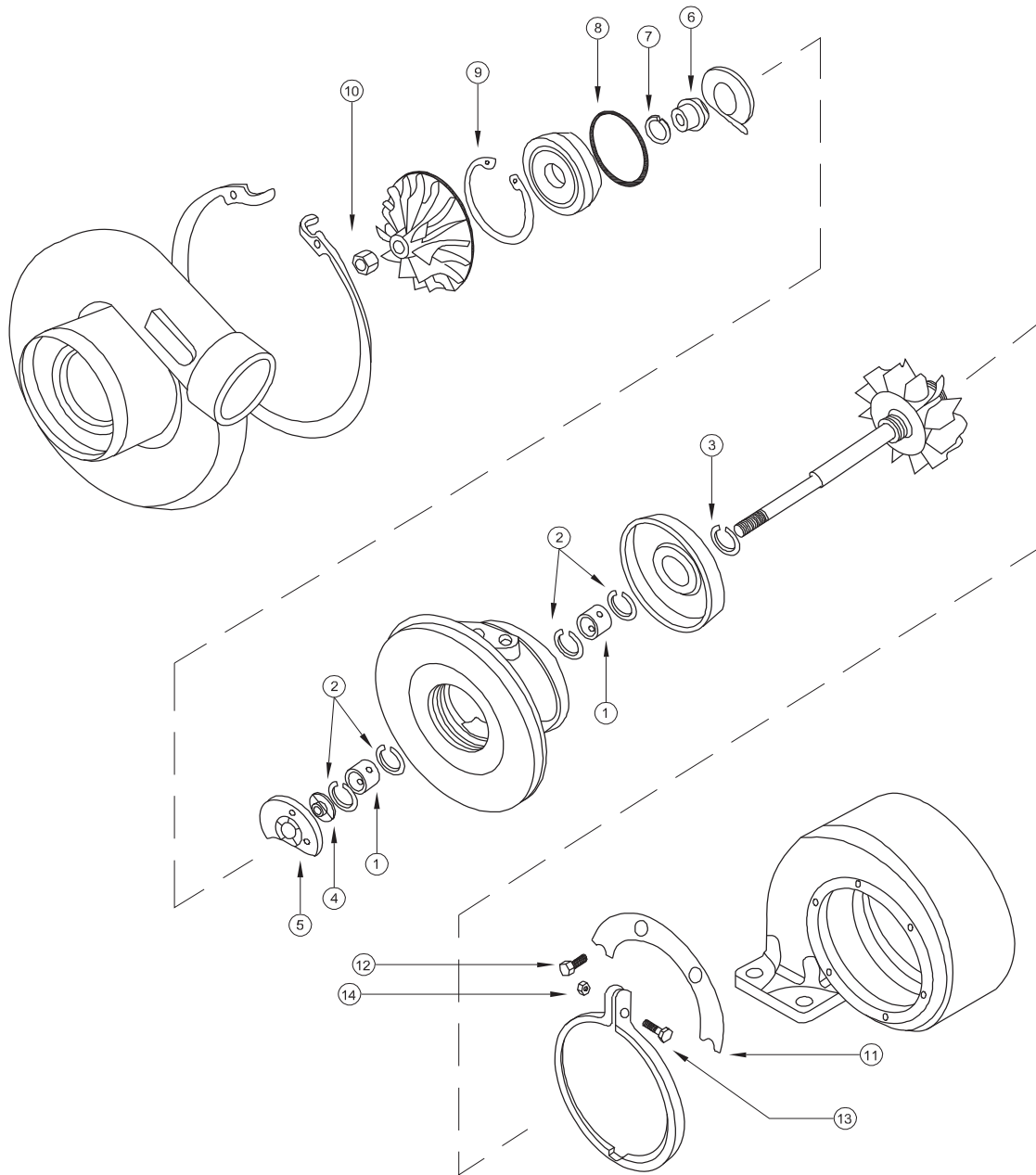
Refitting

30 Fit the turbo charger on mounting and tighten the mounting bolts of manifold.

31 Reconnect the oil pipe on turbo charger. Connect hose pipe on compressor side.

32 Start the engine and check for proper functioning of the engine.

Fig 15



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Checking the exhaust system in engine off mode

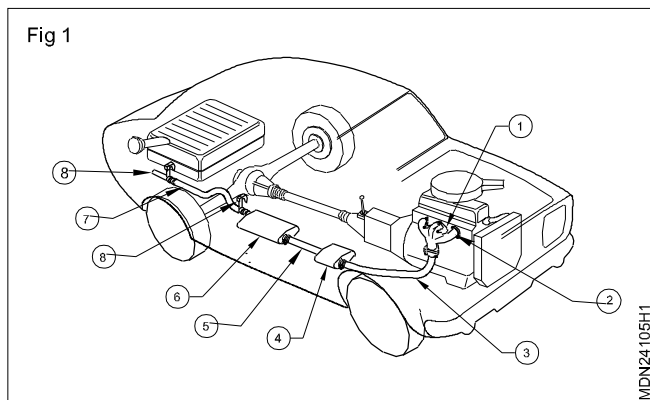
Objectives: At the end of this exercise you shall be able to
 • **Examine the exhaust system of an engine in off position.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee tools kit	- 1 No.	• Cotton waste	- as reqd.
• Box spanner set	- 1 No.	• Tray	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Heavy motor vehicle	- 1 No.	• Strap	- as reqd.
		• Gas welding plant	- 1 No
		• Welding wire	- as reqd

PROCEDURE

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

1 Visually check the exhaust manifold(1) mounting(2) tightness and gasket leakage symptoms



2 Examine the heat strap and exhaust damper damages

3 Examine the downpipe connection (3) gasket and mounting with exhaust manifold flange

4 Examine both side mountings of catalytic converter (4)

5 Visually check the outside damages of resonator pipe (5)

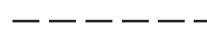
6 Visually check the muffler mountings (6) and connections

7 Visually check the loose connection of tail pipe (7)

8 Visually check the exhaust pipe having strap (8) with vehicle body

9 Visually check the deteriorate parts in exhaust system

10 Visually check the exhaust pipe dent and damages



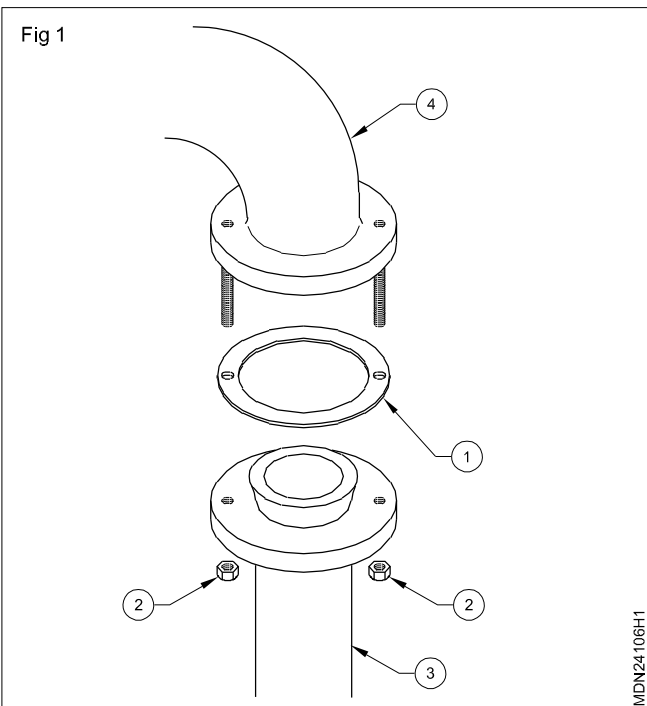
Servicing the exhaust system.

- 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, muffler and refit it.

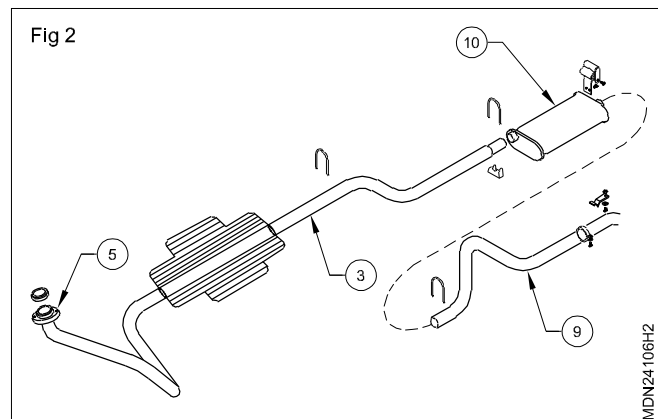
Requirements			
Tools/Instruments		Materials/Components	
• Trainees tools kit	- 1 No.	• Kerosene	- as reqd.
• Scraper	- 1 No.	• Soap oil	- as reqd.
• Straight edge	- 1 No.	• Cleaning cloth	- as reqd.
• Feeler gauge	- 1 No.	• Emmery sheet	- as reqd.
• Scraper	- 1 No.	• Wire brush	- as reqd.
Equipments/Machineries		• Manifold gaskets	- as reqd.
• Diesel engine	- 1 No.		

PROCEDURE

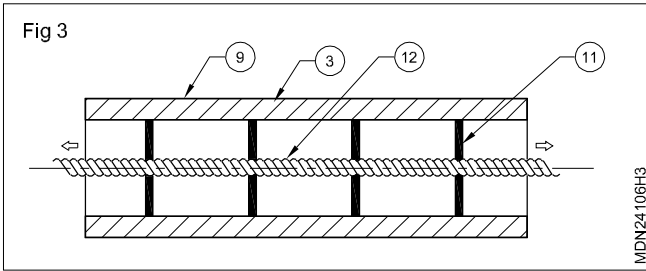
- 1 Loosen the nuts (2) and disconnect the exhaust pipe (3) from the exhaust manifold (4). (Fig 1)



- 2 Remove the exhaust manifold (4) from the cylinder head.
- 3 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)
- 4 Scrape the carbon deposits from the mounting faces of the manifold with a scraper (8).
- 5 Inspect the manifold flanges (5) for alignment of level by using a straight edge (6).



- 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.)
- 7 Inspect the exhaust manifold for any damage/crack. if necessary, replace it.
- 8 Inspect the tailpipe (9) and exhaust pipe (3) for any crack/damage etc.
- 9 Attach the scrapers (11) on the wire rope (12). (Fig 5)
- 10 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).
- 11 Inspect the catalytic converter for any damage or crack, if necessary replace it.
- 12 For cleaning the muffler (10) some manufacturers recommend to cut the outer cover and weld after cleaning the baffles inside. (Consult your instructor.)



- 13 Fix new gaskets on the exhaust manifold flange and fit the exhaust manifold (4).
- 14 Fix a new gasket (1) between the exhaust manifold and exhaust pipe (3) and fit the exhaust pipe on the exhaust manifold.

- 15 Fit the catalytic converter (11) with exhaust pipe
- 16 Fit the muffler (10) with the exhaust pipe and tighten the clamp. (Fig 1)
- 17 Fit the tailpipe (9) on the muffler and tighten the clamp.
- 18 Align the assembly and fix it in the supporting clamps to the chassis.

checking the exhaust system in engine running mode

Objective: At the end of this exercise you shall be able to

- examine the exhaust system of an engine.

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Kerosene	- as reqd.
• Box spanner set	- 1 No.	• Soapwater	- as reqd.
• safety glasses or goggle	- 1 Set.	• Clean cloth	- as reqd.
Equipments/Machineries		• Emery sheet	- as reqd.
• Diesel engine	- 1 No.	• Wire brush	- as reqd.
• Water sprayer	- 1 No.	• Metal sealing compound	- as reqd.
• Are welding machine	- 1 Set.	• Pipe clamp	- as reqd.
		• Bolts/ nuts	- as reqd.
		• Gasket/ Asbestos	- as reqd.

PROCEDURE

- 1 Start the engine
- 2 Identify leak in between the engine head and exhaust manifold joint (Gasket)
- 3 Conform the leakage by spraying soapwater on it
- 4 Stop the engine and allow to cool
- 5 Remove and clean the surface and studs with the helps rust remove and emery paper.
- 6 Place a new gasket, align and tighten it with recomended torque.
- 7 Restart the engine and check the leakage
- 8 Identify leaks by loose connection between muffler and tail pipe.
- 9 Dismantle the fittings, remove carbon, rust and clean
- 10 Apply metal sealing compound in between sleeve
- 11 Join the tail pipe and properly tighten it.
- 12 Restart the engine and check its smooth running without noise.
- 13 Ensure,there is no exhaust gas leaks in the exhaust system.

Servicing the fuel tank and fuel lines

Objectives: At the end of this exercise you shall be able to

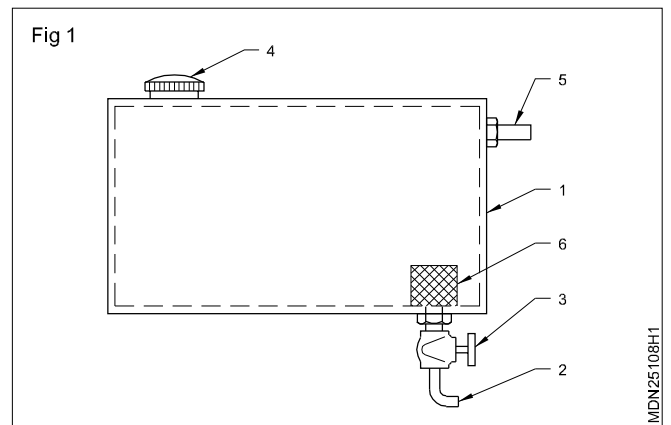
- **remove and clean the fuel tank**
- **remounting the fuel tank**
- **replace banjo bolts and washers**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Kerosene	- as reqd.
Equipments/Machineries		• Diesel	- as reqd.
• Multicylinder diesel engine	- 1 No.	• Soap oil	- as reqd.
• Air compressor	- 1 No.	• Lubricant Oil	- as reqd.
		• Cleaning cloth	- as reqd.

PROCEDURE

TASK 1: Servicing fuel tank

- 1 Disconnecting the mounting of fuel tank
- 2 Drain the fuel from the tank (1) (Fig 1).
- 3 Disconnect suction line (2) and overflow line (5) and injector leak off pipe.
- 4 Remove fuel tank from the vehicle.
- 5 Clean outside and inside of the fuel tank with diesel.
- 6 Wash it with water pressure.
- 7 Remove the fuel cock (3) from tank and clean it along with strainer (6) for free passage of fuel from tank.
- 8 Dry tank with air pressure.
- 9 Ensure that the vent hole of the fuel tank cap (4) is open.

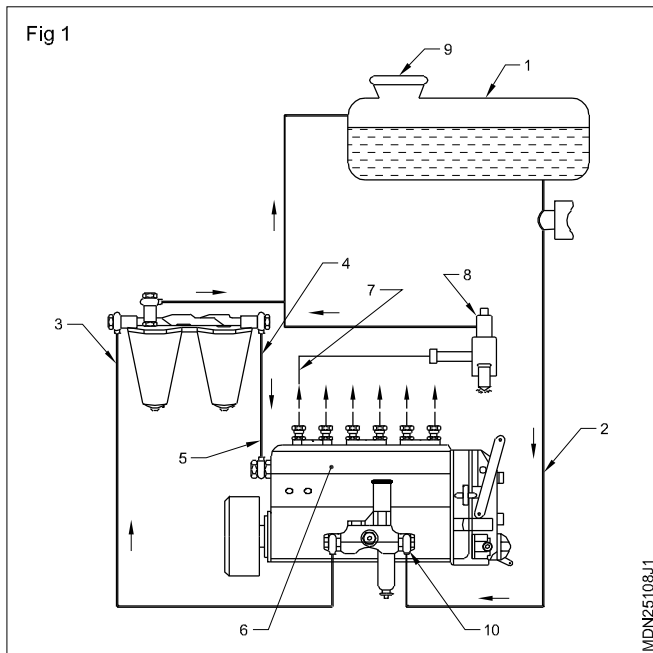


TASK 2: Remounting of fuel tank

- | | |
|--|---|
| 1 Refit the fuel cock (3) along with the strainer. | 3 Connect the pipe lines with fuel tank |
| 2 Place the fuel tank on vehicle and fit it. | 4 Fill the tank with fuel. |

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 21 for procedure for bleeding).
 - 7 Start the engine and ensure no leakage in fuel system.

Repairing of metal fuel lines

Objectives: At the end of this exercise you shall be able to

- **solder the hair line crack on fuel pipe**
- **solder the diesel pipe union**
- **braze the high pressure diesel pipe nipple**
- **service the water separator.**

Requirements			
Tools/Instruments			
• Trainee's tools kit	- 1 No.	Materials/Components	
• Socket spanner set	- 1 No.	• Flux	- as reqd.
• Soldering iron	- 1 No.	• Solder	- as reqd.
• Blow lamp	- 1 No.	• Filler rod	- as reqd.
• goggles	- 1 Pair.	• Union	- as reqd.
Equipments/Machineries		• Nipple	- as reqd.
• Gas welding unit	- 1 No.	• Emery paper	- as reqd.
		• Rag	

PROCEDURE

TASK 1: Solder the hair line crack on fuel pipe

- | | |
|--|---------------------------------------|
| Remove the leaky pipe of fuel pump | Apply heat to the pipe by below lamp |
| Check the leak point and mark on it | Add the solder on the hair line crack |
| Clean the hair line crack with sand paper | Wipe of excess solder |
| Apply a thin film of flux to the outside of pipe | Check the pipe by compressed air. |



TASK 2: Solder diesel pipe union

- | | |
|---|---|
| 1 Remove the diesel pipes | 5 Apply flux on outside of the matting surface with sand paper |
| 2 Check fuel pipe union | |
| 3 Remove the faulty union | 6 Heat the fittings and pipe until a complete ring of solder appears at the mouth of the fittings |
| 4 Clean the outside of the union and inside of the fittings with sand paper | 7 Allow it to cool without disturbance match and tight the fitting until the grip jaw stops |



TASK 3 : Brazing high pressure diesel pipe nipple

- | | |
|--|--|
| 1 Disconnect the damaged nipple high pressure line. | 7 Make a thin brazing at the end of the brass tube. |
| 2 Cut the pipe with a cutter near the ripple | 8 Ensure the brazing completely covers |
| 3 Remove the burr | 9 Clean the bend and joint and remove the fulx residue thoroughly. |
| 4 Choose a correct size of ripple | |
| 5 Soften the end of the fuel tube by heating | 11 Assemble and check the leakage |
| 6 Insert the ripple and drive into the softened end of the tube evenness | |



TASK 4: Servicing the water separators

- 1 Locate the drain valve of the water separator
- 2 Place the tray bottom the water separator
- 3 Unscrew the drain plug in the bottom of the fuel tank to drain the sediments and condensed water periodically [sediment space is kept atleast 1/2" above from the bottom of the fuel tank to avoid solution of water]
- 4 Remove the water separators filter
- 5 Check the water separator and note how fast it fills up under normal condition.
- 6 Wipe inside of the filter housing
- 7 Clean the fuel of water reside and other deposits by use of kerosene/diesel
- 8 Place a new 'o' ring in the filter cover assembly.
- 9 Place a new filter element in the filter housing
- 10 Assemble the housing with top cover and tighten the centre bolt
- 11 Bleed the fuel system and start the engine.
- 12 Ensure there is no leakage in fuel system

— — — — —

Overhauling the fuel feed pump in diesel engine

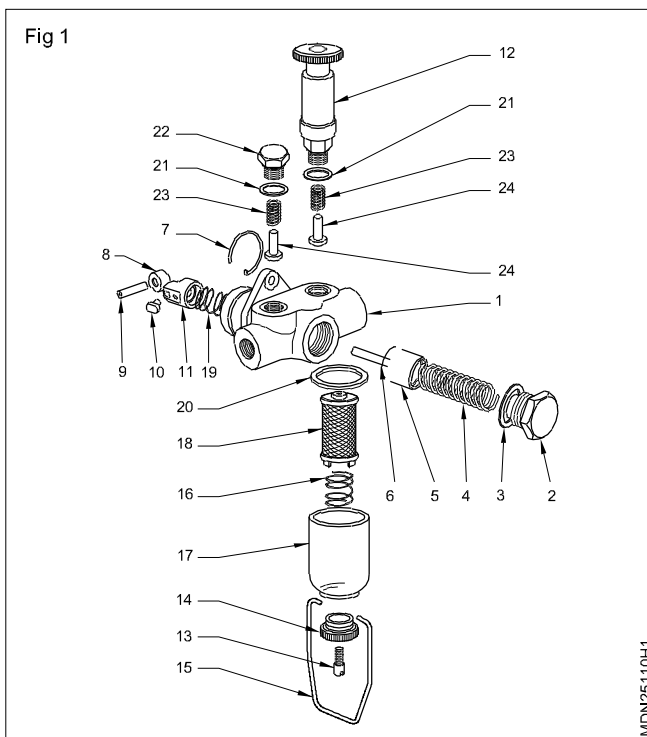
Objectives: At the end of this exercise you shall be able to

- Overhaul the mechanical fuel feed pump
- Overhaul the electrical fuel feed pump

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Kerosene	- as reqd.
• Circlip plier	- 1 No.	• Diesel	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multicylinder diesel engine	- 1 No.	• Cotton cloth	- as reqd.
• Air compressor	- 1 No.	• New gasket	- as reqd.

PROCEDURE

TASK 1: 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).

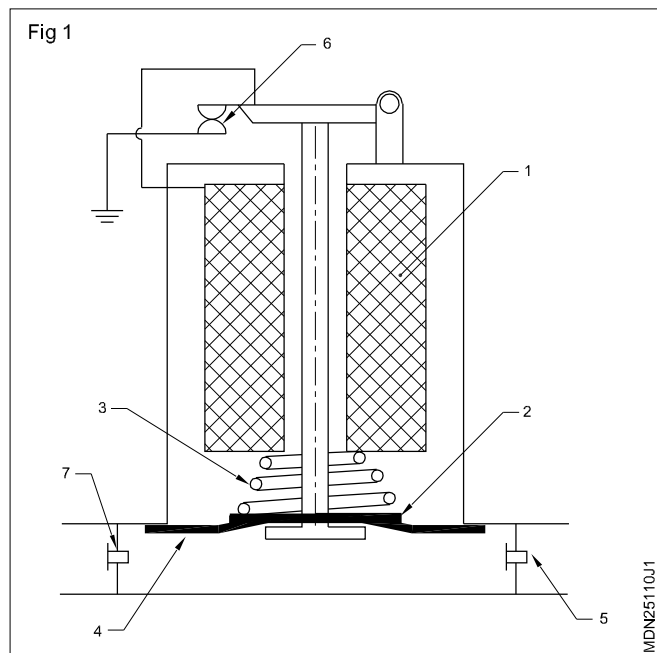
- 4 Remove the snap ring (7) and take out the roller tappet assembly of the feed pump.
- 5 Remove the screw plug (2) and gasket (3) and take out the plunger and spindle (5 & 6) with the return spring (4).
- 6 Remove the hand priming pump (12) and gasket (21).
- 7 Remove the screw plug (22), gasket (21) 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 Cleaning and Inspection
- 11 Cleaning all the parts of the fuel feed pump with kerosene or diesel.
- 12 Check visually all the parts for wear and replace if required.
- 13 Check the tension of all the springs, and replace if necessary.
- 14 Check the valve seats.
- 15 Check the gaskets, and replace if necessary.
- 16 Check the filter clamping nut threads.

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.Ps camshaft so that the heel of the cam driving and the 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
- 13 Check the diaphragm, if damaged replace it
- 14 Assemble all the part of and 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 leaky in fuel pump.



Remove and replace the fuel filter and bleed the system

Objectives: At the end of this exercise you shall be able to

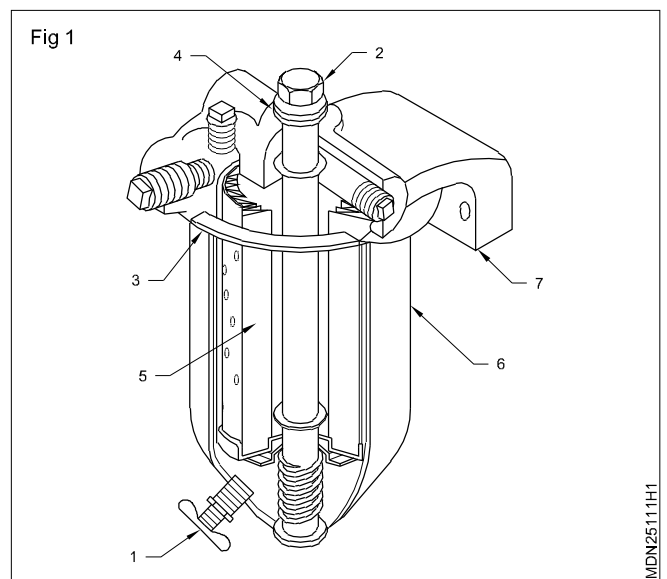
- **dismantle and replace filter element**
- **bleed the fuel system.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No,	• Kerosene	- as reqd.
Equipments/Machineries		• Diesel	- as reqd.
• Multicylinder diesel engine	- 1 No.	• Soap oil	- as reqd.
• Air compressor	- 1 No.	• Cotton cloth	- as reqd.
		• gasket	- as reqd.
		• filter element	

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).
- 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)

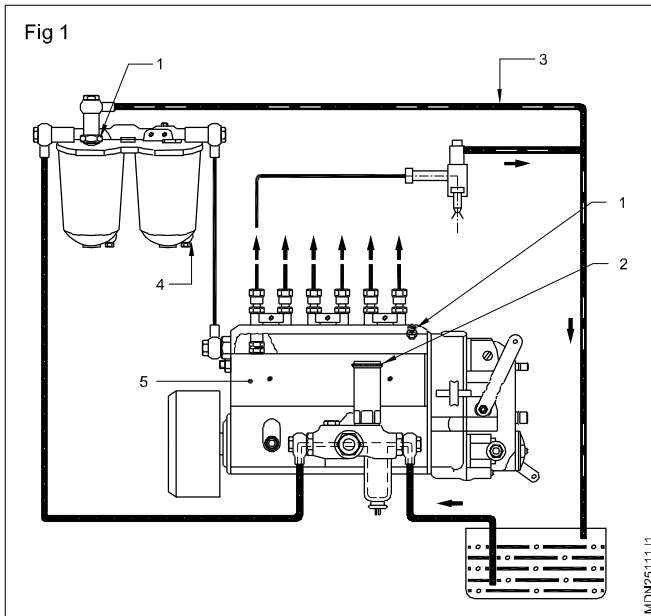


13 Assemble the housing with cover and tighten the centre bolt.

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 filter
- 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 tighten
- 11 Start the engine and check to performance

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		Materials/Components	
<ul style="list-style-type: none"> • Trainee's tool kit 	- 1 No.	<ul style="list-style-type: none"> • Kerosene • Diesel • Soap oil • Cleaning cloth • New gasket • Swam neck pipe 	<ul style="list-style-type: none"> - as reqd. - as reqd. - as reqd. - as reqd. - as reqd. - 1 No.
Equipments/Machineries			
<ul style="list-style-type: none"> • Multicylinder diesel engine • Air compressor 	<ul style="list-style-type: none"> - 1 No. - 1 No. 		

PROCEDURE

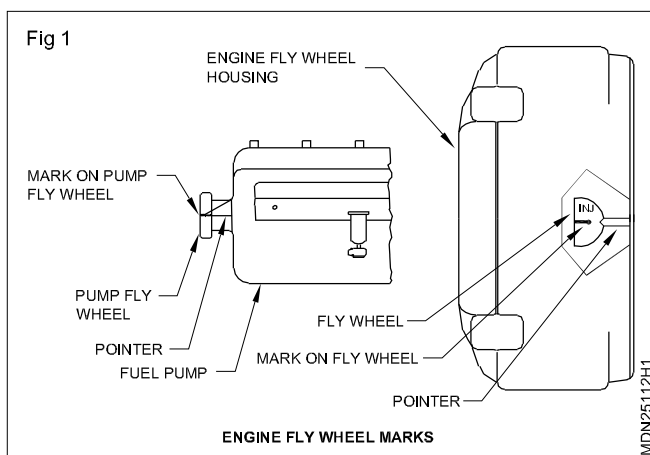
TASK 1: Removing F.I.P from the engine

- | | |
|--|--|
| <ol style="list-style-type: none"> 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 | <ol style="list-style-type: none"> 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. |
|--|--|

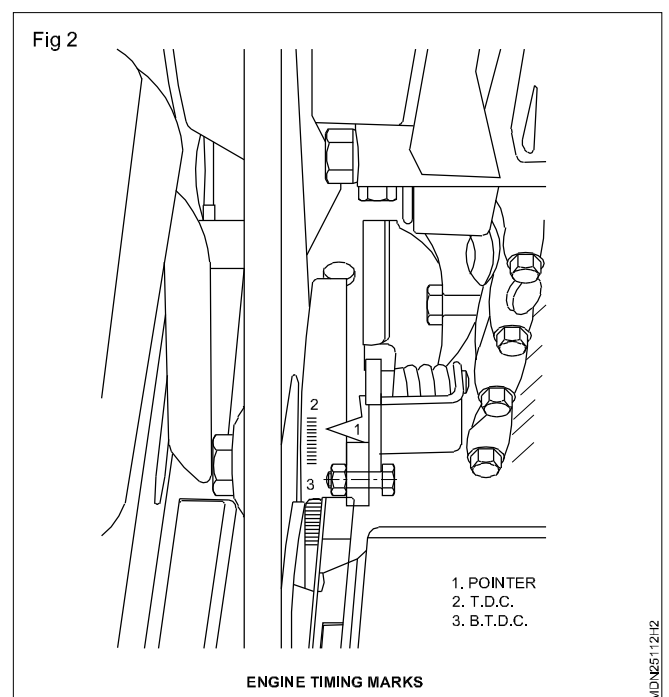


TASK 2: Setting timing of the fuel injection pump in relation to the engine

- 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)



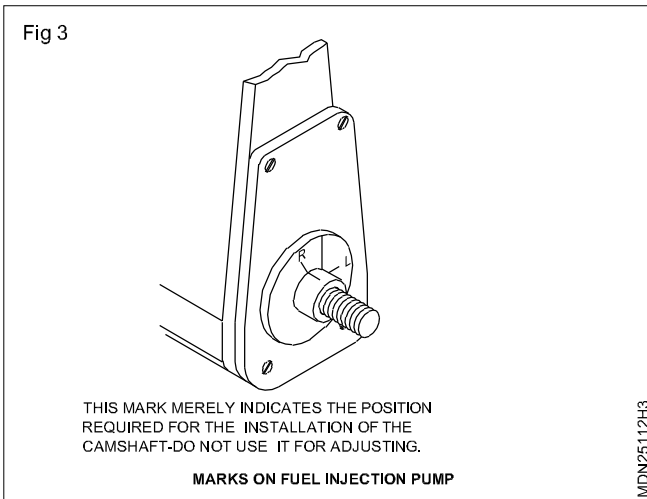
- 3 Observe the TDC/BTDC (Injection marks) and a pointer made in the flywheel, on the 'V' belt pulley or on the vibration damper. (Fig 3)



- Crank the engine in a 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.

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

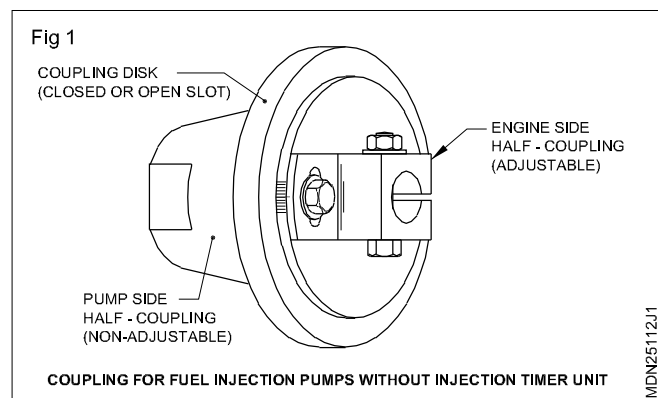
- Now the engine is ready for coupling with the FIP.
- Preparing the F.I.P pump for coupling to the engine.



- The pump plunger next to the drive end must be set to the commencement of delivery position for respective direction of rotation.
- Observe the timing marks on FI pump shaft and housing.
- 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)
- 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.
- Observe the line mark on the coupling boss aligning with R or L mark on the pump housing.
- 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.

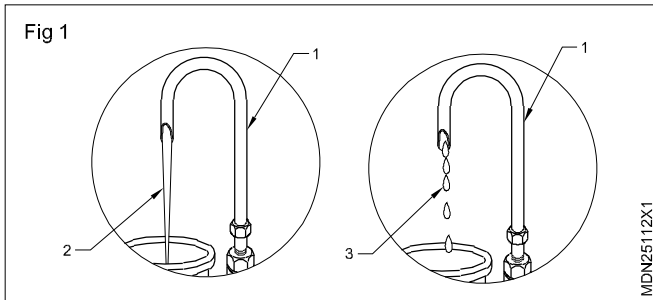
TASK 3: Coupling the pump with the engine (Fig 1)

- Assemble the coupling unit on the pump with their zero marks exactly matching. (There are 3 units in all)
- 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)
- 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).
- Insert the fastening bolts on the pump mounting holes and tighten them with nuts to the specified torque.
- Crank the engine and check for free rotation of the pump shaft along with exhauster/air compressor shaft.



TASK 4: Spill cut method (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.
- 3 Fit the delivery valve holder.
- 4 Fit the swan neck pipe (1) on the 1st delivery valve holder. (Fig 1)
- 5 Connect the fuel gallery of the FIP to the fuel container placed at a higher level.



- 6 Move the FIP towards the engine till the fuel (2) starts flowing freely through the swan neck pipe.
- 7 Now move the FIP away from the engine till the fuel flow is cut off completely.
- 8 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.
- 9 Remove the swan neckpipe (1) and delivery valve holder and replace the pin and spring and fit the delivery valve holder.
- 10 Remove the swan neckpipe (1) and delivery valve holder and replace the pin and spring and fit the delivery valve holder.
- 11 Connect the pressure pipes between the injectors and fuel injection pump.
- 12 Fill the governor lubrication oil
- 13 Start the engine and adjust idle speed.

Overhauling and testing the fuel injector

Objectives: At the end of this exercise you shall be able to

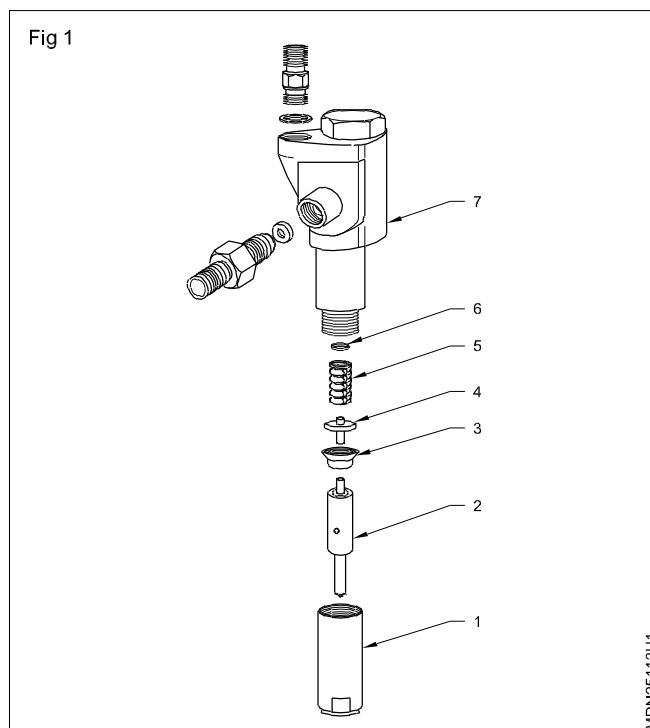
- **dismantle the injectors**
- **inspect and assemble injector**
- **testing injectors.**

Requirements	
<p>Tools/Instruments</p> <ul style="list-style-type: none"> • Trainee's tools kit • Injector cleaning kit <p>Equipments/Machineries</p> <ul style="list-style-type: none"> • Multicylinder diesel engine • Injector testing machine • Air compressor 	<p>Materials/Components</p> <ul style="list-style-type: none"> • Kerosene - as reqd. • Diesel - as reqd. • Soap oil - as reqd. • Cleaning cloth - as reqd. • injector - as reqd.

PROCEDURE

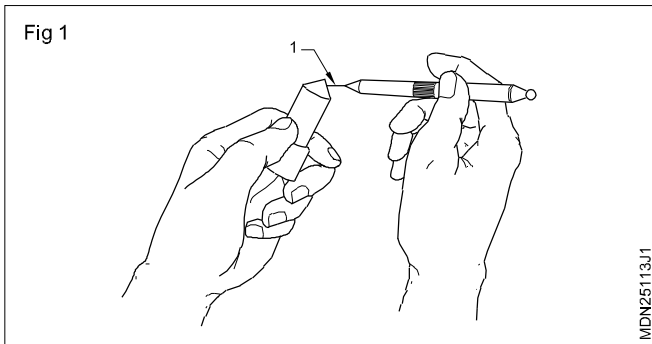
TASK 1: Dismantling (Fig 1)

- 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).



TASK 2: Cleaning and inspection (Fig 1)

- | | |
|--|--|
| <ol style="list-style-type: none"> 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. | <ol style="list-style-type: none"> 3 Inspect the nozzle needle for damage, roughness and wear. 4 Inspect the nozzle body (7) for damage. |
|--|--|

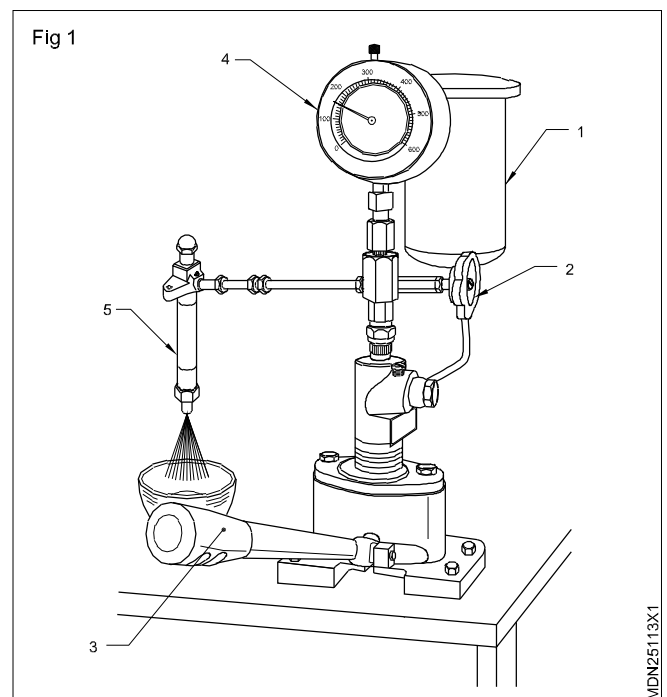


- 5 Clean the nozzle either by blowing air or with a nozzle cleaning wire. Cleaning wire's (1) diameter should be smaller than spray hole's diameter. Ensure that while cleaning wire does not break inside the hole (Fig 1).
- 6 Rinse nozzle needle and nozzle with clean testing oil.
- 7 Hold the nozzle 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.

TASK 3: Testing

- 1 Fit injector (5) on injector tester (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 nozzle.
- 5 Caution do not put your hand underneath the injector being tested.
- 6 Open the shut off valve knob.
- 7 Operate hand lever and observe the maximum pressure from gauge (4) at which test oil sprays out of nozzle.
- 8 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.
- 9 Observe that the test oil is sprayed from all the holes of nozzle. If not, then clean the nozzle hole.
- 10 Observe that the test oil does not dribble after spraying. If it does, then grind the nozzle needle.
- 11 Remove injector (5) from injector tester.
- 12 Fit injector on engine with new seating washer.
- 13 Connect high pressure pipe.
- 14 Connect over flow pipe.



General maintenance of fuel injection pumps

Objectives: At the end of this exercise you shall be able to
• **maintenance of F.I.P.**

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Cleaning tray	- as reqd.
Equipments/Machineries		• Cottoncloth	- as reqd.
• Multicylinder diesel engine	- 1 No.	• 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 ejection
- 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 start 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

Adjusting the idle speed of pneumatic governor

Objective: At the end of this exercise you shall be able to

- **Adjust idling speed in pneumatic governor.**

Requirements	
Tools/Instruments	
• Trainee's tools kit	
Equipments/Machineries	
• diesel engine with pneumatic governor	- 1 No.
• 12V battery with cables	- 1 Set.
Materials/Components	
• Cleaning tray	- as reqd.
• Cotton cloth	- as reqd.
• Soap oil	- as reqd.
• Diesel	- as reqd.
• Engine oil	- as reqd.
• Coolant water	- as reqd.

PROCEDURE

- 1 Check the engine foundation bolt and tighten if necessary.
2. Check water level in radiator, top up if required.
3. Check lubricating oil level in a sump, top up if required.
4. Check fuel level in fuel tank and fill if required.
5. Connect the battery with cables to the starting motor properly.

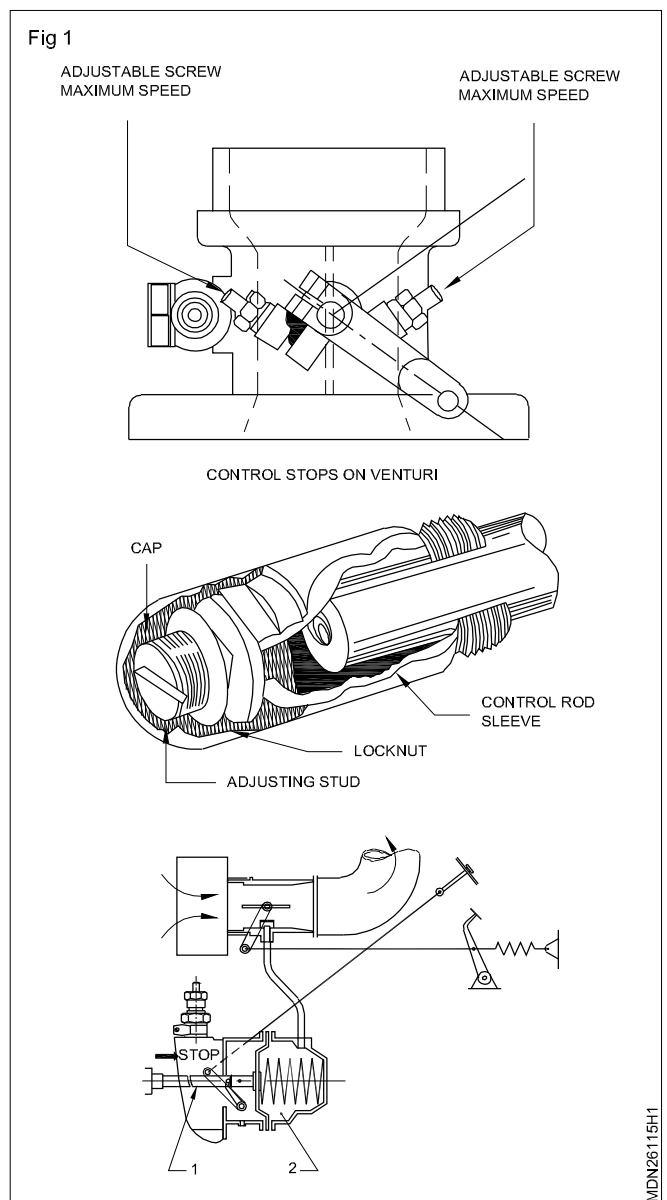
Bleed the fuel system until the system is free from air with help of hand priming device

- 6 Check the fan belt tension and adjust if required.
- 7 On the ignition switch with help of ignition key.
- 8 Start the engine with help of start or button.

Do not hold the start or button for longer time to start

- 9 Release the starter button immediately after engine starts.
- 10 Raise the engine speed slowly with help of accelerator level (or) throttle lever.
- 11 Observe the engine speed to conform the engine to running smoothly with out any leakages and sound.
- 12 Release the accelerator lever, and ensure the engine is running at slow speed.
- 13 Observe any abnormal vibration of the engine.
- 14 Lubricate the spindle and linkages of butterfly valve mounted in the venture throat.
- 15 Loosen the idling adjusting screw nut with ring spanner
- 16 Adjust the idling screw with screw driver set the proper idling speed RPM of the engine of specified by the manufacturer.
- 17 Keep the screw driver and lock the next in position

- 18 Adjust the maximum speed similarly. (Fig 1)
- 19 Start the engine and check idling and high speed smooth performance



MDN26115H1

Adjusting the idling speed of mechanical governor

Objectives: At the end of this exercise you shall be able to
• **adjust the idling and high speed operation of the engine.**

Requirements	
Tools/Instruments	Materials/Components
<ul style="list-style-type: none">• Trainee's tools kit	<ul style="list-style-type: none">• Cleaning tray - 1 No.• Cotton cloth - as reqd.• Soap oil - as reqd.• Diesel - as reqd.• Lubrication oil - as reqd.
Equipments/Machineries	
<ul style="list-style-type: none">• Multicylinder four stroke diesel engine with mechanical governor - 1 No.• 12 volt battery with cables - 1 Set.	

PROCEDURE

- 1 Check the engine foundation bolt and tighten if necessary.
2. Check water level in radiator, top up if required.
3. Check lubricating oil level in a sump, top up if required.
4. Check fuel level in fuel tank and fill if required.
5. Connect the battery with cables to the starting motor properly.

Bleed the fuel system until the system is free from air with help of hand priming device

- 6 Check the fan belt tension and adjust if required.
- 7 Observe the timing marks on F1 pump shaft and housing
- 8 On the ignition switch with help of ignition key.
- 9 Start the engine with help of starter button.

Do not hold the starter button for longer time to start

- 10 Release the starter button immediately after engine starts.
- 11 Raise the engine speed slowly with help of accelerator lever.
- 12 Observe the engine speed to conform the engine to running smoothly with out any leakages and sound.
- 13 Release the accelerator lever, now the engine is running at slow speed.
- 14 Observe any abnormal vibration of the engine.
- 15 Adjust the idling stop screw with help of spanner and screw driver set the proper idling speed as per manufactures specification (or) manual.
- 16 start the engine and check the idle and high speed operation perform

Care should be taken after adjusting idling speed the idling speed lock nut must be lock position

- 17 Stop the engine with help of 'OFF' level (or) stop level.

Identify the defective injector of an engine

Objectives: At the end of this exercise you shall be able to

- check the engine vibration
- inspect and test the injectors

Requirements			
Tools/Instruments		Materials/Components	
• Trainee's tool kit	- 1 No.	• Kerosene	- as reqd.
• injector cleaning kit	- 1 No.	• Diesel	- as reqd.
Equipments/Machineries		• Soap oil	- as reqd.
• Multicylinder four stroke diesel engine	- 1 No.	• Cotton waste	- as reqd.
• Injector testing machine	- 1 No.		
• Air compressor	- 1 No.		

PROCEDURE

- 1 Check the engine oil, water level before start the engine
- 2 Start the engine and run it idle speed
- 3 Record the engine RPM
- 4 Observe the knocking sound/ vibration of the engine
- 5 Remove the high pressure pipe nipple from the 1st cylinder nozzle to one by one
- 6 Check the rpm of the engine variation
- 7 Which injector's fuel line disconnection is not vary the engine operation, Means the injector is defective.
- 8 Faulty injector indicate same the initial reading and knocking sound
- 9 Stop the engine and takeout the faulty injector from the cylinder head
- 10 Place it in a tray and dismantled the injector and clean the dismantled injector parts and inspect the parts.
- 11 Replace the damaged or workout parts
- 12 Assemble the dismantle parts of the injector and adjust it.
- 13 Test the injector with injector test machine
- 14 Fit the injector on the particular cylinder
- 15 Start the engine observe the engine r.p.m and its smooth running.

Diesel engine smoke testing

Objectives: At the end of this exercise you shall be able to

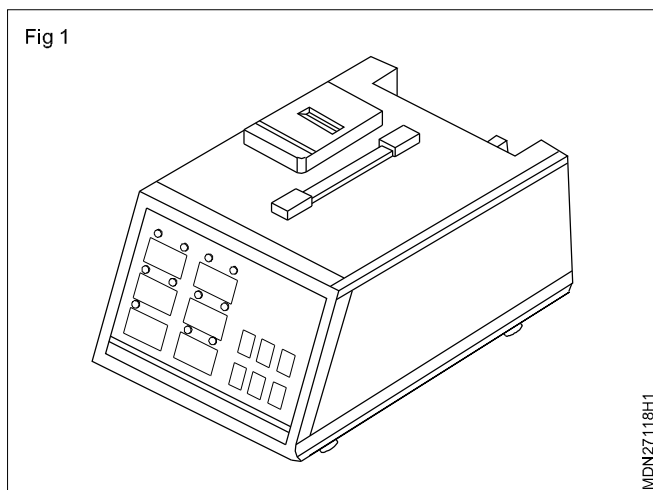
- use of 4/5 gas analyser
- installation of 4/5 gas analyser
- setup of instrument for measuring emission parameter
- perform leak test
- measure CO, HC, CO₂, O₂, X, AFR/NO_x
- understand the result.

Requirements	
Tools/Instruments	Equipments/Machineries
<ul style="list-style-type: none">• Trainee's tool kit - 1 No.• 4/5 gas analyser - 1 No.• Screw Driver - 1 No.	<ul style="list-style-type: none">• Running vehicle 1 No.

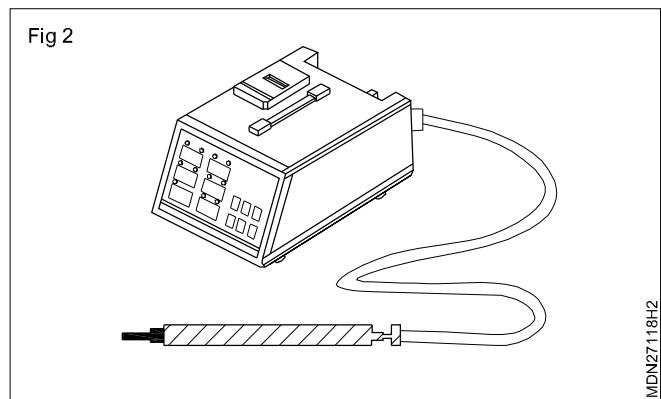
PROCEDURE

TASK 1: Installation

Note: Safety instructions
This procedure applies to the product of 4/5 gas analyzer
This analyzer (Fig 1) is a equipment to measure the gas emission density of an automobile enabling to diagnose the automobile status and its preventive maintenance so that it can provide a function to prevent the air pollution in advance.



- 1 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.

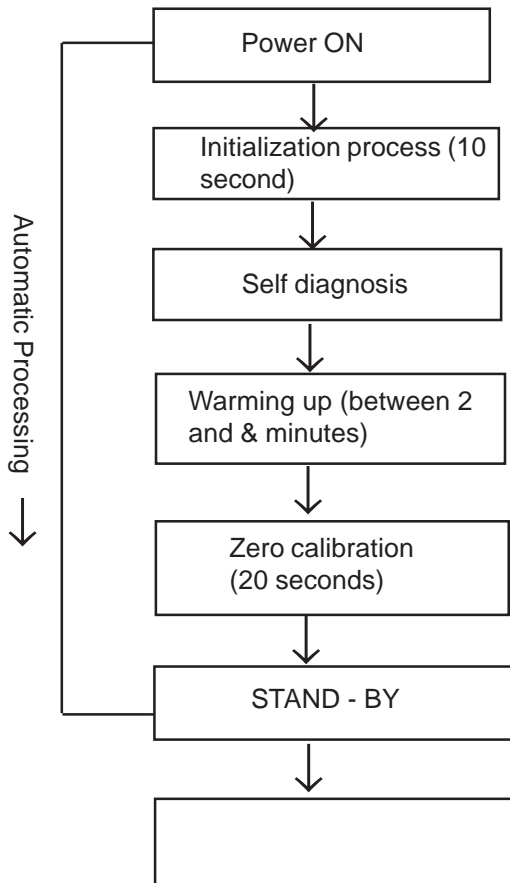


- 2 Turn off the power switch and then connect the power cable to the power socket located in the rear of the analyzer
- 3 Verify the fitting conditions of measuring probe filter and various filters located in the rear of the analyzer.
- 4 Verify again the connection status of the analyzer and then turn on the power switch.

TASK 2: Measurement

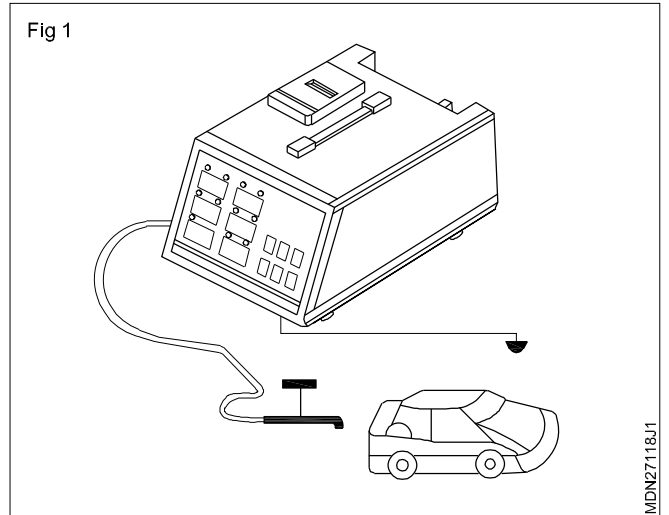
Measurement Mode

- 1 Place the probe in the clean air to perform the [Zero calibration].
- 2 Push the probe deep into the exhaust outlet of the vehicle (Fig 3) and measure exhaust gas by pressing measurement key. (Fig 2)



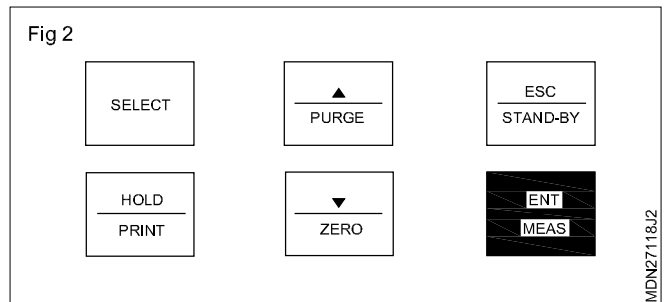
- 3 The measurement operates for 30 minutes and the pump is automatically stopped by the activation of the power-saving mode. Press **MEAS** key again to measure the exhaust gas for more than 30 minutes.
- 4 Pull the probe out of the exhaust outlet of the vehicle. Then clean the inside of analyser with the clean air by pressing the **PURGE** key until the measurement values drop to 0. (Fig 1)

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 2,3 & 4.

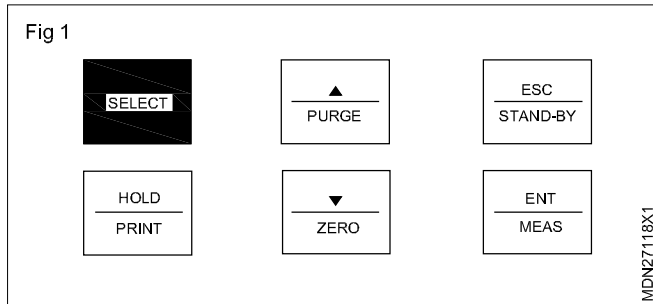
Fig 2



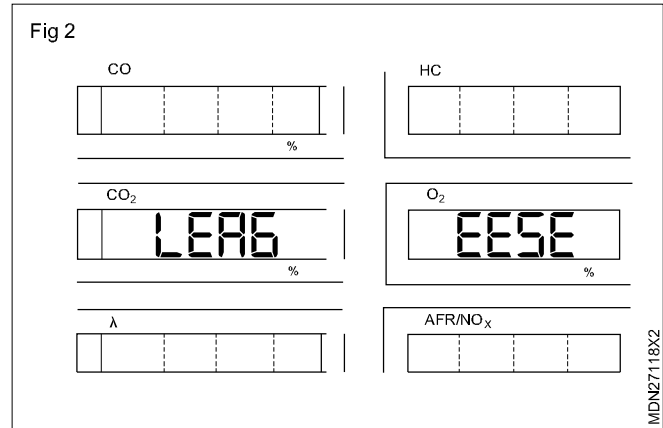
TASK 3: Leak test

A function that looks for any possible air leakage from the sample-cell in order to indicate the exact result

- 1 Press the SELECT key (Fig 1) once in the stand-by mode to select the Leak Test mode



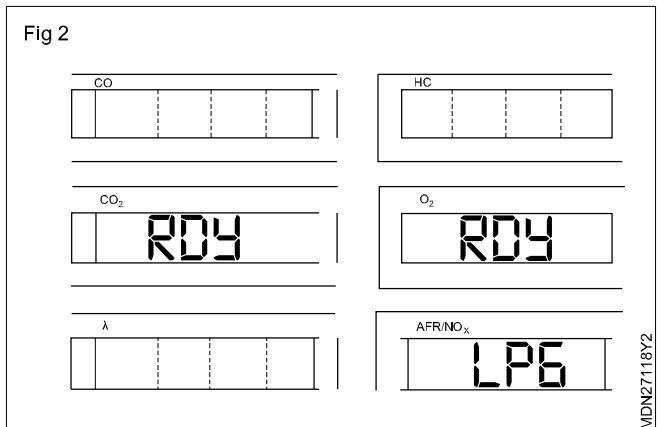
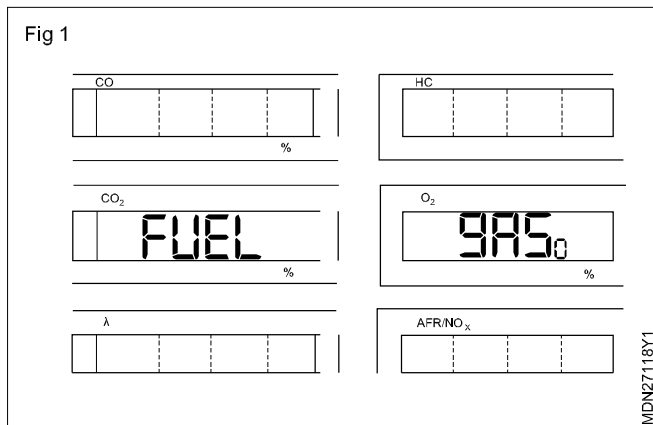
- 2 If the message 'Leak test' is indicated on the indication window as shown above (Fig 2) mount the leak test cap on the front side of the probe.



- 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'.

TASK 4: Selection of fuel

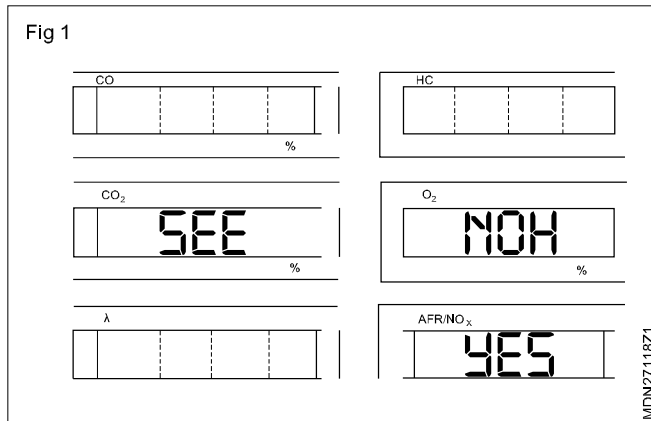
- 1 This is the function that selects fuel for testing vehicle. It is used to calculate air surplus rate (?) and AFR. This analyzer can select the fuel such Gasoline, LPG, CNG, and Alcohol. (Fig 1)
- 2 Selected fuel is indicated as in the above. Use ▲, ▼ keys until it indicates the fuel to select.



TASK 5: NOX setup

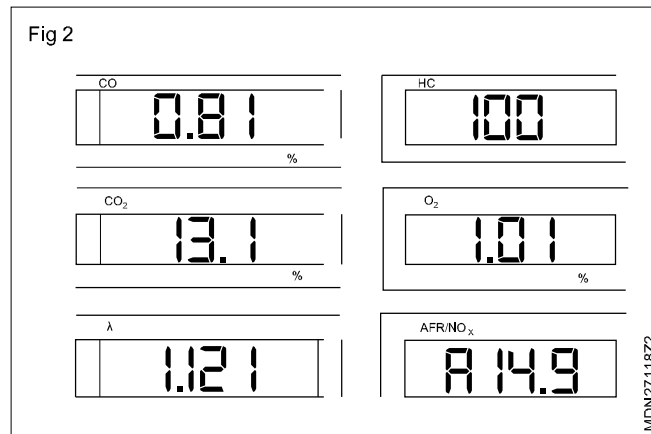
It is a function selecting where to attach NOX sensor.

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 (fig 1), NO for non-NOX display mode, then press ENT



4 "A" is attached as shown below (fig 2) in the AFR(Air/fuel rate) display mode and disappears in the NOx display mode. NOx/AFR mode is changed as the ENT key is pressed in measurement mode.

By measuring NO_x, CO₂, and O₂, in addition to HC and CO a mechanic gets a better look at the efficiency of the engine (Fig 3). Maximum limits for the measured gases are set by regulation according to Euro and BS standards. It is always desirable to have low amounts of four of five measured gases at all engine speeds.

The readings of the chemicals in the exhaust can lead the Technician to the cause of a driveability problem.

	Idle	2500 RPM	PROBABLE CAUSE
HC ppm	0-150	0-75	Normal reading
CO%	1-15	0-0.8	
CO ₂ %	10-12	11-13	
O ₂ %	0.5-2.0	0.5-1.25	
NO _x ppm	100-300	200-1,000	
HC ppm	0-150	0-75	Rich mixture
CO%	3.0+	3.0+	
CO ₂ %	8-10	9-11	
O ₂ %	0-0.5	0-0.5	
NO _x ppm	0-200	100-500	
HC ppm	0-150	0-75	Lean mixture
CO%	0-1.0	0-0.25	
CO ₂ %	8-10	11	
O ₂ %	1.5-3.0	1.0-2.0	
NO _x ppm	300-1,000	1,000+	
HC ppm	50-850	50-750	Lean mixture
CO%	0-0.3	0-0.3	
CO ₂ %	5-9	6-10	
O ₂ %	4-9	2-7	
NO _x ppm	300-1,000	1,000+	
HC ppm	50-850	50-750	Mixture
CO%	0.1-1.5	0-0.8	
CO ₂ %	6-8	8-10	
O ₂ %	4-12	4-12	
NO _x ppm	0-200	100-500	

Checking PCV valve and EVAP system

Objectives: At the end of this exercise you shall be able to

- inspect PCV hose
- inspect PCV valve.

Requirements			
Tools/Equipments/Instruments		Materials	
• Trainee's tool kit	- 1 No.	PCV solvent/lacquer thinner	- as reqd.
• Digital multimeter/ohmmeter	- 1 No.	Baniyan cloth	- as reqd.
• 12V battery	- 1 No.	PCV valve	- 1 No.
• Scan tool	- 1 No.	EVAP	- 1 No.

PROCEDURE

Note: Be sure to check that there is no obstruction in PCV valve or its hoses before checking

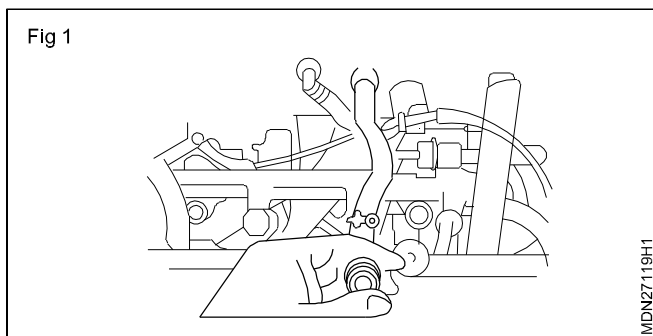
engine idle speed/IAC duty, for obstructed PCV valve or hose hampers its accurate checking.

TASK 1: PCV HOSE Inspection

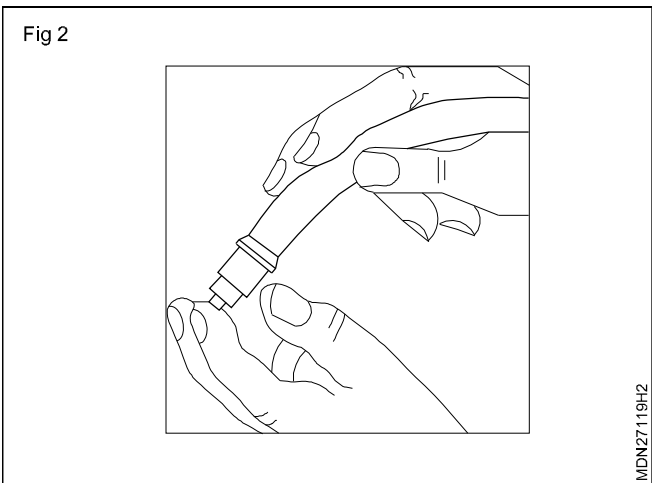
- 1 The PCV valve is usually located next to the valve cover of the engine, or in the intake manifold.
- 2 If you cannot identify it quickly, check with the workshop manual.
- 3 Check hoses for connection, leakage, clog and deterioration. Replace as necessary

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).

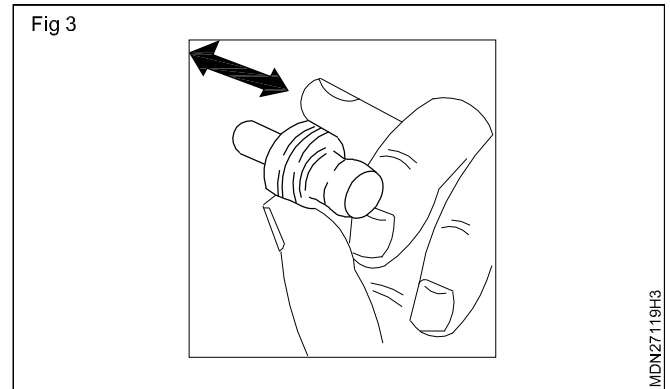


- 3 Run engine at idle speed.
- 4 Place your finger over end of PCV valve (1) as shown in Fig 2 to check for vacuum. (Fig 2)
- 5 If there is no vacuum, check for clogged valve.



- 6 Try cleaning it and to observe if it is working by with PCV solvent or lacquer thinners or immersing it in carburettor 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.



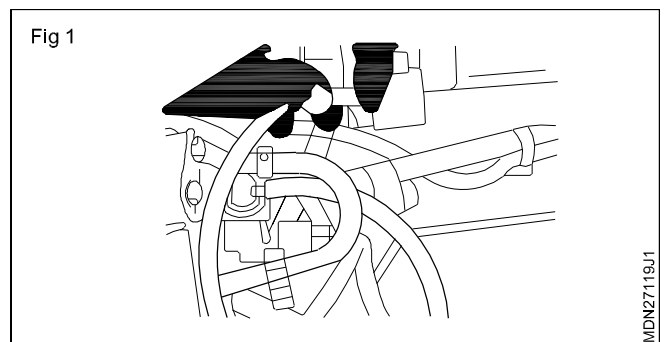
Practice on inspection of evaporative (EVAP) canister purge system with the use of scan tool

Objectives : At the end of this exercise you shall be able to

- check for vacuum
- inspect vacuum passage
- measure the resistance of EVAP canister purge valve
- use of scan tool.

TASK 3: Check for vacuum

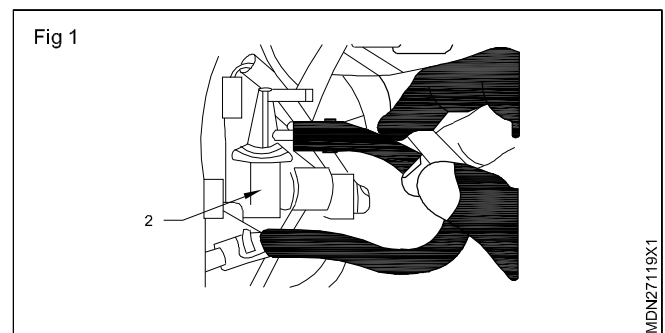
- 1 To make sure that gear shift lever is in neutral position
- 2 In case of Auto transmission (A / T) model, selector lever in "P" range
- 3 Parking brake lever is pulled all the way up.
- 4 Warm up engine to normal operating temperature.
- 5 Disconnect purge hose as shown in (Fig 1) (1) from EVAP canister
- 6 Place your finger against the end of disconnected hose and check that vacuum is not felt there when engine is running at idle speed.
- 7 check that vacuum is felt when engine speed is increased to higher than about 3000 rpm.



- 8 If check result is not satisfactory, check vacuum passage, hoses, EVAP canister purge valve, wire harness and ECM (PCM).

TASK 4: Vacuum passage inspection

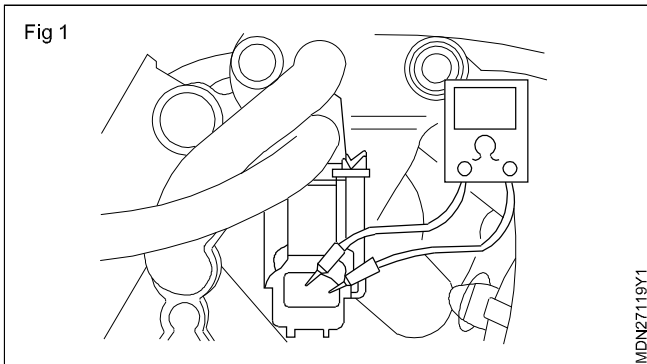
- 1 Start engine and run it at idle speed.
- 2 Disconnect vacuum hose from EVAP canister purge valve (Fig 1) (2). With finger placed against hose disconnected, check that vacuum is applied.
- 3 If it is not applied, clean vacuum passage by blowing compressed air
- 4 Check hoses for connection, leakage, clog and deterioration. Replace as necessary.



Evap canister purge valve inspection by use of scan tool

TASK 5: Measure the resistance of EVAP canister purge valve

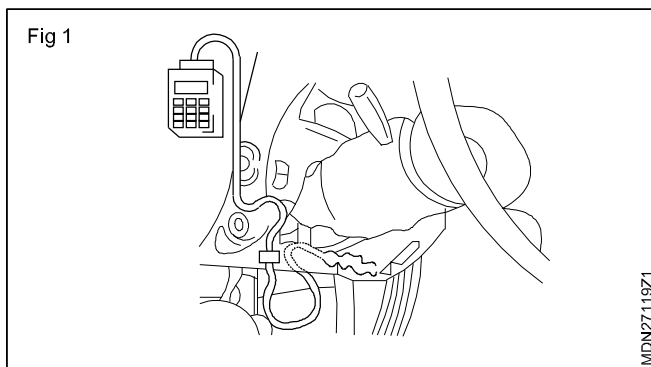
- 1 With ignition switch OFF, disconnect coupler from EVAP canister purge valve.
- 2 Check resistance between two terminals of EVAP canister purge valve.(Fig 1)



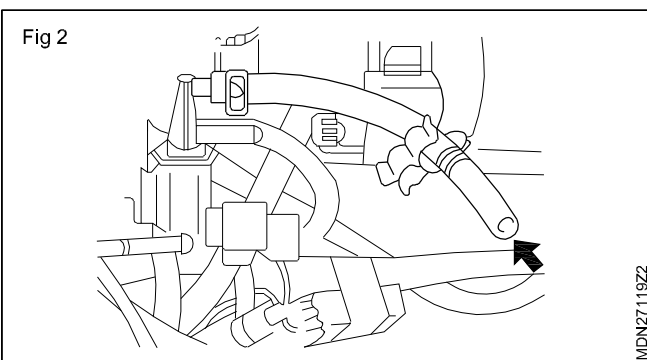
- 3 Resistance of EVAP canister purge valve to be 30-34 at 20°C
- 4 If resistance is as specified as per manual, proceed to next operation check.
- 5 If not, replace the EVAP canister purge valve
- 6 Connect coupler to EVAP canister purge valve.

TASK 6: Use of scan tool

- 1 Connect scan tool (Fig 1) (1) to Data Link Connector (DLC) (2) with ignition switch OFF



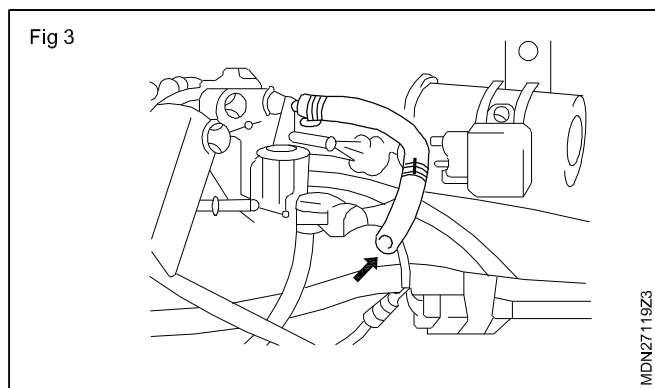
- 2 Disconnect vacuum hoses from intake manifold.
- 3 Blow into hose "A". Air should not come out of nozzle "B".as shown in (Fig 2)



- 4 Open EVAP canister purge valve by executing "EVAP CANI PURGE" under "MISC TEST" mode of SUZUKI scan tool with ignition switch ON. In this state, blow hose "A". Air should come out of nozzle "B". (Fig 3) (for other scan tool ref to scan tool manual)

Warning: Do not suck the air through valve. Fuel vapor inside valve is harmful.

- 5 If check result is not as described, check wire harnesses for open or short. If it is in good condition, replace EVAP canister purge valve and recheck
- 6 Connect vacuum hoses.



Removing and refitting of EGR valve

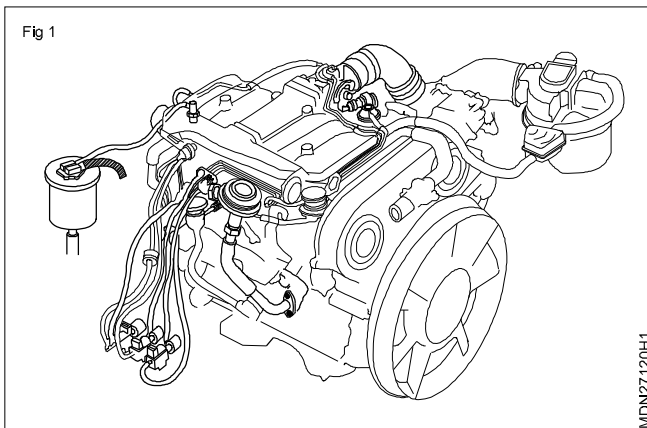
Objectives: At the end of this exercise you shall be able to

- identify EGR Valve
- disconnect EGR valve connection
- measure EGR Valve Resistance
- remove EGR Valve
- inspect EGR valve
- replace EGR Valve

Requirements			
Tools/Equipments/Instruments		Material	
• Traniee's tool kit	- 1 No.	Tray	- 1 No.
• Screw Driver set	- 1 No.	Cotton waste	- 1 No.
• Box Spanner set	- 1 No.	Kerosene	- as reqd.
• Digital Multimeter/Ohmmeter	- 1 No.	Vaccum hose	- as reqd.
		EGR valve	- 1 No.

PROCEDURE

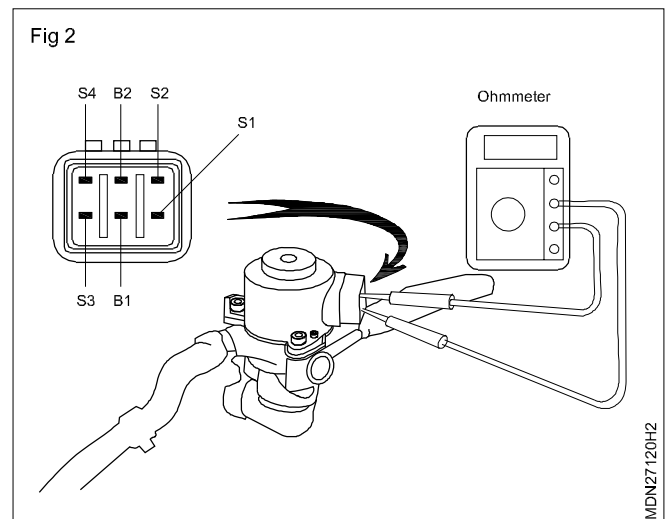
1 Locate the EGR Valve (Fig1)



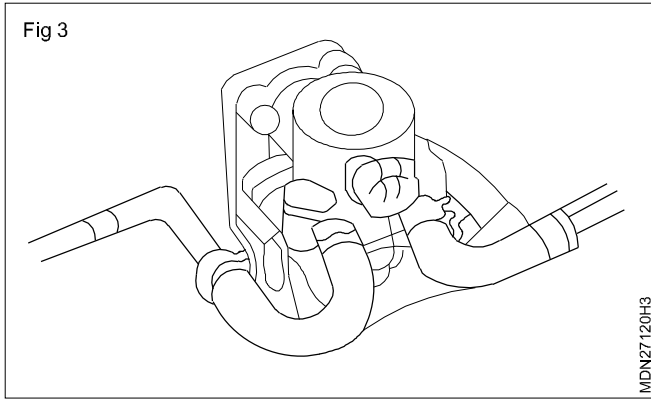
2 Disconnect negative terminal cable from battery.

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.

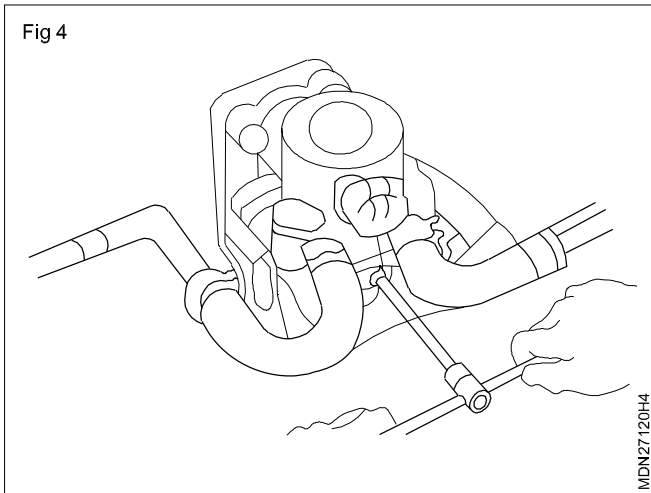
- 3 Disconnect exhaust gas recirculation valve connector (Fig 1)
- 4 Inspect exhaust gas recirculation valve resistance
- 5 Using an ohmmeter measure the resistance between terminal B1 (or B2) and other terminals (S1, S2,S3 and S4) .(Fig 2)
- 6 Resistance (Cold) should be 19.9 to 23.4 Ohms



- 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)
- 12 Visually inspect EGR valve for sticking and heavy carbon deposits (Fig 5)
- 13 If problem is found replace the EGR valve assembly

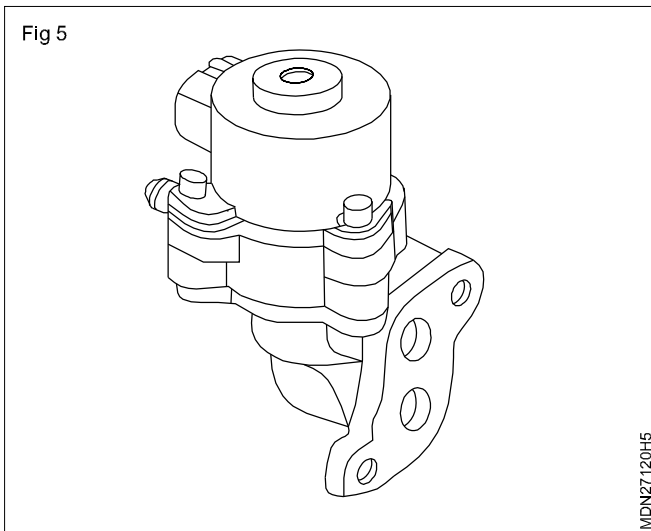


MDN27120H3



MDN27120H4

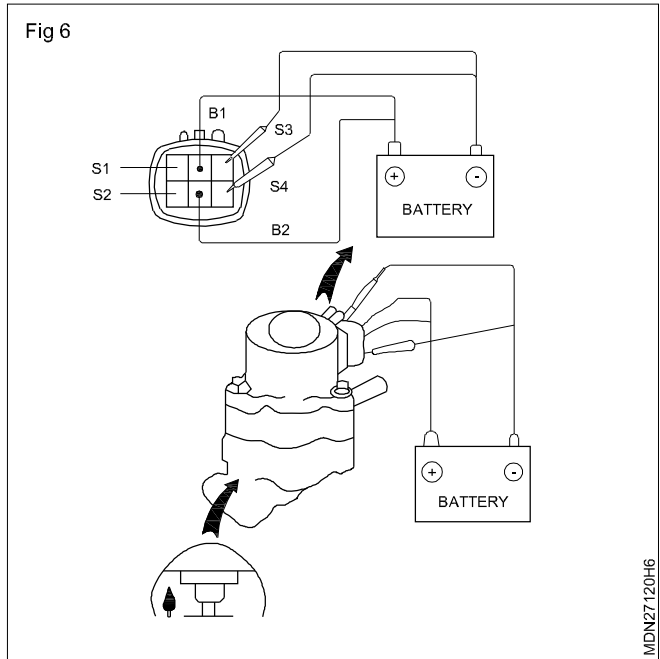
14 If not, Inspect EGR valve operation



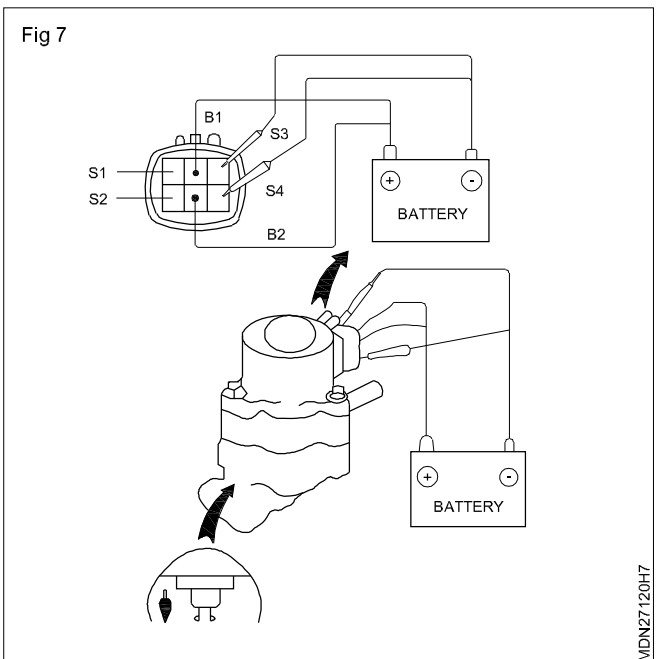
MDN27120H5

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.)

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.)



MDN27120H6



MDN27120H7

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.

Overhauling and testing of an alternator

Objectives : At the end of this exercise you shall be able to

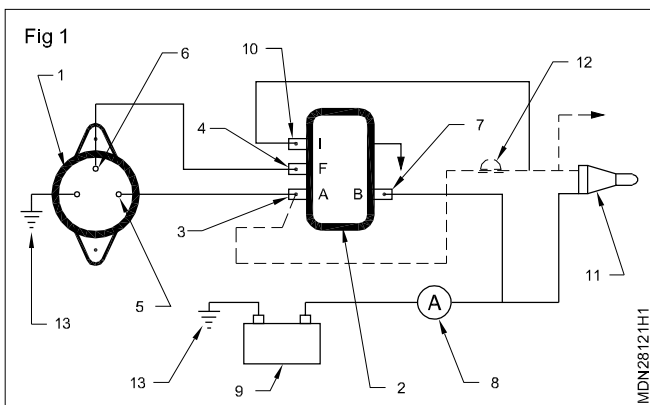
- locate the circuit from the alternator to the battery
- remove the alternator
- dismantle the alternator
- check the stator
- check the rotor
- check the diodes
- check the condition of the brushes
- check the slip-rings
- assemble the alternator.

Requirements			
Tools/Instruments		Materials	
• Trainee's tools kit	- 1 No.	• Kerosene	- as reqd.
• Socket spanner set	- 1 No.	• Emery paper	- as reqd.
• 12 volt lead acid battery	- 1 No.	• Rotor	- as reqd.
• Test lamp and cables	- as reqd.	• Banian cloth	- as reqd.
Equipments		• Grease	- as reqd.
• Alternator	- 1 No.	• Diodes	- as reqd.
		• Bearing	- 2 Nos.

PROCEDURE

TASK 1: Identify the alternater circuit

- 1 Locate the circuit from the alternator's (1) output terminal (5) to the voltage regulator's (2) terminal A (3). (Fig 1)

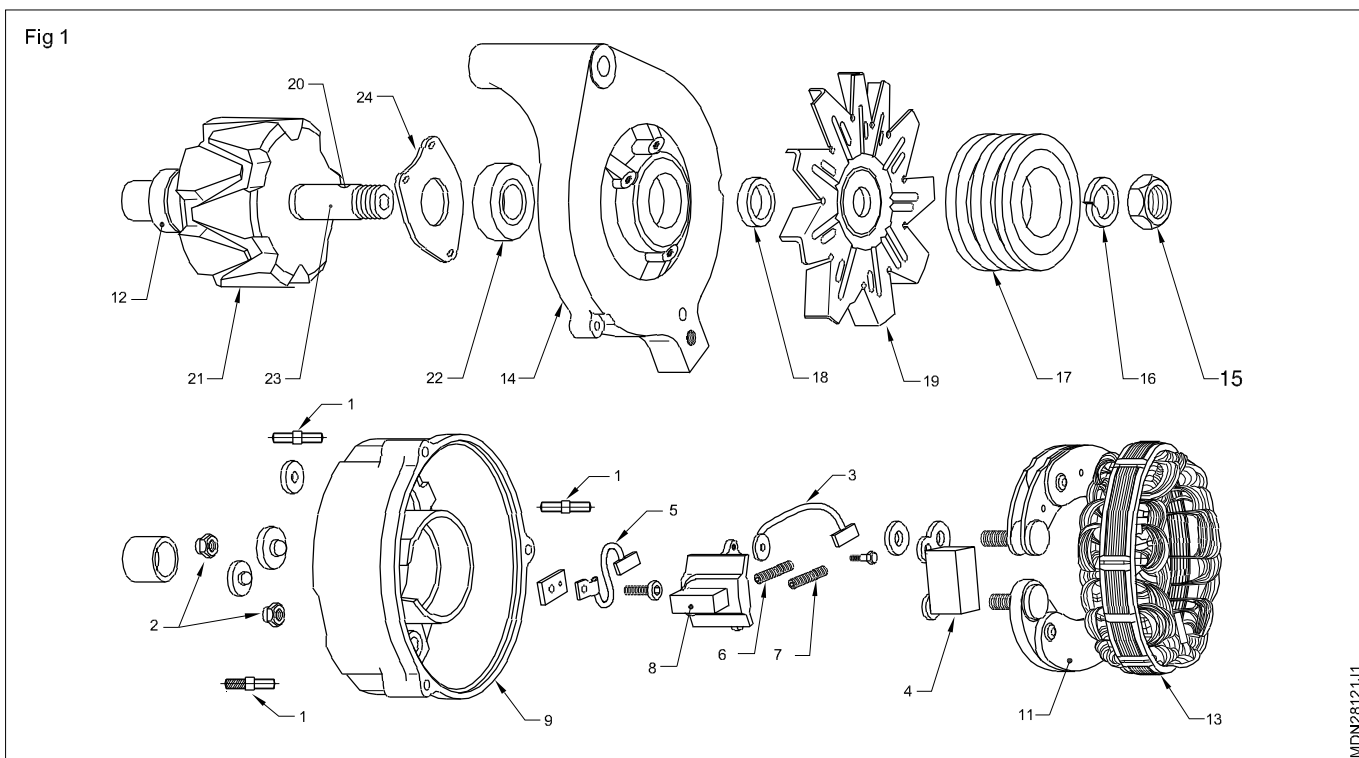


- 2 Locate the feedback circuit from the voltage regulator's (2) 'F' terminal (4) to the alternator's (1) field terminal (6).
- 3 Locate the circuit from the voltage regulator's (2) 'B' terminal (7) to the ammeter (8).
- 4 Locate the circuit from the ammeter (8) to the battery (9).
- 5 Locate the circuit from the voltage regulator's (2) 'A' terminal (3) to the indicator lamp (12).
- 6 Locate the circuit from the indicator lamp (12) to the ignition starting switch (11).
- 7 Locate the ground connection (13).
- 8 Locate the circuit from the ammeter (8) to the ignition starting switch (11).

TASK 2: 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 3: Dismantling (Fig 1)



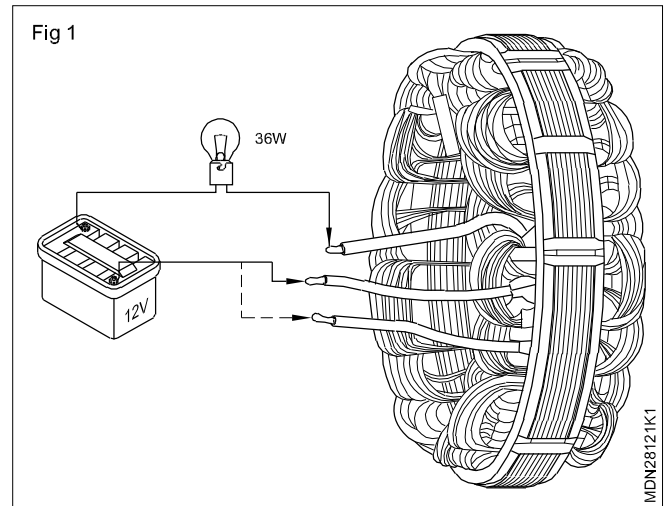
- 1 Mark a line across both the end shields (14 & 9) and the stator to facilitate alignment during reassembling.
- 2 Remove the cover securing studs and nuts (1 & 2) and lift the cover. (Fig 1)
- 3 Disconnect the regulator leads (3) and (5) (+ve, -ve).
- 4 Remove the screw securing the regulator(4) to 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).

TASK 4: Cleaning and inspection

- 1 Clean all the parts with kerosene and a nylon brush except the 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.

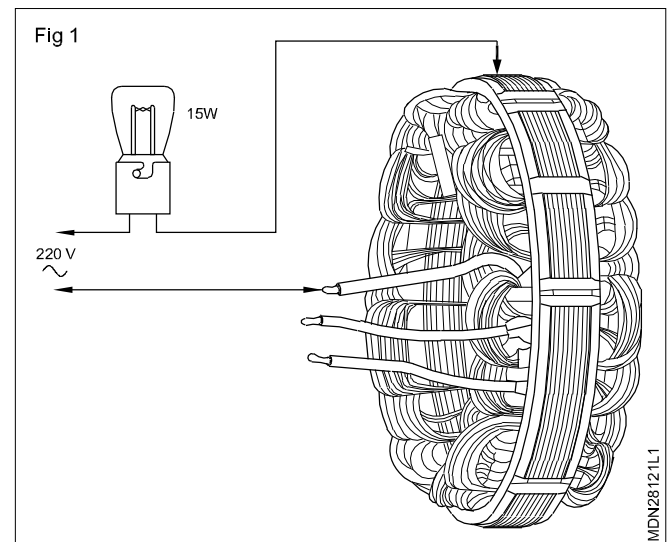
TASK 5: Test for open circuit in the stator

- 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.



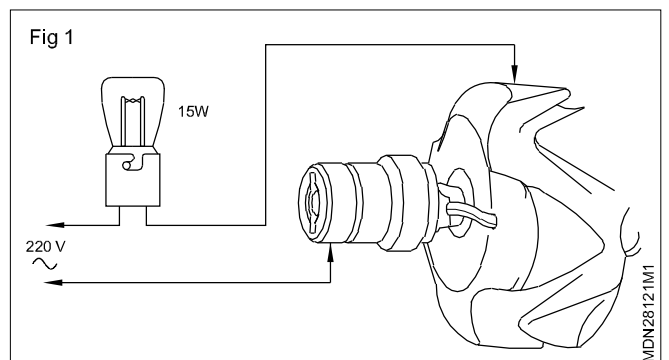
TASK 6: Test for short circuit in stator

- 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. If the test lamp glows then the stator winding is defective, renew the same (Fig.1).



TASK 7: Test for short circuit in rotor

- 1 Check the rotor winding insulation by connecting to a 220 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).

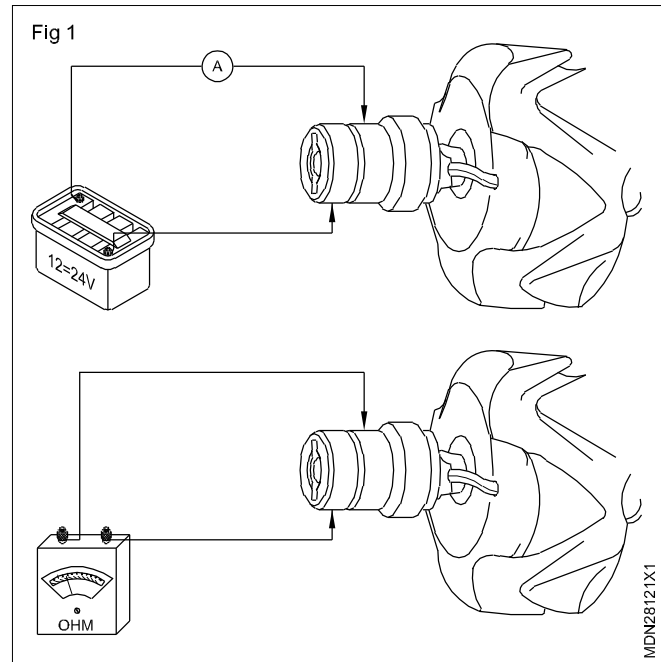


TASK 8: Test for open circuit in Rotor winding

- 1 Check the motor winding continuity by connecting a 12 V/ 24 V battery and the moving coil ammeter between the slip-rings. (Fig 1)

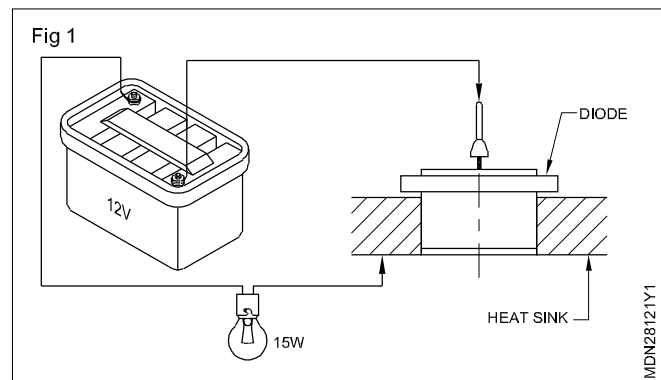
The current should be 2 to 2.5 A approximately for 12 V. If it is not of the correct value then renew the rotor.

- 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 9: 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)
- 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 10: 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.

Refitting alternator on the vehicle and testing

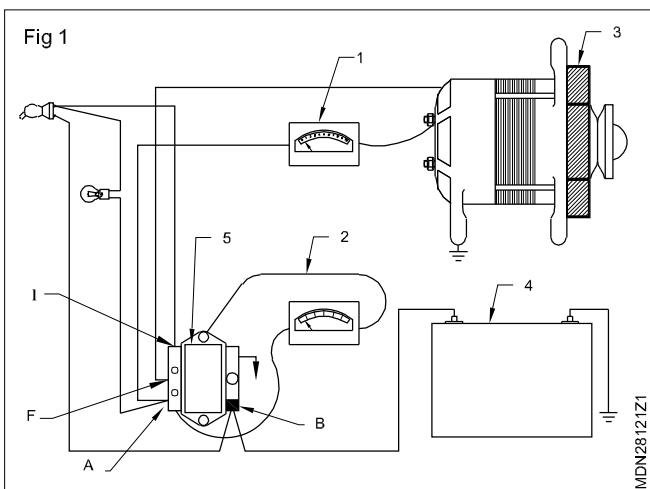
Objectives : At the end of this exercise you shall be able to

- refit an alternator to the diesel engine
- connect the battery to the circuit
- test the alternator's performance
- adjust the fan belt play.

Refitting alternator to the vehicle

- 1 Place and secure the alternator in its bracket using bolts & nuts.
- 2 Connect all the wires of the alternator which you disconnected earlier. Connect the battery cables to the circuit. (Fig 1)

Testing alternator's performance



- 3 Check the fan belt for overstretched or damaged condition.
- 4 Check if all the ends of the battery cables are clean. check all the wire connections for loose, dirty or broken connections.
- 5 Disconnect the battery earth cable. Connect the ammeter (1) in series. Connect the voltmeter (2) parallel to the alternator terminal and earth. Connect a wire across the field output terminal in the alternator (3). Connect the battery cable and put on the starting switch. Note the ammeter reading.

The ammeter reading should be 2A approximately in the field current drawn from the battery (4).

The 'F' lead should be disconnected from the regulator, and the wire end should be insulated to avoid accidental earthing.

- 6 Run the engine at medium speed .Switch on the lights and other electrical appliances.

The voltmeter reading should be of 14.2 V approximately.

The ammeter reading should also be the maximum.

- 7 If the voltmeter (2) and ammeter (1) read low, the regulator (5) needs replacement.

Adjusting fan belt tension

- 8 Check the fan belt for proper tension.
- 9 If the fan belt tension is low/high adjust by removing the alternator to the appropriate side.

General maintenance of alternator.

- Clean the alternator periodically.
- Check the mounting bolts for tightness.
- Check the fan belt condition and tension to the recommended value.
- Check the specific gravity of the battery electrolyte.
- Check the battery terminals for tightness and cleanliness.
- Check the brush once in a year (1000 hours). If necessary replace it.
- Check the bearings once in two years. renew, if worn out.
- Use fine emery-paper to clean the slip rings.

Mechanical Diesel - Starting and charging system

Overhauling and testing of starter motor

Objectives : At the end of this exercise you shall be able to

- remove the starter motor
- dismantle the starter motor
- test the magnetic switch
- test the armature
- clean and test the commutator
- check continuity of field coils
- check over-running clutch
- check end cover's shaft bushes
- assemble the starter motor
- test the starter motor for performance
- fit the starter motor on the engine.

Requirements

Tools/Instruments

- Trainees tools kit - 1 No
- Socket spanner set - 1 No
- Star/screw driver set - 1 No
- Circlip plier - 1 No
- Multimeter - 1 No
- Growber - 1 No
- 'V' block - 2 No
- Dial gauge - 1 No

Equipment/ Machine

- Running engine - 1 No.
- Vernier caliper - 1 No.
- Spring tension tester - 1 No.

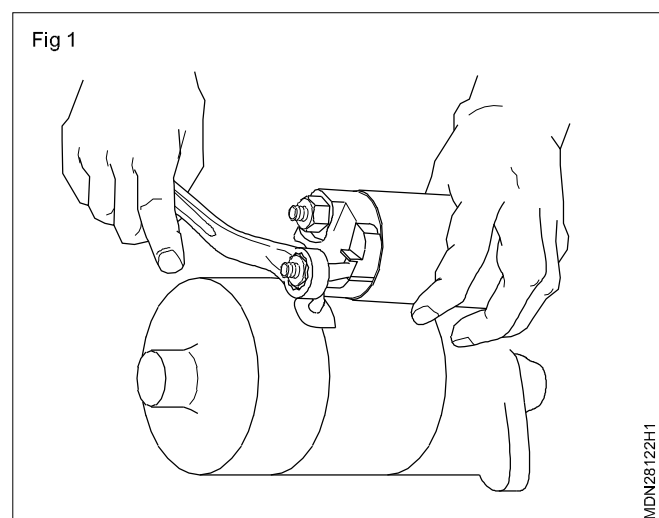
Materials

- Kerosene - as reqd.
- Grease - as reqd.
- Emery paper - as reqd.
- Hacksaw blade - as reqd.
- Cleaning brush - as reqd.
- Copper/ carbide brush - as reqd.

PROCEDURE

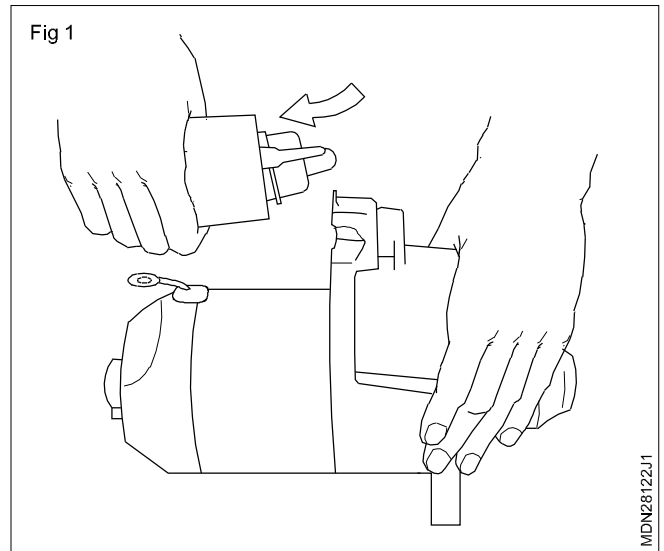
TASK 1: Dismounting the starter motor

- 1 Disconnect the earth lead from the battery.
- 2 Disconnect the Solenoid (Magnetic) switch lead wires (1) and the battery cable(2) from the starting motor terminals.
- 3 Remove the starter motor mounting bolts (3) (Fig 1)
- 4 Remove the starter motor.



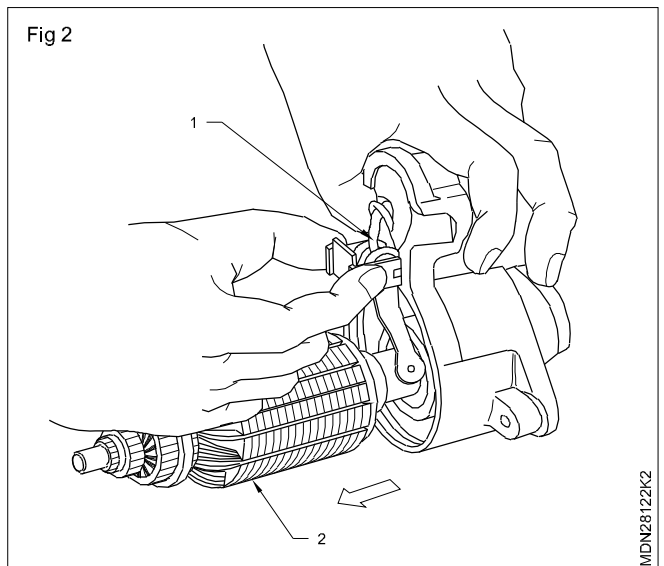
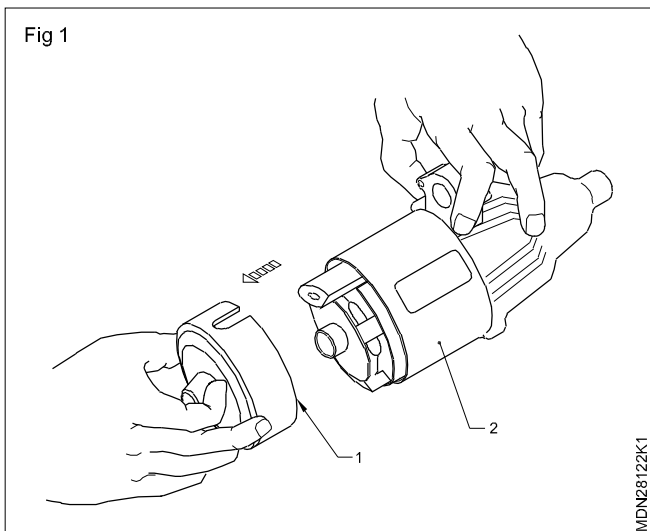
TASK 2: Removal of the Solenoid switch assembly

- 1 Remove the cable terminal nut and disconnect the lead wires (4) from the solenoid magnetic switch.
- 2 Remove the two mounting nuts (1) and then take out the magnetic switch by slight tilting. (Fig 1)

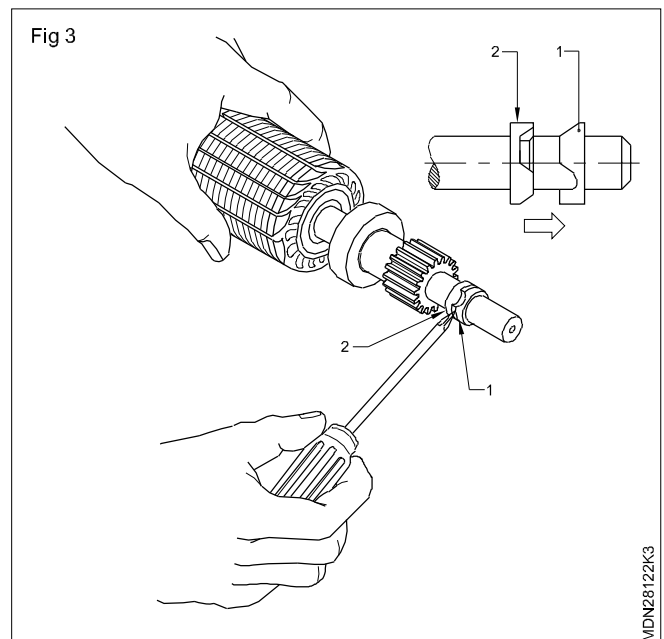


TASK 3: Dismantling of the motor assembly

- 1 Remove the through bolts.
- 2 Remove the commutator end cover (1). (Fig.1)

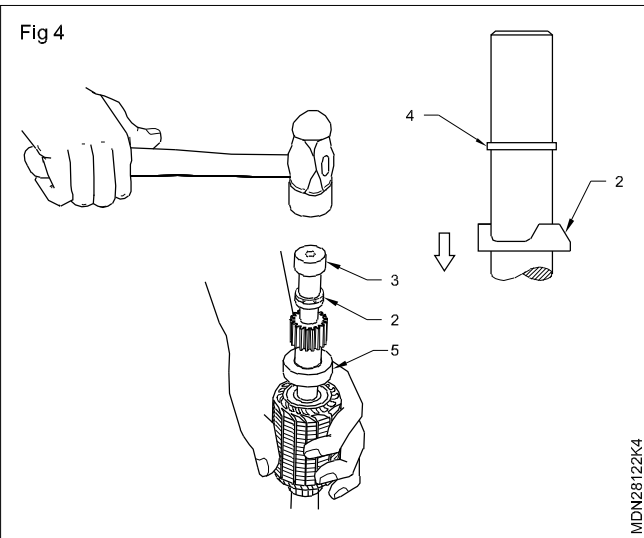


- 3 Remove the brush holder cover from the brush holder (2).
- 4 Remove the brush springs and copper brushes, and Starter body (3).
- 5 Remove the yoke assembly (Fig 2)
- 6 Remove the armature (2) along with the pinion drive lever (1).
- 7 Insert the screwdriver tip in the gap between the two stop collars (1) and (2). (Fig.3)
- 8 Push the front collar (1) outward.

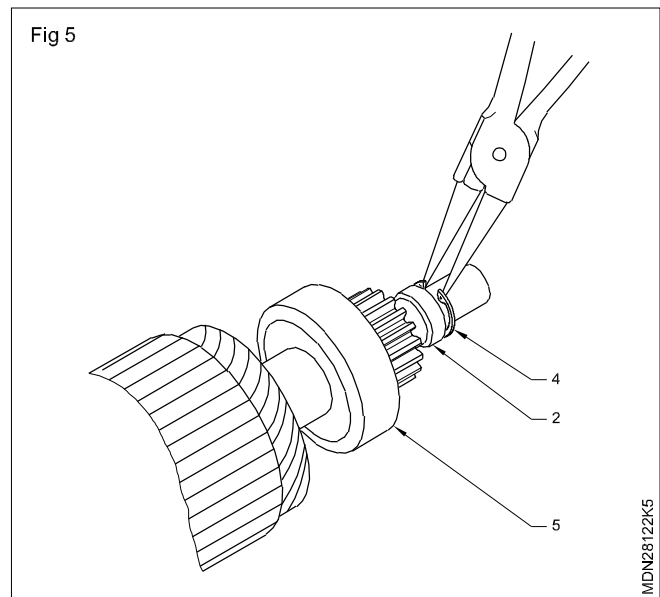


9 Using a 14 mm socket (3) push the rear stop collar (2) downwards. (Fig.1).

10 Remove the armature circlip (4) by using a circlip plier, and with the help of a screw driver.



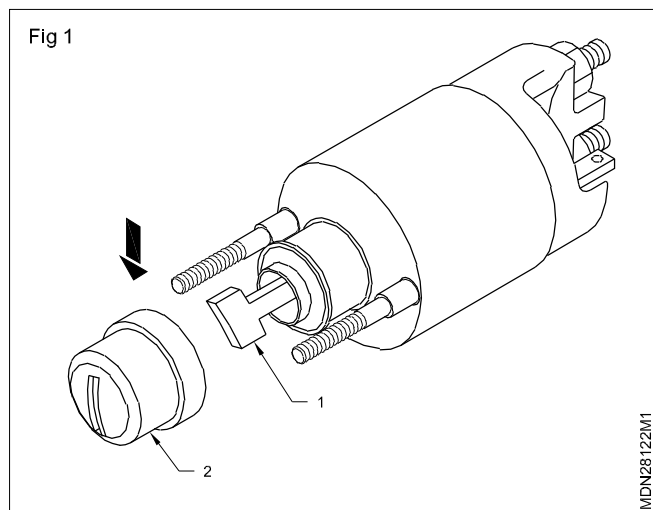
11 Pull out the rear pinion stop collar (2), and over-running clutch (5). (Fig 2)



TASK 4: Magnetic Switch (Solenoid switch)

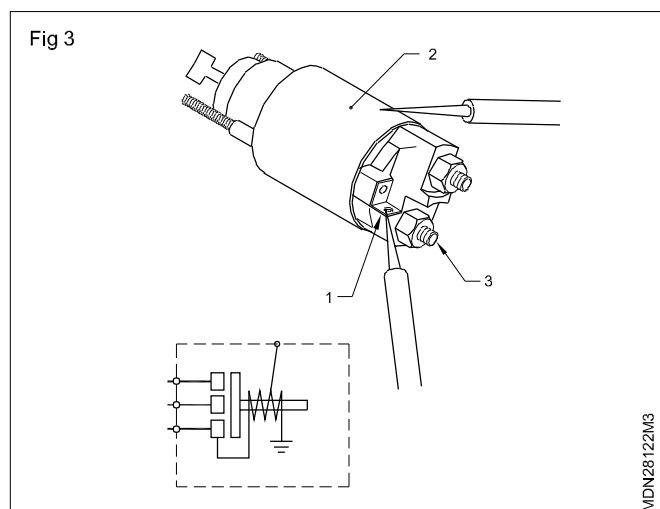
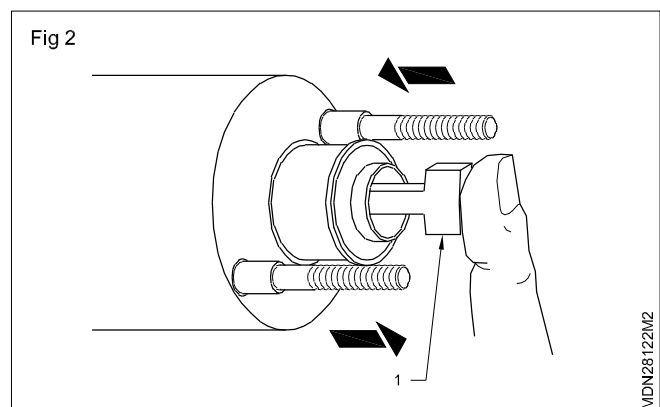
1 Inspect the magnetic switch boot (2) for breakage.

2 Inspect the plunger (1) for wear or damage. Replace if necessary. (Fig 1)



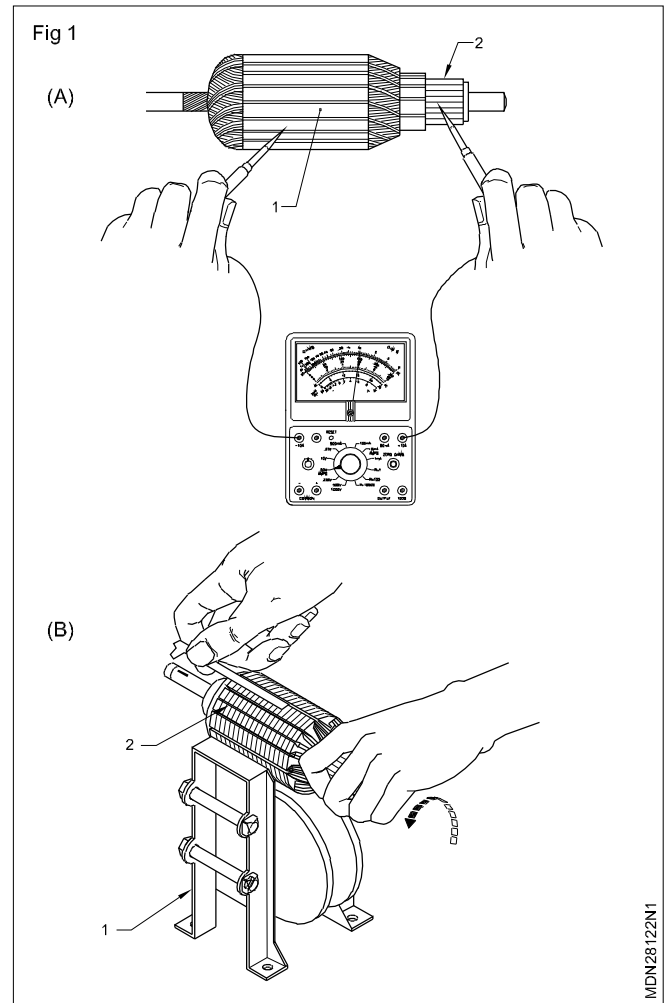
3 Push the plunger (1) in and release it. The plunger should return quickly to its original position. Replace if necessary. (Fig 2)

4 Check for continuity across the magnetic switch's terminal (1) and coil case (2). If no continuity exists, the coil is open and should be replaced. (Fig.10) Check for continuity across magnetic switch terminal (1) and terminal (3). If no continuity exists, the coil is open and should be replaced. (Fig 3)



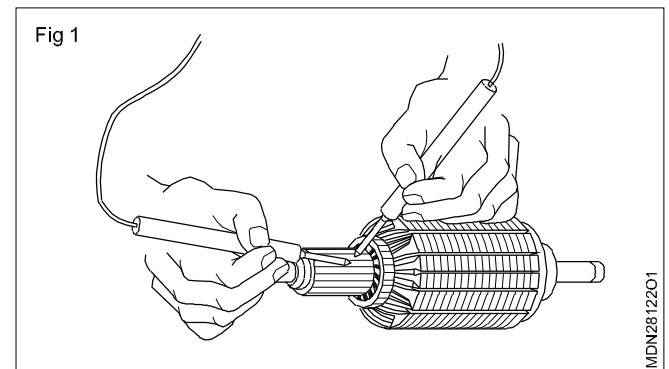
TASK 5: Armature for ground

- 1 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. (Fig 1A)
- 2 Placing armature (2) on the growler (1) and switch on.
- 3 Lay a thin steel strip (4) on the armature core with small air gap.
- 4 Rotate the armature slowly by hand. (Fig 1B)
- 5 The steel strip will vibrate if a coil is shorted. Then replace the armature.



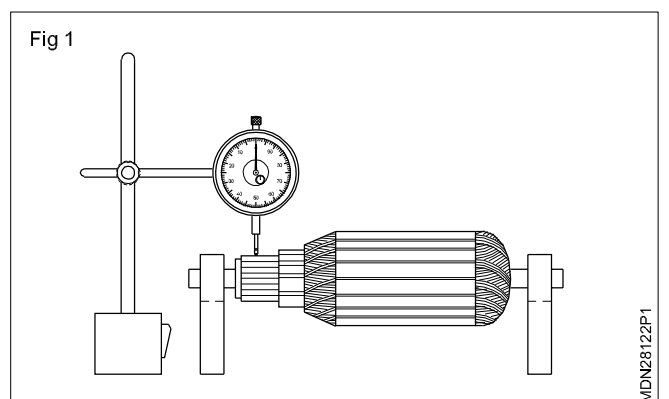
TASK 6: Open circuit

- 1 Check for continuity between each pair of adjacent commutator segments, using an ohmmeter. (Fig 1).
- 2 If there is any discontinuity the ohmmeter needle will not deflect. Replace the armature assembly. (Fig 1)

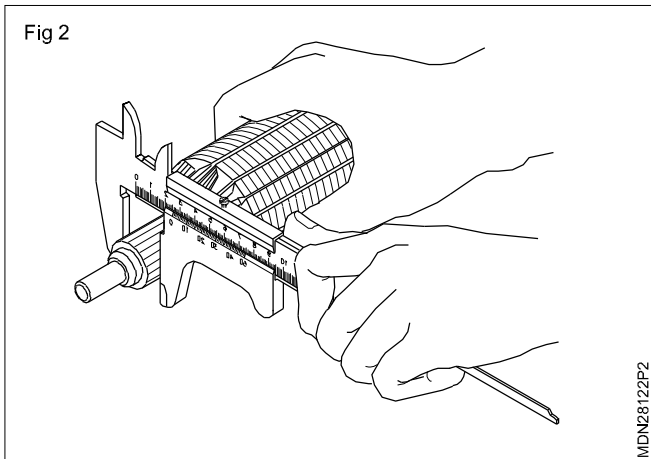


TASK 7: Commutator run out

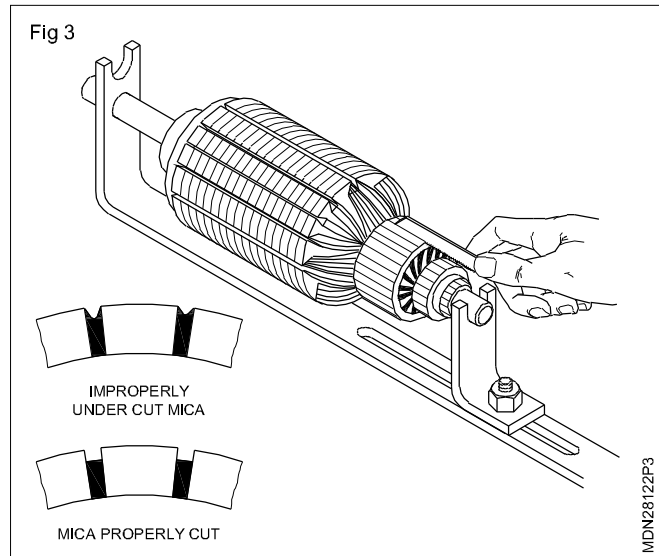
- 1 Place the armature between two 'V' blocks. (Fig.1) or stand.
- 2 Using a dial gauge check the commutator for run out by slowly rotating it by hand. (Fig 1)



- 3 Correct it on lathe if required. (Fig 2)
- 4 Check for wear and replace the commutator if the diameter is below limit. (Fig 2)

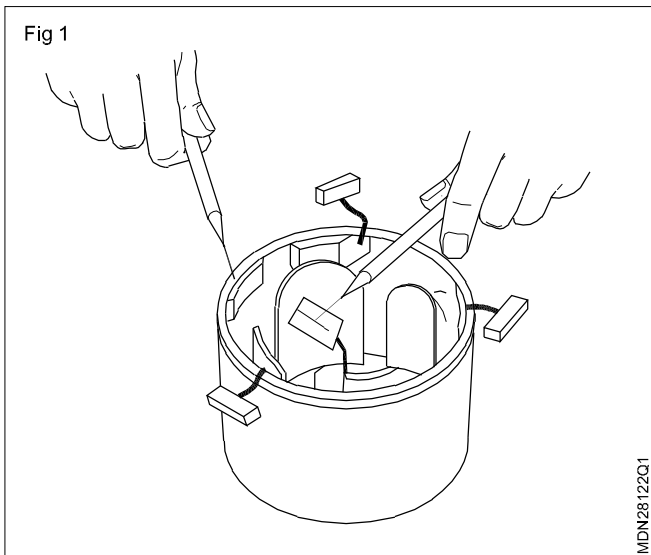


- 5 Clean the surface by using 400 emery cloth. Check the mica depth to a minimum of 0.2 mm and correct by using a hacksaw blade or knife, if required. (Fig 3)

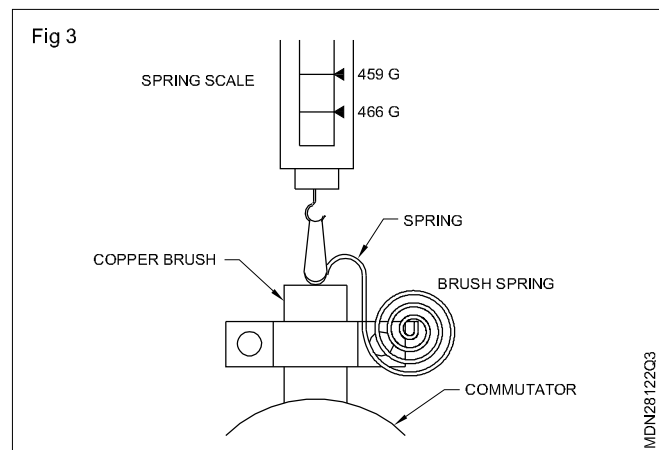
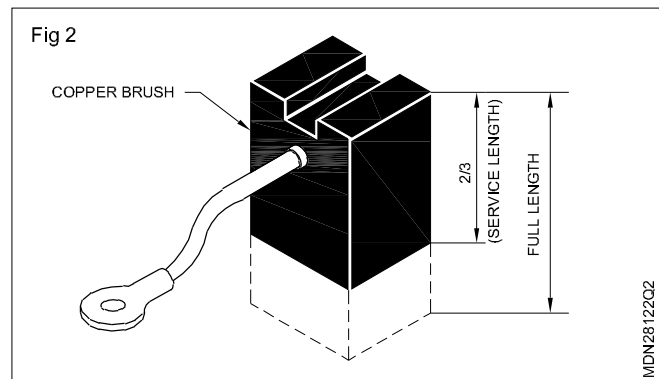


TASK 8: Check field coil

- 1 Open circuit and short circuit. (Fig 1) Using an ohmmeter or test lamp, check for continuity between the field coil and the insulated brushes. If continuity is not indicated, the insulation has failed. Replace the field coil. Check each field coil for short circuit with self body. If coil is short with body, replace it.

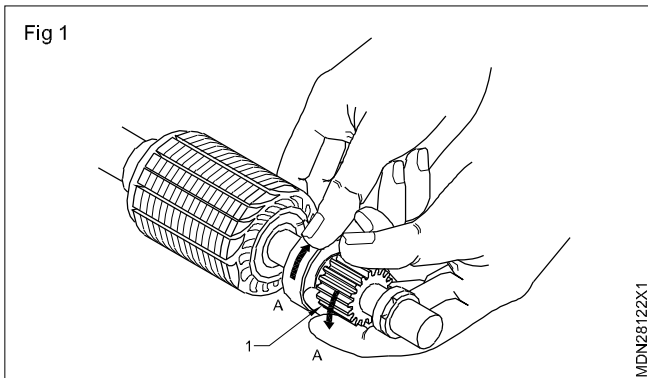


- 2 Measure the length of the copper brushes (Fig 2). If brushes are worn down to the service limit, replace them and self proper bedding.
- 3 Check the brush springs (1) for tension, rust or breakage. (Fig 2)
- 4 Check brush holder for insulation and earth (Fig 3)

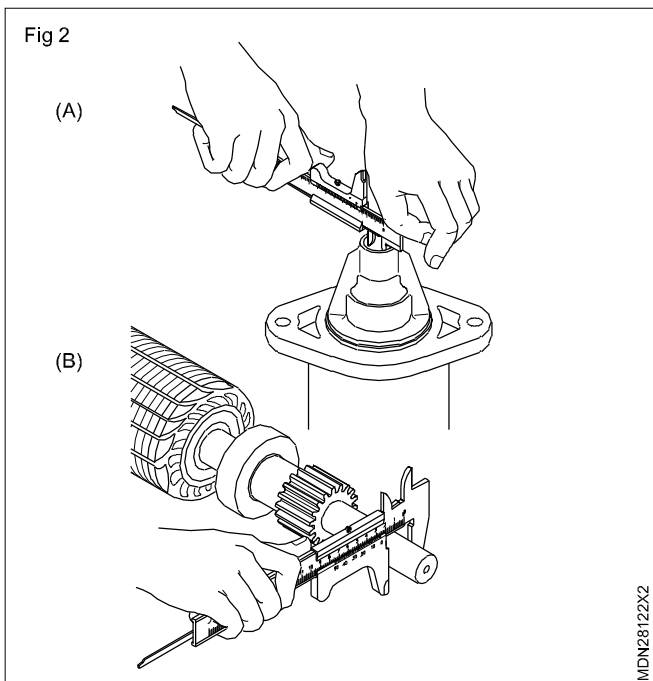


TASK 9 : Over-running clutch

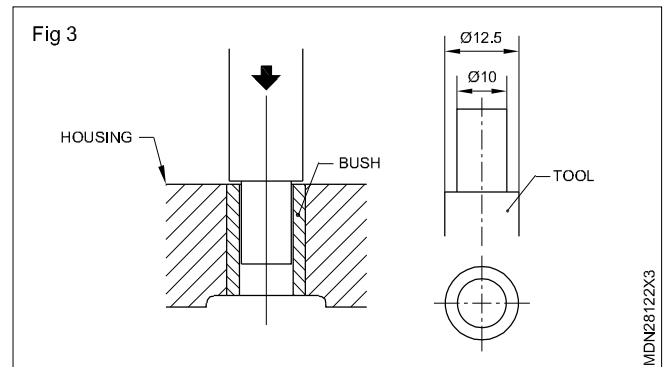
- 1 Inspect the one way clutch for free rotation in direction 'A', and locked up the other way round. (Fig 1)
- 2 Check the pinion(1) for abnormal wear and replace it as assembly if required.(Fig 1)



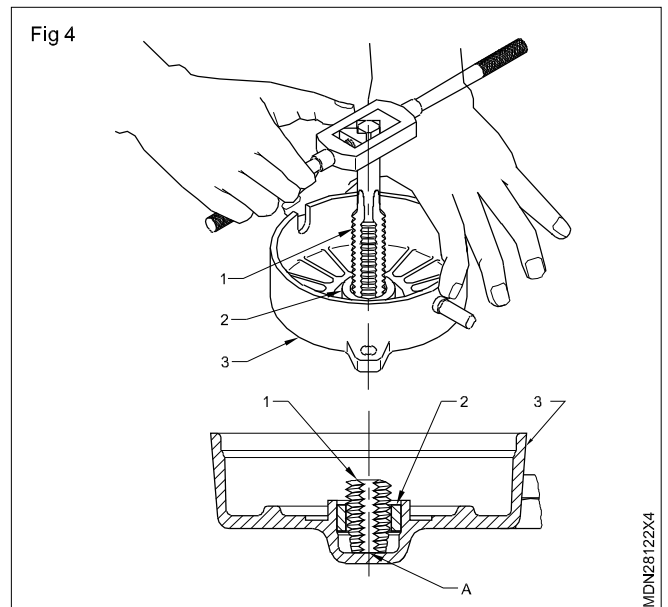
- 3 Armature shaft and drive end cover bush
- 4 Using a 10 mm rod, take out the bush cap.
- 5 Measure the internal diameter of the drive bush. (Fig. 2A)
- 6 Measure the outer diameter of the armature shaft at the drive end. (Fig.2B)
- 7 If clearance exceeds the limit, replace the bush.



- 8 Using the tool as shown in the (Fig 3), remove the bush from the drive housing on the arbour press.



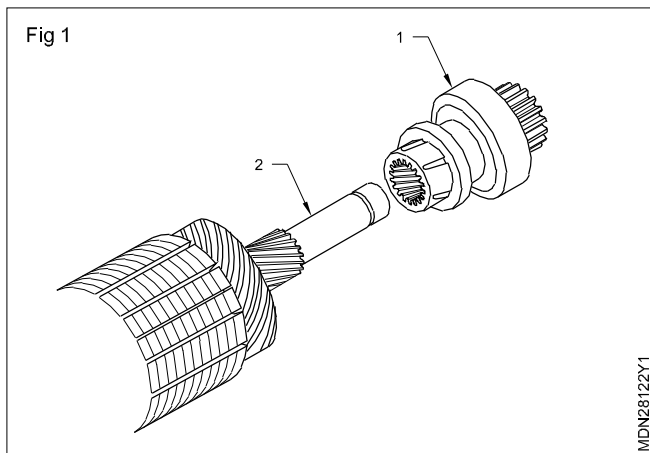
- 9 Measure the outer diameter of armature shaft at the commutator end.
- 10 If clearance exceeds the limits, replace the bush. (Fig 4)



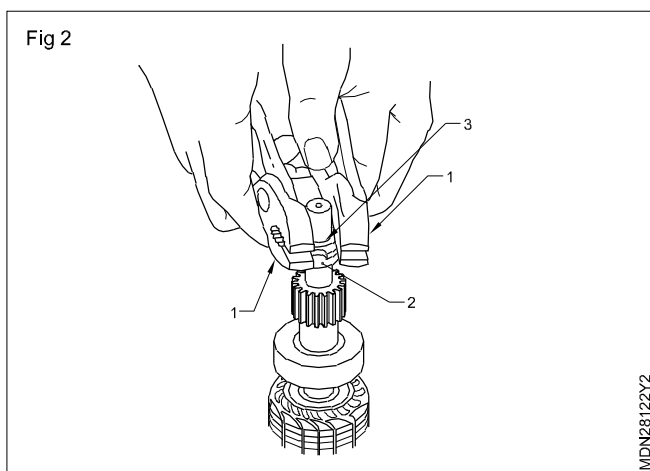
- 11 Thread in with a suitable tap (1) in the bush.
- 12 When the end of the tap reaches the bottom of the frame (3), tighten it further.
- 13 The bush will come out.
- 14 Fit new bushes as press fit on the arbour press.
- 15 Ream the inside surface of the bush to obtain oil clearance (0.05 mm) between the armature shaft and bush.

TASK 10: Assembly

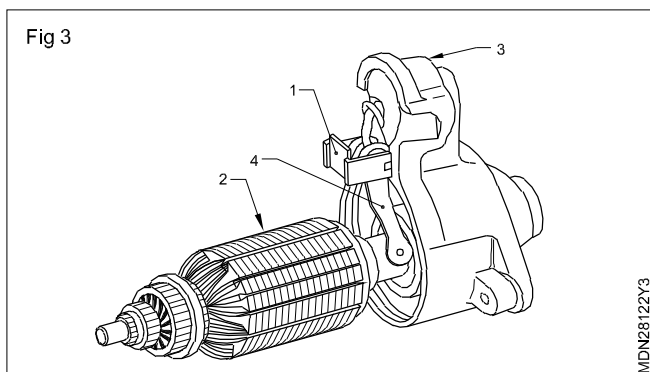
- 1 Apply grease and install the over-running clutch (1) to the armature shaft (2) as shown in the (Fig 1).



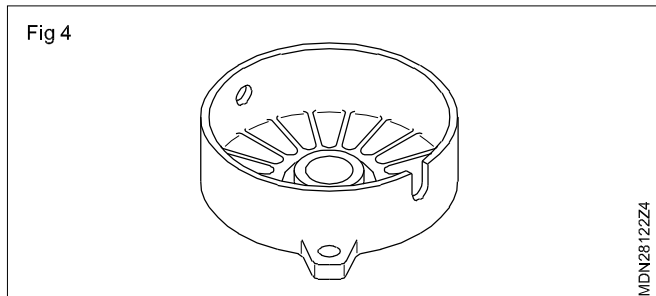
- 2 Insert the rear stop collar (2) in the armature shaft (Fig 2)



- 3 Insert a circlip in the armature shaft.
- 4 Insert the front stop collar (3) in the armature shaft.
- 5 Press by two pliers (1) as shown in the (Fig 3).
- 6 Apply grease to the drive lever (1). (Fig 3)
- 7 Combine it with the armature (2). (Fig 3)

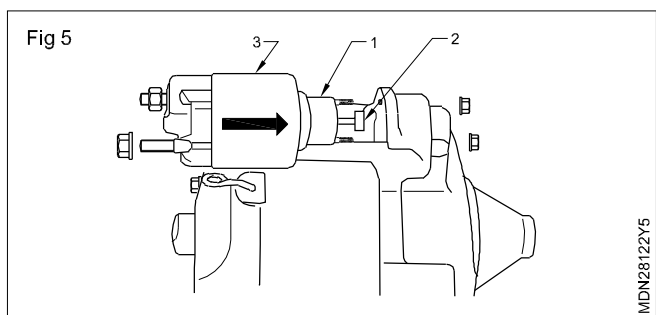


- 8 Assemble them with the drive housing (3).
- 9 Install the yoke (4).
- 10 Install the brush holder.
- 11 Install 4 sets of brushes with the springs.
- 12 Install the brush holder cover.
- 13 Apply grease and install the commutator end housing as shown in the (Fig 4).



- 14 Replace the magnetic switch (3) and its boot (1) with a new one if required. (Fig. 5)

- 15 Apply grease to the plunger's (2) hook. (Fig 5)



- 16 Hook the switch plunger with the drive lever. (Fig. 5)

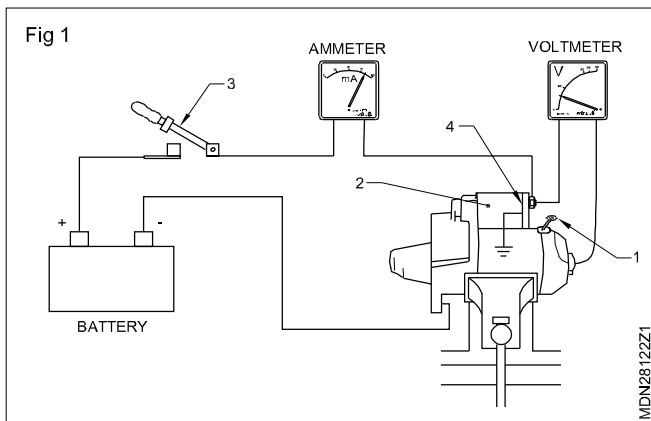
- 17 Fasten the switch assembly with nuts.

- 18 Connect the lead wires.

TASK 11: Performance test and remounting

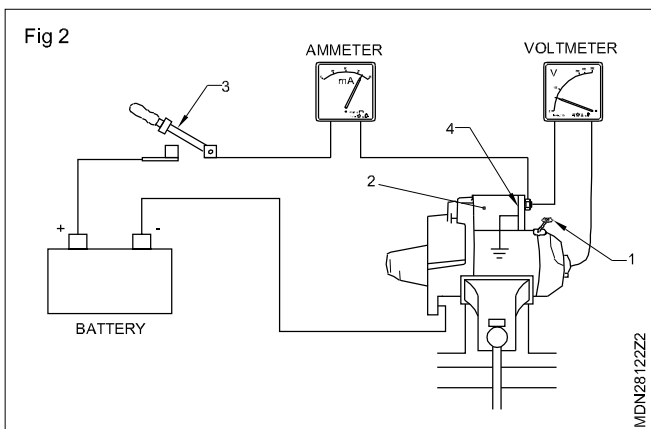
1 pull in test

- Hold starting motor in vice or stand.
- Disconnect field coil terminal (1) from solenoid switch.
- Connect the test lead, switch, Ammeter, Voltmeter, as shown in the Fig 1
- Operate switch (3) and check that the pinion (overrunning clutch) jumps out if does not rectify the fault.



2 Hold Test

Remove (Disconnect) negative lead from terminal (4). (Fig 2)

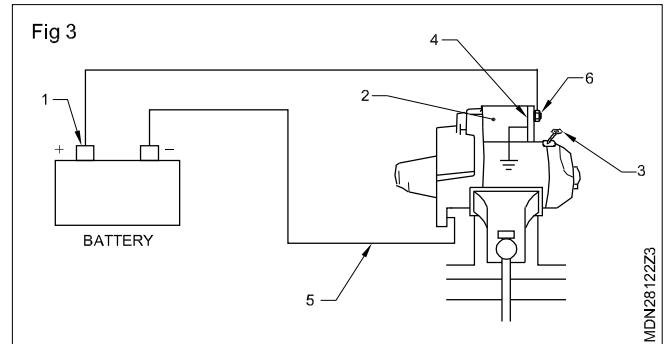


- Check that the pinion remains out, if not rectify the fault of magnetic switch. If necessary replace it.

3 Pinion return test

- Disconnect the switch (3).
- Check to make sure that the pinion returns inward quickly.

4 No Load performance test (Fig 3)



- Connect the battery leads (5) as shown in the Fig (30). From Battery Terminal (1) to solenoid switch terminal (6) second battery lead (5) to the starting motor.
- Operate solenoid switch (4) and check the starting motor runs without fail with the pinion moved out.

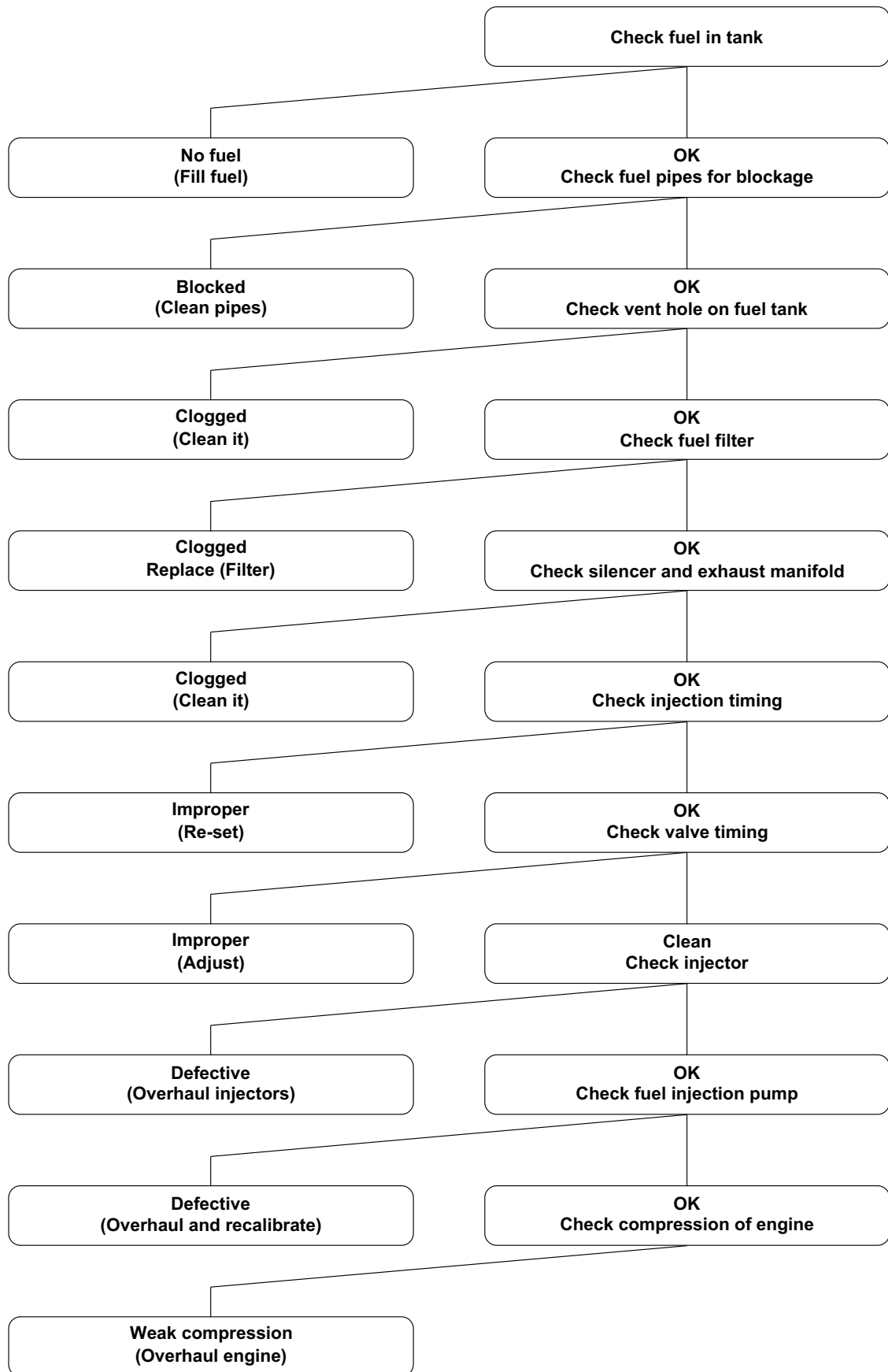
- 5 Place the starter motor in its position on the vehicle
- 6 Tighten the two mounting bolts.
- 7 Connect the battery cable and magnetic switch lead wires to the starter motor terminals.
- 8 Connect the negative lead to the battery.
- 9 Start the vehicle and check the operation of starter motor.

Diesel engine trouble shooting

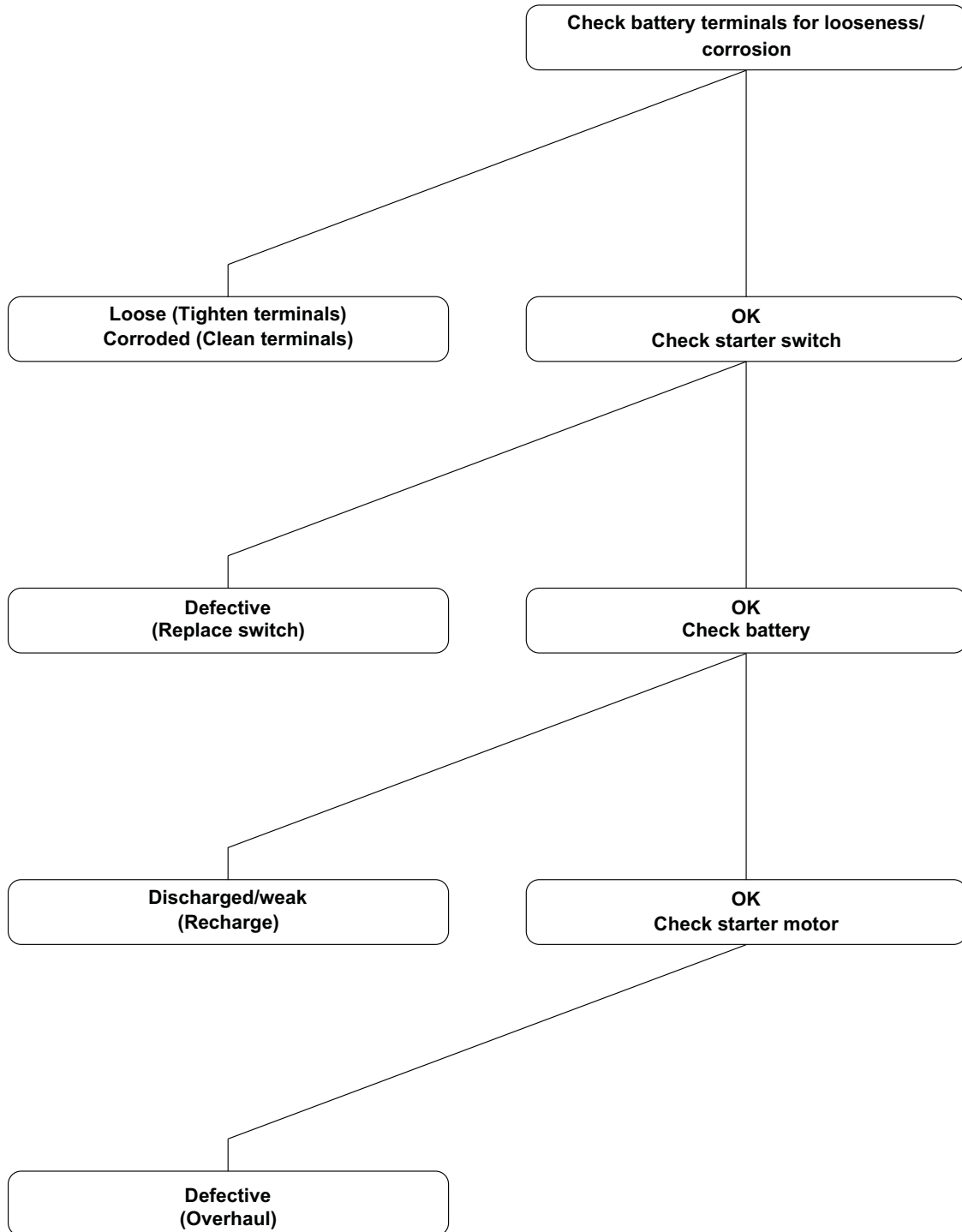
Objectives: At the end of this exercise you shall be able to

- rectify the causes for engine does not start (Mechanical)
 - rectify the causes for engine does not start (Electrical)
 - rectify the causes for high fuel consumption
 - rectify the causes for engine over heating
 - rectify the causes for low power generation
 - rectify the causes for engine oil consumption
 - rectify the causes for low/high engine oil pressure
 - rectify the causes for engine noise.
-

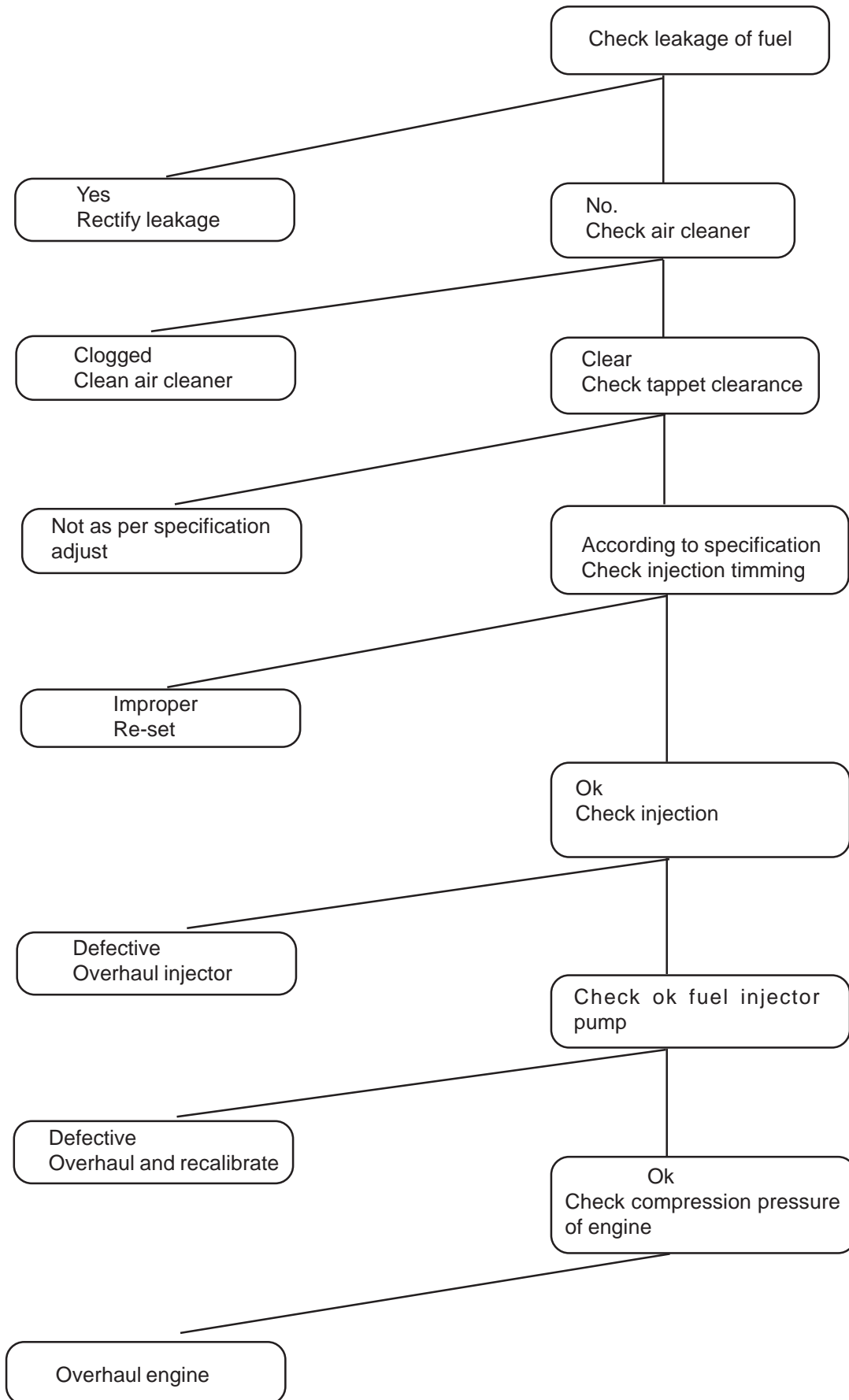
(I) Engine does not start (mechanical causes)



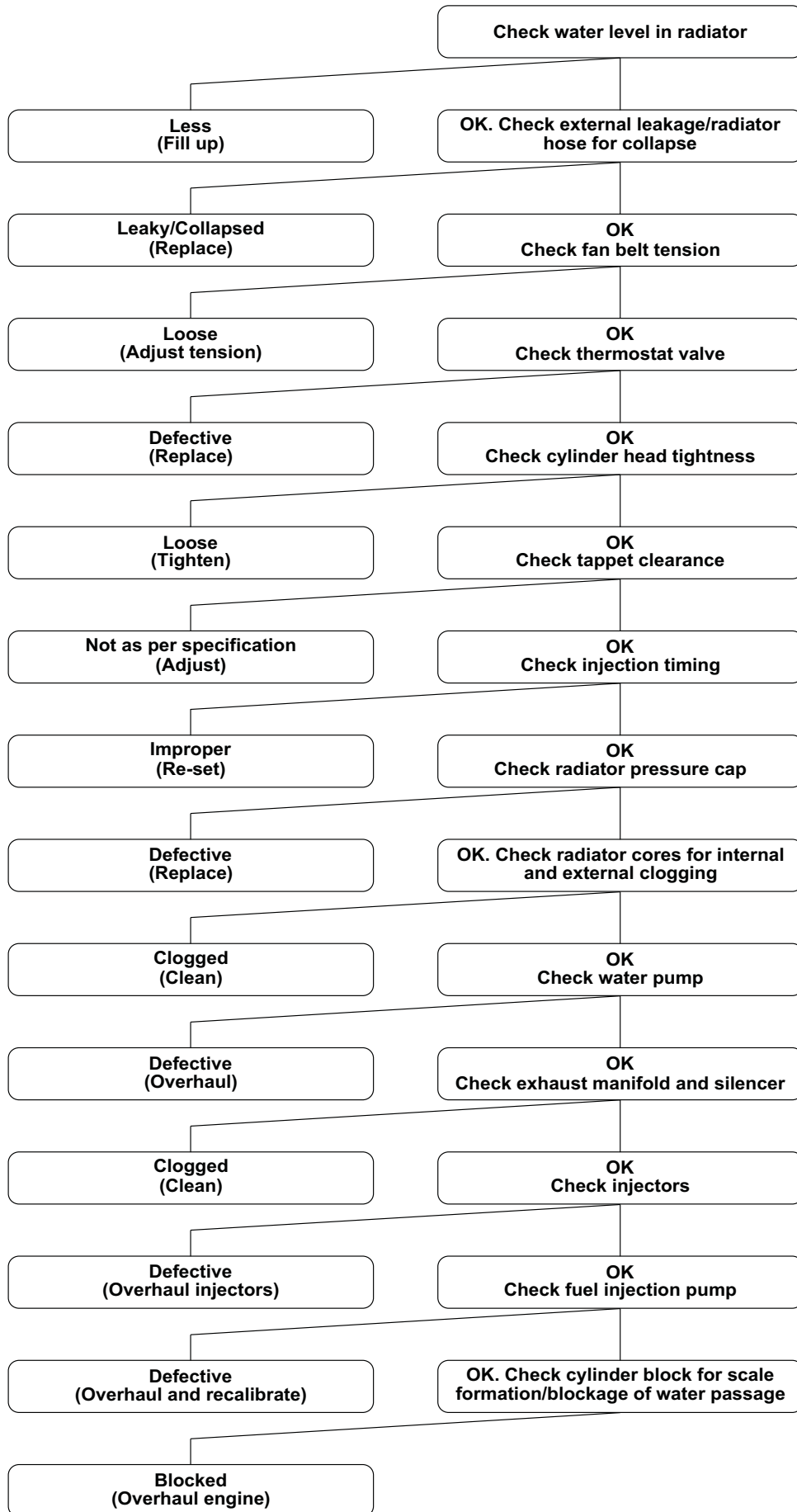
(II) Engine does not start (electrical causes)



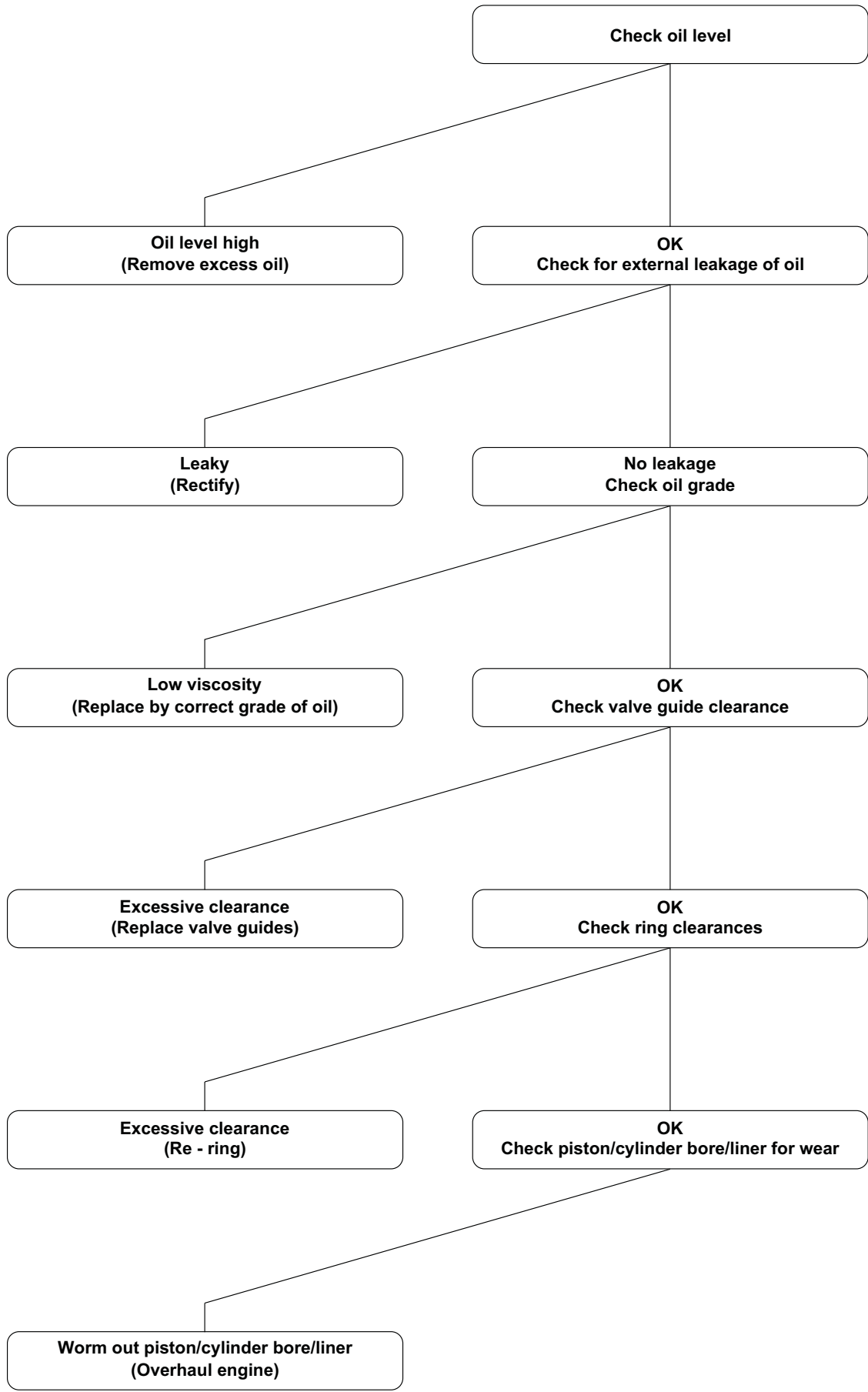
(III) High fuel consumption (diesel)



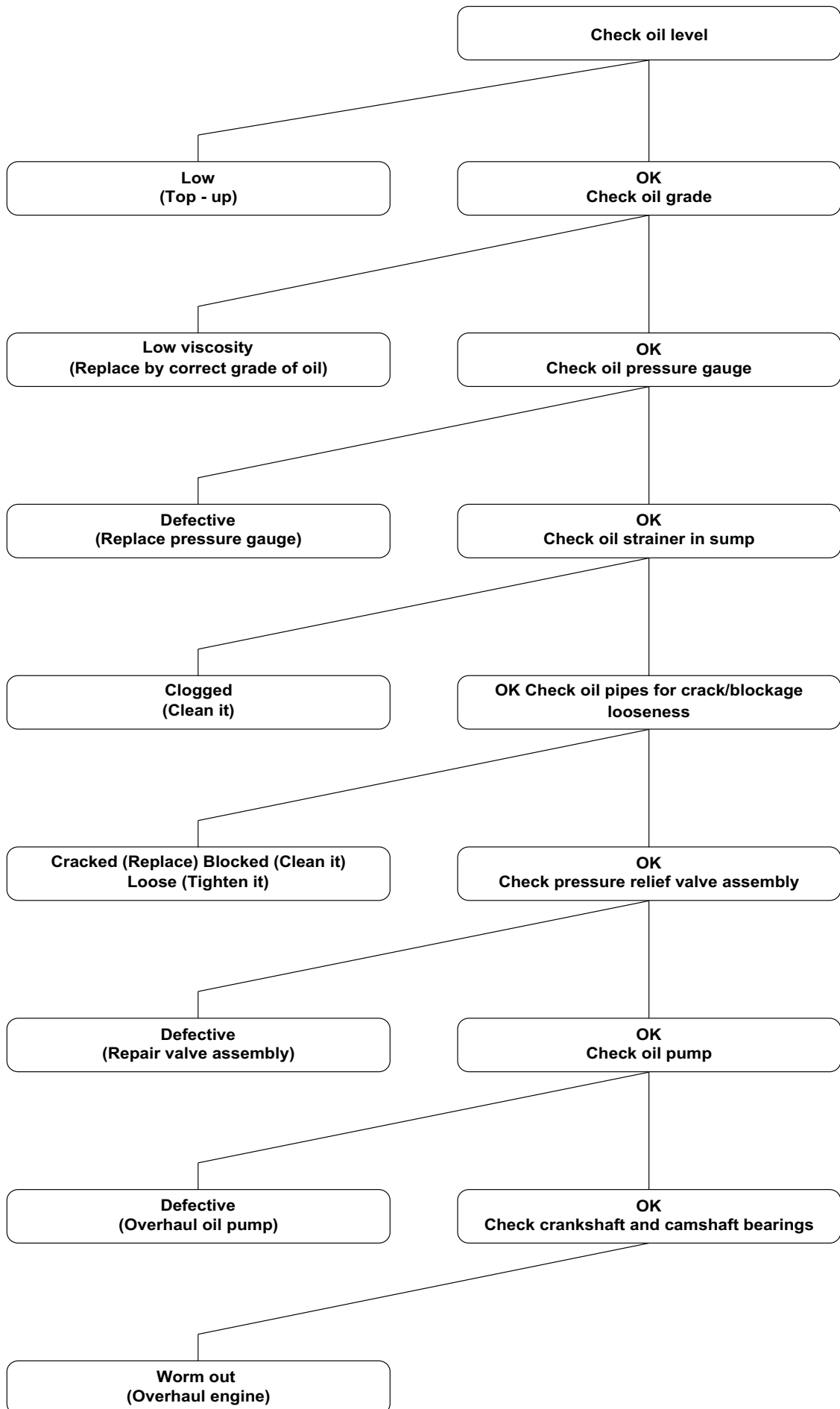
(IV) Engine over heating



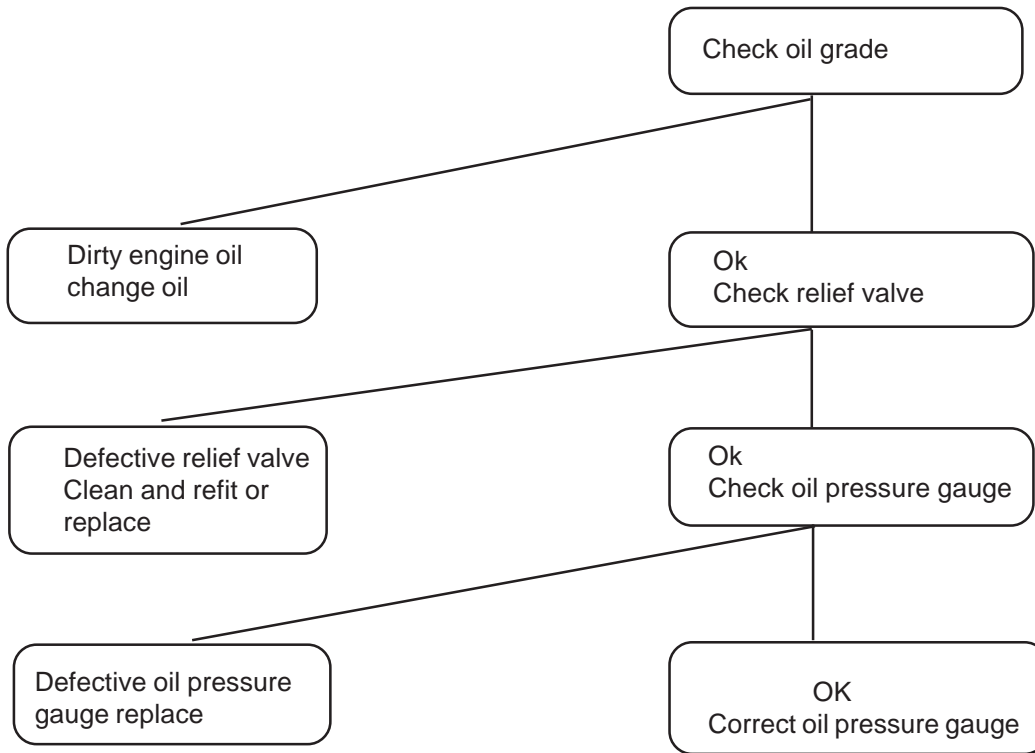
(VI) Excessive oil consumption



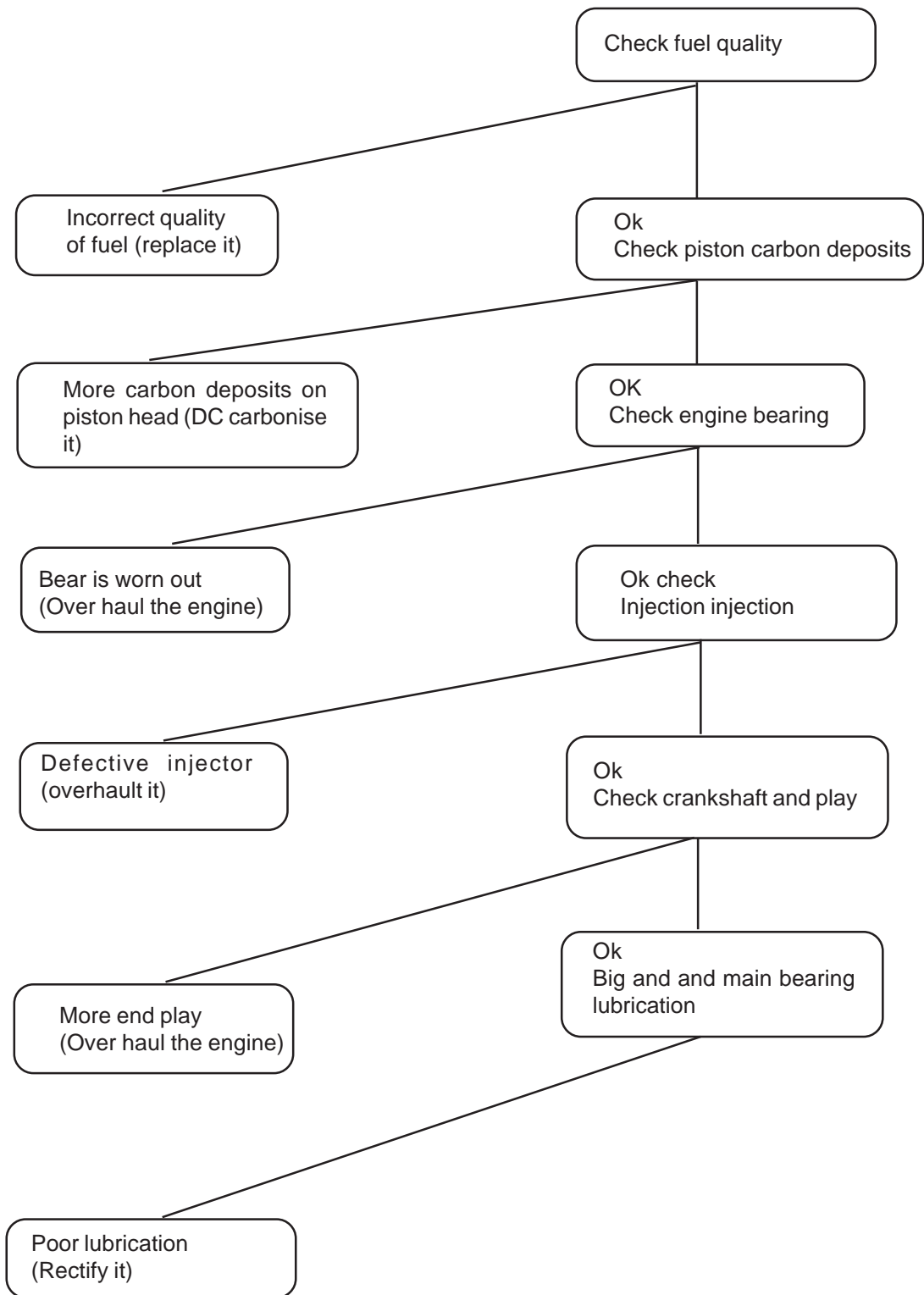
(VII) Low oil pressure



(VIII) High oil pressure



(VIII) Engine noise



Fault Finding chart - All Applications

	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 Compressor 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 as required	●	●	●		●	●	●	●	●	●	
Restricted air duct from compressor to intake manifold Remove restriction or replace damaged parts as required	●	●		●	●			●			
Restricted intake manifold Refer to engine manufacturer's manual and remove restriction	●	●		●	●			●			
Air leak in feed from air cleaner to compressor Replace seals, gaskets or tighten fasteners as required	●	●	●	●	●	●	●	●			
Air leak in feed from compressor to intake manifold Replace seals, gaskets or tighten fasteners as required	●		●	●	●	●	●	●			
Air leak between intake manifold and engine Refer to engine manufacturer's manual and replace gaskets or tighten fasteners as required				●	●	●	●	●		●	
Foreign object in exhaust manifold (from engine) Refer to engine manufacturer's manual and remove obstruction	●			●	●					●	
Restricted exhaust system Remove restriction or replace damaged parts as required		●	●	●	●			●			
Exhaust manifold cracked, gaskets blown or missing Refer to engine manufacturer's manual and replace gaskets 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 Compressor 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 manufacturer'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 manufacturer's manual, clear 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 manufacturer's manual and replace or adjust faulty components as required				●	●						
Engine valve timing incorrect Refer to engine manufacturer's manual for correct settings and adjust as required				●	●	●	●			●	●
Worn engine piston rings or liners Refer to engine manufacturer's manual and repair as required				●	●	●	●			●	●
Burnt valves and/or pistons Refer to engine manufacturer's manual and repair as required				●	●	●	●	●	●	●	●
Excessive dirt build up on compressor wheel and/or diffuser vanes Contact your local approved dealer											
Turbocharger damaged Find and correct cause of failure, or replace turbocharger as necessary				●	●	●	●	●		●	●

Fault Finding chart - Wastegate Applications

	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 Compressor Seal	Oil Leak from Turbine Seal
Failed actuator diaphragm Replace using correct Actuator Service Kit	●							●			
Seized wastegate valve (in turbine housing) Free valve in accordance with details in the appropriate Holset publication replace complete turbine housing sub-assembly	●	●									
Leaking actuator hose Replace hose and clips	●							●			
Wastegate mechanism set incorrectly Contact your approved Holset agent for correct setting procedure	●	●	●	●				●			