MECHANIC DIESEL

NSQF LEVEL - 3

TRADE PRACTICAL

SECTOR: AUTOMOTIVE

(As per revised syllabus July 2022 - 1200 Hrs)

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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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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 stakeholder's 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 - Trade Practical - NSQF Level - 3 (Revised 2022) in Automotive Sector under Annual Pattern.** The NSQF Level - 3 (Revised 2022). 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 - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these 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

Ms. Trishaljit Sethi
Additional Secretary / Director General (Training)
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New Delhi - 110 001

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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 the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF) 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 transparencies 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.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

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 **EXECUTIVE DIRECTOR**

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

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NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

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INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the Course of the **Mechanic Diesel** 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 - 3 (Revised 2022) syllabus are covered. This manual is divided into Fourteen modules.

Module 1	Safety Workshop Practices
Module 2	Measuring and Marking Practice
Module 3	Fastening and Fitting
Module 4	Electrical and Electronics
Module 5	Hydraulics and Pneumatics
Module 6	Specifications and Service Equipments
Module 7	Diesel Engine Overview
Module 8	Diesel Engine Components
Module 9	Cooling and Lubrication System
Module 10	Intake and Exhaust System of Engine
Module 11	Diesel Fuel System
Module 12	Emission Control System
Module 13	Charging and Starting System
Module 14	Troubleshooting

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.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Mechanic Diesel** Trade. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 3 (Revised 2022) syllabus on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional 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 indications about the corresponding practical exercises 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.

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

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No
1	Check & perform Measuring & marking by using various Measuring & Marking tools (Vernier Calipers, Micrometer, Telescope gauges, Dial bore gauges, Dial indicators, straight edge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge.) Following safety precautions.	1.1.01 to 1.2.17
2	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools&equipments.	1.2.18 to 1.3.23
3	Trace and Test all Electrical & Electronic components & circuits and assemble circuit to ensure functionality of system.	1.3.24 to 1.4.31
4	Trace & Test Hydraulic and Pneumatic components.	1.4.32 to 34
5	Check & Interpret Vehicle Specification data and VIN. Select & operate various Service Station Equipments.	1.5.35 to 1.5.38
6	Dismantle & assemble of Diesel Engine from vehicle (LMV/HMV) along with other accessories.	1.6.39 to 1.7.42
7	Overhaul & service Diesel Engine, its parts and check functionality.	1.7.43 to 1.8.69
8	Trace, Test & Repair Cooling and Lubrication Systemof engine.	1.8.70 to 1.9.77
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10	Service Diesel Fuel System and check proper functionality.	1.10.82 to 1.11.87
11	Plan & overhaul the stationary engine and Governor and check functionality.	1.11.88 to 1.11.90
12	Monitor emission of vehicle and execute different operation to obtain optimum pollution as per emission norms.	1.11.91 to 1.11.93
13	Carryout overhauling of Alternator and Starter Motor.	1.12.94 to 1.12.95
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SYLLABUS FOR MECHANIC DIESEL

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 142 Hrs; Professional Knowledge 34 Hrs	Check & perform Measuring & marking by using various Measuring& Marking tools (Vernier Calipers, Micrometer, Telescope gauges, Dial bore gauges, Dial indicators, straight edge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge.) Following safety precautions.	1 Demonstration of Machinery used in the trade. (05hrs) 2 Identify safety Gear/PPE (Personal Protective Equipments) and their uses (10 hrs) 3 Importance of maintenance of safety equipment used in Workshop. (05hrs) 4 Demonstration on safe handling and Periodic testing of lifting equipment, and Safety disposal of used engine oil. (10 hrs.) 5 Demonstration on health hazards, occupational safety & first Aid. (05 hrs) 6 Demonstration fire service station to provide demo on Fire safety. (05hrs) 7 Perform use of fire extinguishers. (05 hrs) 8 Perform marking using all marking aids, like steel rule with spring callipers, dividers, scriber, punches, chisel etc. on MS Flat/Sheet Metal. (17 hrs) Measure a wheel base of a vehicle with measuring tape. (08 hrs) 9 Perform to remove wheel lug nuts with use of an air impact wrench (08 hrs) 10 Operate General workshop tools & power tools. (15 hrs)	- Importance & scope of Mechanic Diesel Trade Training. - General discipline in the Institute - Elementary First Aid, Occupational Safety & Health - Knowledge of Personal Safety & Safety precautions in handling Diesel machine. - Concept about HouseKeeping & 5S method. - Safety disposal of Used engine oil, - Electrical safety tips. - Safe handling of Fuel Spillage, - Safe disposal of toxic dust, safe handling and Periodic testing of lifting equipment. (10 hrs) **Hand & Power Tools** - Marking scheme, marking material chalk, Prussian blue. - Cleaning tools-Scraper, wire brush, Emery paper, - Description, care and use of Surface plates, steel rule, measuring tape, try square. Callipers-inside and outside. Dividers, surface gauges, scriber, - Punches-prick punch, centre punch, pin punch, hollow punch, number and letter punch. Chisel-flat,cross-cut.Hammer-ball pein, lump, mallet. Screwdrivers-blade - Screw driver, Phillips screwdriver, Ratchet screw driver. Allen key, bench vice & C-clamps, - Spanners-ring spanner, open end spanner & the combination spanner, universal adjustable open end spanner. Sockets & accessories, - Pliers - Combination pliers, multi grip, long nose, flat-nose, Nippers or pincer pliers, Side cutters, Tin snips, Circlip pliers, external circlips pliers. - Air impact wrench, air ratchet, wrenches-Torque wrenches, pipe wrenches, Pipe flaring & cutting tool, pullers-Gear and bearing. (15 hrs)

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		11 Perform measuring practice on Cam height, Camshaft Journal dia, crankshaft journal dia, Valve stem dia, piston diameter, and piston pin dia with outside Micrometres. (05 hrs) 12 Perform measuring practice on cylinder bore for taper and out-of-round with Dial bore gauges. (10 hrs) 13 Perform measuring practice to measure wear on crankshaft end play, crankshaft run out, and valve guide with dial indicator and magnetic stand (05 hrs) 14 Perform measuring practice to check the flatness of the cylinder head is warped or twisted with straightedge is used with a feeler gauge. (10 hrs) 15 Perform measuring practice to check the end gap of a piston ring, piston-to- cylinder wall clearance with feeler gauge. (09 hrs) 16 Perform practice to check engine manifold vacuum with vacuum gauge. (05hrs) 17 Perform practice to check the air pressure inside the vehicle tyre is maintained at the recommended setting. (05hrs)	**Systems of measurement** - Description, Least Count calculation, care & use of -Micrometers-Outside, and depth micrometer, - Micrometer adjustments, - Description, Least Count calculation, care & use of Vernier Calliper. - Telescope gauges, Dial bore gauges, Dial indicators, straight edge, feeler gauge, thread pitch gauge, vacuum gauge, tire pressure gauge. (09 hrs)
Professional Skill 90 Hrs; Professional Knowledge; 17 Hrs	Plan & perform basic fastening & fitting operation by using correct hand tools, Machine tools&equipments.	18 Perform removal of stud/bolt using stud extractor (05hrs) 19 Perform practice on cutting tools like Hacksaw, file, chisel, Sharpening of Chisels, center punch, safety precautions while grinding. (10hrs) 20 Perform practice on Hacksawing and filing to given dimensions. (25 hrs)	- Different types of metal joint (Permanent, Temporary), methods of, Soldering, etc. **Fasteners** - Study of different types of screws, nuts, studs & bolts, locking devices, Such as locknuts, cotter, split pins, keys, circlips, lockrings, lock washers and locating where they are used. Washers & chemical compounds can be used to help secure these fasteners. Function of Gaskets, Selection of materials for gaskets and packing, oil seals. Types of Gaskets - paper, multilayered metallic, liquid, rubber, copper and printed. - Thread Seal ants-Various types like, locking, sealing, temperature resistance, antilocking, lubricating etc. **Cutting tools** - Study of different type of cutting tools like Hacksaw, File-Definition, parts of a file, specification, Grade, shape,

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			different type of cut and uses., OFF-hand grinding with sander, bench and pedestal grinders, safety precautions while grinding. (7 Hrs)
		21 Perform practice on Marking and Drilling clear and Blind Holes, Sharpening of Twist Drills Safety precautions to be observed while using a drilling machine. (10hrs) 22 Perform practice on Tapping a Clear and Blind Hole, Selection of tape drill Size, use of Lubrication, Use of stud extractor. (15 hrs) 23 Perform practice cutting Threads on a Bolt/ Stud. Adjustment of two piece Die, Reaming a hole/ Bush to suit the given pin/ shaft, scraping a given machined surface. (25 hrs)	**Drilling machine** - Description and study of Bench type Drilling machine, Portable electrical Drilling machine, drill holding devices, Work Holding devices, Drillbits. **Taps and Dies** - Hand Taps and wrenches, Calculation of Tap drill sizes for metric and inch taps. Different type of Die and Die stock. Screw extractors. - Hand Reamers Different Type of hand reamers, Drill size for reaming, Lapping, Lapping abrasives, type of Laps.(10 hrs)
Professional Skill 92 Hrs; Professional Knowledge; 14 Hrs	Trace and Test all Electrical & Electronic components & circuits and assemble circuit to ensure functionality of system.	24 Perform practice in joining wires using soldering Iron. (20 hrs) 25 Prepare simple electrical circuits, measuring of current, voltage and resistance using digital multimeter. (20 hrs) 26 Perform practice continuity test for fuses, relay and diodes (09 hrs)	**Basic electricity** - Electricity principles, - Ground connections, - Ohm's law, - Voltage, Current, Resistance, Power, Energy. - Voltmeter, ammeter, Ohmmeter, Multimeter, - Conductors & insulators, Wires, Shielding, Length vs. resistance, Resistor ratings (04Hrs)
		27 Check circuit using of service manual wiring diagram for troubleshooting (08 hrs)	- Fuses& circuit breakers, - Ballast resistor, - Stripping wire insulation, - Cable colour codes and sizes, Resistors in Series circuits, - Parallel circuits and Series- parallel circuits (04Hrs)
		28 Execute cleaning and topping up of a lead acid battery. (10 hrs) 29 Perform testing battery with hydrometer. (12 hrs) 30 Perform connecting battery to a charger for battery charging and checking & testing a battery after charging. (08 hrs)	- Description of Chemical effects, Batteries & cells, Lead acid batteries & Stay Maintenance Free (SMF) batteries, - Magnetic effects, Heating effects, Thermo-electric energy, Thermistors, Thermo couples, - Electrochemical energy, Photo-voltaic energy, Piezo- electric energy, Electromagnetic induction,

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		31 Perform test of relay and solenoids and its circuit. (05 Hrs)	- Relays, Solenoids, Primary & Secondary windings, Transformers, stator and rotor coils. (6 Hrs)
Professional Skill 35 Hrs; Professional Knowledge; 9 Hrs	Trace & Test Hydraulic and Pneumatic components.	32 Identify of Hydraulic and pneumatic components used in vehicle. (10 hrs) 33 Tracing of hydraulic circuit on hydraulic jack, hydraulic, and Brake circuit. (15hrs) 34 Identify components in Air brake systems (10hrs)	**Introduction to Hydraulics & Pneumatics** - Description, symbols and application in automobile of Gear pump-Internal & External, single acting, double acting & Double ended cylinder; Directional control, Pressure relief valve, Non return valve, Flow control valve used in automobile. (9 hrs)
Professional Skill 25Hrs; Professional Knowledge; 5 Hrs	Check & Interpret Vehicle Specification data and VIN. Select & operate various Service Station Equipments.	35 Identify of different types of Vehicle. (05 hrs) 36 Demonstrate of vehicle specification data. (05hrs) 37 Identify of vehicle information Number (VIN). (05 hrs). 38 Demonstrate of Garage, Service station equipments - Vehicle hoists Two post and four post hoist, Engine hoists, Jacks, Stands. (10hrs)	- Classification of vehicles on the basis of load as per central motor vehicle rule, wheels, final drive, and fuel used, axles, position of engine and steering transmission, body and load. Brief description - Uses of Vehicle hoists - Two post and four post hoist, Engine hoists, Jacks, Stands. (05 Hrs)
Professional Skill 50 Hrs; Professional Knowledge; 8 Hrs	Dismantle & assemble of Diesel Engine from vehicle (LMV/ HMV) along with other accessories.	39 Identify the different parts of IC Engine (10hrs) 40 Identify the different parts in a diesel engine of LMV/ HMV (10 hrs) 41 Perform practice on starting and stopping of diesel engines. Observe and report the reading of Tachometer, Odometer, temp and Fuel gauge under ideal and on load condition. (10hrs) 42 Practice on dismantling Diesel engine of LMV/HMV as per procedure. (20hrs)	**Introduction to Engine** - Description of internal & external combustion engines, Classification of IC engines, Principle &working of 2 & 4-stroke diesel engine (Compression ignition Engine (C.I), - Principle of Spark Ignition Engine (SI), differentiate between 2-stroke and 4 stroke, C.I engine and S.I Engine, - Main Parts of IC Engine - Direct injection and indirect injection, Technical terms used in engine, Engine specification. - Study of various gauges/ instrument on a dash board of a vehicle- Speedometer, Tachometer, Odometer and Fuel gauge, and Indicators such as gearshift position, Seat belt warning light, Parking-brake-engagement warning light and an Engine-malfunction light. - Different type of starting and stopping method of Diesel Engine - Procedure for dismantling of diesel engine from a vehicle. (8 hrs)

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Professional Skill; 160 Hrs; Professional Knowledge; 25 Hrs	Overhaul & service Diesel Engine, its parts and check functionality.	43 Perform Overhauling of cylinder head assembly, Use of service manual for 44 clearance and other parameters. (10hrs) 45 Perform practice on removing rocker arm assembly manifolds. (05hrs) 46 Perform practice on removing the valves and its parts from the cylinder head, cleaning. (05hrs) 47 Inspection of cylinder head and manifold surfaces for warping, cracks and flatness. Checking valve seats & valve guide-Replacing the valve if necessary. (05hrs) 48 Check leaks of valve seats for leakage - Dismantle rocker shaft assembly-clean & check rocker shaft - and levers, for wear and cracks and reassemble.(05hrs) 49 Check valve springs, tappets, pushrods, tappet screws and valves tem cap. Reassembling valve parts insequence, refit cylinder head and manifold & rocker arm assembly, adjustable valve clearances, starting engine after adjustments. (10 hrs)	**Diesel Engine Components** - Description and Constructional feature of Cylinder head, Importance of Cylinder head design, - Type of Diesel combustion chambers, - Effect on size of Intake & exhaust passages, Head gaskets. - Importance of Turbulence. Valves & Valve Actuating Mechanism - - Description and Function of Engine Valves, different types, materials, - Type of valve operating mechanism, Importance of Valve seats, Valve seats inserts in cylinder heads, - Importance of Valve rotation, Valve stem oil seals, size of Intake valves, Valve trains, Valve- timing diagram, concept of Variable valve timing. - Description of Camshafts & drives , - Description of Overhead camshaft (SOHC and DOHC), importance of Cam lobes, Timing belts & chains, Timing belts & tensioners. (07hrs)
		50 Perform Overhauling piston and connecting rod assembly. Use of service manual for clearance and other parameters. (05 hrs) 51 Perform Practice on removing oil sump and oil pump - clean the sump. (04 hrs) 52 Perform removing the big end bearing, connecting rod with the piston. (04 hrs) 53 Perform removing the piston rings; Dismantle the piston and connecting rod. Check the side clearance of piston rings in the piston groove & lands for wear. Check piston skirt and crown for damage and scuffing, clean oil holes. (05 hrs) 54 Measure -the piston ring close gap in the cylinder, clearance between the piston and the liner, clearance between crank pin and the connecting rod big end bearing. (03 hrs) 55 Check connecting rod for bend and twist. Assemble the piston and connecting rod assembly. (04 hrs)	- Description&functionsof different types of pistons, piston rings and piston pins and materials. - Used recommended clearances for the rings and its necessity precautions while fitting rings, common troubles and remedy. - Compression ratio. - Description & function of connecting rod, - importance of big- end split obliquely - Materials used for connecting rods big end & main bearings. Shells piston pins and locking methods of piston pins. (05 Hrs)

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		56 Perform Overhauling of crankshaft, Use of servicemanual for clearance andotherparameters (05hrs) 57 Perform removing damper pulley, timing gear/timing chain, flywheel, main bearing caps, bearing shells and crankshaft from engine (05hrs). 58 Inspect oil retainer and thrust surfaces for wear. (05 hrs) 59 Measure crankshaft journal for wear, taper and ovality. (05hrs) 60 Demonstrate crankshaft for filletradii, bend & twist. (05hrs)	- Description and function of Crank shaft, camshaft, - Engine bearings-classification and location - materials used & composition of bearing materials-Shell bearing and their advantages-special bearings material for diesel engine - Application bearing failure & its causes-care & maintenance. - Crank-shaft balancing, firing order of the engine. (04Hrs)
		61 Inspect fly wheel and mounting flanges, spigot and bearing. (05hrs) 62 Check vibration damper for defect. (02hrs) 63 Perform removing camshaft from engine block, Check for bend & twist of camshaft. Inspection of cam lobe, camshaft journals and bearings and measure cam lobe lift. (05 hrs) 64 Fixing bearing inserts in cylinder block & cap check nip and spread clearance & oil holes & locating lugs fix crankshaft on block-torque bolts-check end play remove shaft-check seating, repeat similarly for connecting rod and Check seating and refit. (08 hrs)	- Description and function of the fly wheel and vibration damper. - Crank case & oil pump, gears timing mark, Chain sprockets, chain tensioner etc. - Function of clutch & coupling units attached to flywheel. (04 Hrs)
		65 Perform cleaning and checking of cylinder blocks. (10 hrs) 66 Surface for any crack, flatness measure cylinder borefor taper & ovality,clean oil gallery passage and oil pipeline. (15hrs) 67 Perform reassembling all parts of engine in correct sequence and torque all bolts and nuts as per workshop manual of the engine. (12hrs) 68 Perform testing cylinder compression, Check idle speed. (08hrs) 69 Perform removing & replacing a cam belt, and adjusting an engine drivebelt, replacing an engine drive belt. (05hrs)	- Description of Cylinder block, - Cylinder block construction, - Different type of Cylinder sleeves (liner). (05 Hrs)
Professional Skill 50 Hrs; Professional Knowledge; 10 Hrs	Trace, Test & Repair Cooling and Lubrication Systemof engine.	70 Perform practice on checking & top up coolant, draining & refilling coolant, checking / replacing a coolant hose. (05 hrs) 71 Perform test cooling system pressure. (04 hrs) 72 Execute on removing & replacing radiator/ thermostat check the radiator pressure cap. (06 hrs)	**Need for Cooling systems** - Heat transfer method, - Boiling point & pressure, - Centrifugal force, - Vehicle coolant properties and recommended change of interval, - Different type of cooling systems,

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		73 Test of thermostat. (03 hrs) 74 Perform cleaning &reverse flushing. (08hrs) 75 Perform overhauling water pump and refitting. (07 hrs) 76 Perform checking engine oil, draining engine oil, replacing oil filter, & refilling engine oil (07 hrs) 77 Execute overhauling of oil pump, oil coolers, air cleaners and air filters and adjust oil pressure relief valves, repairs to oil flow pipe lines and unions if necessary. (10 hrs)	**Basic cooling system components** - Radiator, Coolant hoses, - Water pump, - Cooling system thermostat, Cooling fans, - Temperature indicators, - Radiator pressure cap, Recovery system, Thermo-switch. **Need for lubrication system** - Functions of oil, Viscosity and its grade as per SAE , - Oil additives, Synthetic oils, The lubrication system, **Splash system** - Pressure system - Corrosion/noise reduction in the lubrication system. - Lubrication system components - Description and function of Sump, Oil collection pan, Oil tank, Pickup tube, different type of Oil pump & Oil filters Oil pressure relief valve, Spurt holes & galleries, Oil indicators, Oil cooler. (10 hrs)
Professional Skill 26Hrs; Professional Knowledge 06 Hrs	Trace & Test Intake and Exhaust system of engine.	78 Execute dismantling air compressor and exhauster and cleaning all parts - measuring wear inthe cylinder, reassembling all parts and fitting the min the engine. (7hrs) 79 Execute dismantling & assembling of turbocharger, check for axial clearance as per service manual. (05hrs) 80 Examine exhaust system for rubber mounting for damage, deterioration and out of position; for leakage, loose connection, dentand damage; (08hrs) 81 Perform practice on exhaust manifold removal and installation, practice on Catalytic converter removal and installation. (06 hrs)	**Intake & exhaust systems** - Description of Diesel induction & Exhaust systems. Description & function of air compressor, exhauster, Super charger, Intercoolers, turbo charger, variable turbo charger mechanism. **Intake system components** - Description and function of Air cleaners, Different type air cleaner, Description of Intake manifolds and material, **Exhaust system components** - Description and function of Exhaust manifold, Exhaust pipe, Extractors, Mufflers-Reactive, absorptive, Combination of Catalytic converters, Flexible connections, Ceramic coatings, Back-pressure, - Electronic mufflers. (06Hrs)
Professional Skill 70 Hrs; Professional Knowledge 12 Hrs	Service Diesel Fuel System and check proper functionality.	82 Perform work on removing & cleaning fuel tanks, checking leaks in the fuel lines. (10hrs) 83 Execute over hauling of Feed Pumps (Mechanical & Electrical). (10hrs)	**Fuel Feed System in IC Engine (Petrol & Diesel)** - Gravity feed system, Forced feed system, main parts, Fuel Pumps- Mechanical & Electrical - Feed Pumps. - Knowledge about function, working &types of Carburetor.

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		84 Perform bleeding of air from the fuel lines, servicing primary & secondary filters. (10hrs) 85 Execute removing a fuel injection pump from an engine-refit the pump tothe engine re- set timing -fill lubricating-oilstart and adjust slow speed of the engine. (15hrs) 86 Execute overhauling of injectors and testing of injector. (15hrs) 87 General maintenance of Fuel Injection Pumps (FIP). (10hrs)	**Diesel Fuel Systems** - Description and function of Diesel fuel injection, fuel characteristics, concept of Quiet diesel technology &Clean dieseltechnology. **Diesel fuel system components** - Description and function of Diesel tanks & lines, Diesel fuel filters, water separator, Lift pump, Plunger pump, Priming pump, - Inline injection pump, Distributor-type injection pump, Diesel injectors, Glow plugs, Cummins & Detroit Diesel injection. **Electronic Diesel control** - Electronic Diesel control systems, Common Rail Diesel Injection (CRDI) system, hydraulically actuated electronically controlled unit injector (HEUI) diesel injection system. Sensors, actuators and ECU (Electronic Control Unit) used in Diesel Engines. (12hrs)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Plan & overhaul the stationary engine and Governor and check functionality.	88 Execute Start engine adjust idling speed and damping device in pneumatic governor and venture control un it checking.(06hrs) 89 Verify performance of engine with off load adjusting timings. Start engine - adjusting idle speed of the engine fitted with mechanical governor checking- high speed operation of the engine. (07 hrs) 90 Check performance form issing cylinder by isolating defective injectors and test-dismantle and replace defective parts and reassemble and refit back to the engine. (12 hrs)	**Marine & Stationary Engine:** **Types,** - double actingengines, - opposed piston engines, starting systems, cooling systems, lubricating systems, supplying fuel oil, hydraulic coupling, - Reduction gear drive, electromagnetic coupling, - Electrical drive, generators and motors, super charging. (05 Hrs)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Monitor emission of vehicle and execute different operation to obtain optimum pollution as per emission norms.	91 Monitor emissions procedures by use of Engine gas analyser or Diesel smoke meter. (10hrs) 92 Checking & cleaning a Positive crankcase ventilation (PCV) valve. Obtaining & interpreting scan tool data. Inspection of EVAP can inter purges system by use of scan Tool. (10hrs) 93 EGR/SCR Valve Remove and installation for inspection.(05hrs)	**Emission Control Vehicleemissions** - Standards- Euro and Bharat II, III, IV, V Sources of emission, Combustion, Combustion chamberdesign. **Types of emissions** - Characteristics and Effect of Hydrocarbons, Hydrocarbons in exhaust gases, Oxides of nitrogen, Particulates, - Carbon monoxide, Carbon dioxide, Sulphur content in fuels Description of Evaporation emission control, Catalytic conversion, Closed loop,

			- Crankcase emission control, Exhaust gas recirculation (EGR) valve, controlling air-fuel ratios, Charcoal storage devices, Diesel particulate filter (DPF). Selective Catalytic, Reduction (SCR), EGR VS SCR (05Hrs)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Carryout overhauling of Alternator and Starter Motor.	94 Perform removing alternator from vehicle dismantling, cleaning checking for defects, assembling and testing for motoring action of alternator & fitting to vehicles. (15 hrs) 95 Practice on removing starter motor Vehicle and overhauling the starter motor, testing of starter motor (10 hrs).	- Basic Knowledge about DC Generator & AC Generator. - Constructional details of Alternator - Description of charging circuit operation of alternators, regulator unit, ignition warning lamp- troubles and remedy in charging system. - Description of starter motor circuit, - Constructional details of starter motor solenoid switches, common troubles and remedy in starter circuit. (05 Hrs)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Diagnose & rectify the defects in LMV/ HMV to ensure functionality of vehicle.	96 Execute troubleshooting in LMV/HMV for Engine Not starting - Mechanical & Electrical causes, High fuel consumption, Engine overheating, Low Power Generation, Excessive oil consumption, Low/High Engine Oil Pressure, Engine Noise. (25 hrs)	- Troubleshooting : - Causes and remedy for - Engine Not starting Mechanical & Electrical causes, - High fuel consumption, Engine overheating, - Low Power Generation, - Excessive oil consumption, - Low/High Engine Oil Pressure, Engine Noise. (05 hrs)

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Identify the machines/equipment in Mechanic (Diesel) trade

Objective: At the end of this exercise you shall be able to
- **identify the air compressor, jib crane, bench drill.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.
- Drilling machine - 1 No.

Equipments/ Machines

- Air compressor - 1 No.
- Jib crane - 1 No.

Materials

- Cotton waste - as reqd.
- Soap oil - as reqd.

PROCEDURE

1 Take the participants around the workshop.

2 Identify the major workshop machinery compressor, drilling machines etc.

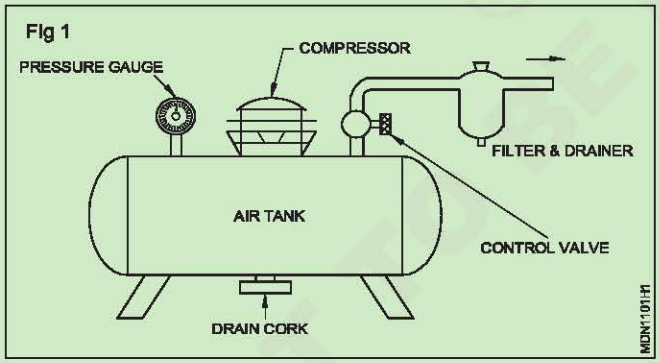
3 Explain the constructional features and the use of compressor, air receiver.

4 Explain the use of compressed air and its applications.

5 Explain bench drilling machine, pillar drilling machine.

6 Explain through display charts, the features of all equipments in an Automotive workshop.

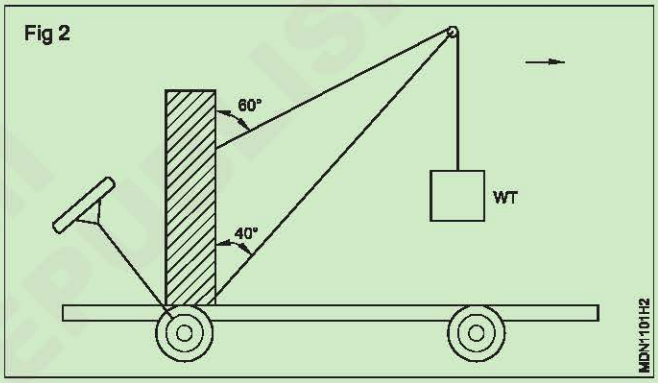
Air compressor (Fig 1)



Compressor is an equipment to produce compressed air at required pressure through air hoses.

Jib crane (Fig 2)

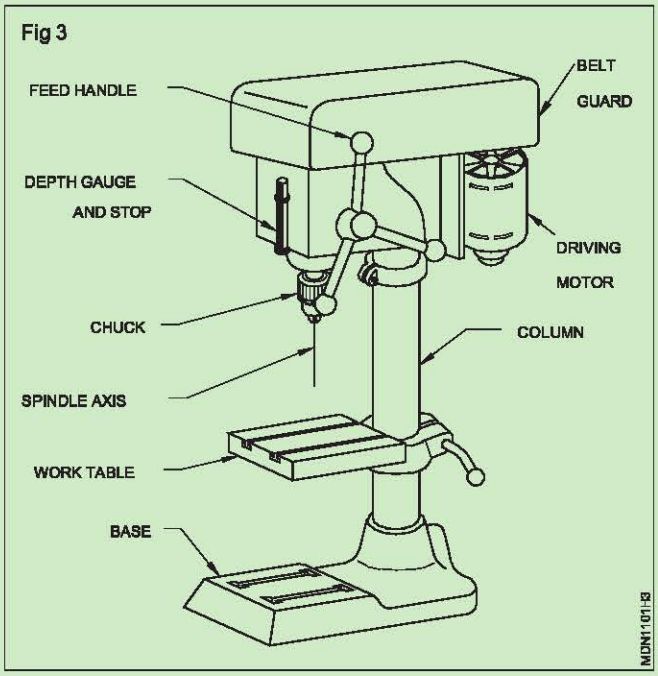
Jib crane is used to transport the objects, from one place to another shop floor.



Sensitive bench drilling machine (Fig 3)

This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

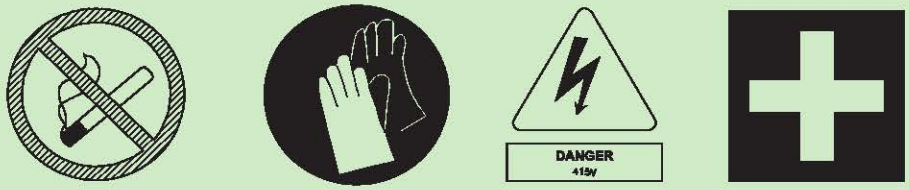
For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted.



Identify Personal Protective Equipments (PPE)

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

- **identify the four basic catagories of safety sign**
- **identify the meanings of the safety sign**
- **read and interpret the different types of personal protective equipments from the chart.**





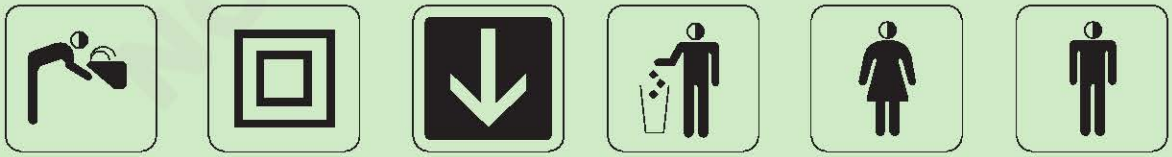
SMOKING AND NAKED FLAMES PROHIBITED | DO NOT EXTINGUISH WITH WATER | PEDESTRIANS PROHIBITED



WEAR HEAD PROTECTION | WEAR EYE PROTECTION | WEAR HEARING PROTECTION



RISK OF FIRE | RISK OF ELECTRIC SHOCK | TOXIC HAZARD | GENERAL WARNING RISK OF DANGER



–	--	--	–	–	--	–
NO.OFF	STOCK SIZE	SEMI-PRODUCT	MATERIAL	PROJECT NO.	PART NO.	EX. NO.

SCALE	IDENTIFY THE CATEGORIES OF THE SAFETY SIGN	DEVIATIONS	TIME
		CODE NO. MDN1102E1	

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TASK 1 : **Safety sign**

Instructor may provide various safety signs chart categories and explain their categories and their meaning, description. Ask the trainee to identify the sign and record in table

1 Identify the safety sign from the chart.

2 Record the name of the category in table1.

3 Mention the meaning description of the safety sign in table1.

Table 1

Fig No.	Basic categories/ safety sign	Meaning - descriptions
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Get it checked by your instructor

TASK 2 : **Personal protective equipments**

Fig 1



Note: The instructor may provide or arrange the different types of personal protection equipment or chart and explain how to identify and select the PPE devices suitable for the work and ask the trainees to write names in the given table.

1 Read and interpret the personal protective equipments by visually on real devices or from the charts.

2 Identify and select the personal protection equipment used for suitable type of protection.

3 Write the name of the PPE to the corresponding type of protective safety equipments in Table 2.

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Table 2

S.No.	Name of the PPE	Hazards	Type of protection
1			
2			
3			
4			
5			
6			
7			
8			
9			

Get it checked by your instructor.

TASK 3 : **Identify the occupational hazard**

Instructor may brief the various types of occupational hazards and their causes.

1 Identify the occupational hazard to the corresponding situation with a potential harm given in table3.

Table 3

S.No.	Source or potential harm	Type of occupational hazards
1	Noise	
2	Explosive	
3	Virus	
4	Sickness	
5	Smoking	
6	Non control device	
7	No earthing	
8	Poor house keeping	

Fill up and get it checked by your instructor.

TASK 4 : **PPE Instruction and uses**

1 Some cleaning agents are toxic. Refer to the information about handling; use and storage of chemicals that may be hazardous, follow any recommendations made by the supplier before using it.

2 Do not use flammable cleaners or water on electrical equipment.

3 Make sure designated walkways are kept clear of any obstructions.

4 Always wear protective clothing and the appropriate safety equipment.

5 Make sure that you understand and observe all legislative and personal safety procedures when carrying out the following tasks. If you are unsure of what these procedures are, ask your instructor.

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Workshop maintenance

Objectives : At the end of this exercise you shall be able to
- **carryout the maintenance of equipment**
- **clean the tools and equipment.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.

Materials

- Cleaning solvent - as reqd.
- Washing powder - as reqd.
- Cotton waste - as reqd.
- Brush - as reqd.

PROCEDURE

TASK 1 : **Maintenance of tools and equipment**

1 Clean tools and equipment and work more efficiently. At the end of each working day clean the tools and equipment used and check them for any damage. If you note any damage, tag the tool as faulty.

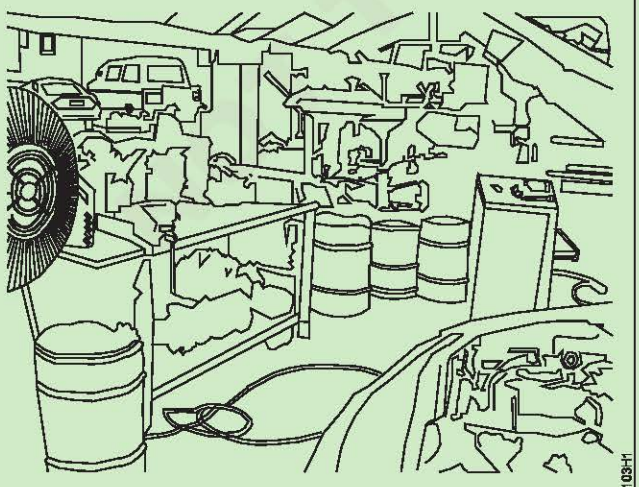
2 Electrical current can travel over oily or greasy surfaces. Keep electrical power tools free from dust and dirt and make sure they are free of oil and grease.

3 All workshop equipment should have a maintenance schedule. Always complete the tasks described on the schedule at the required time. This will help to keep the equipment in safe working order.

4 Store commonly used tools in an easy-to-reach location.

5 If a tool, or piece of equipment, is too difficult to be returned, it could be left on a workbench or on the floor where it will become a safety hazard. (Fig 1)

Fig 1

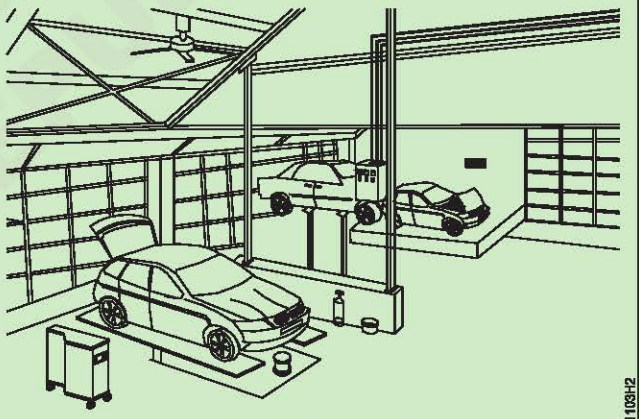


UNORGANIZED WORKSHOP

MDN1103H1

6 Keep your work area clean. This will help you work more efficiently and safely. (Fig 2)

Fig 2



ORGANIZED WORKSHOP

MDN1109H2

7 Have a waste bin close to your work area and place any waste in it as soon as possible.

8 Dispose of liquid and solid waste, such as oils, coolant and worn components, in the correct manner.

9 Do not pour solvents or other chemicals into the sewage system. This is both environmentally damaging and illegal.

9 Always use chemical gloves when using any cleaning material because excessive exposure to cleaning materials can damage skin.

10 Some solvents are flammable. Never use cleaning materials near an open flame. Never smoke inside the workshop.

11 The fumes from cleaning chemicals can be toxic, so wear appropriate respirator and eye protection wherever you are using these products.

TASK 2 : **Cleaning hand tools, jack, power tool and machinery**

1 Clean hand tools

Keep your hand tools in clean condition with two sets of cabinet. One cabinet should be lint-free to handle precision instruments or components.

The other should be oily to prevent rust and corrosion.

2 Clean floor jacks

Wipe off any oil or grease on the floor jack and check for fluid leaks. If you find any leaks, rectify the leaks and top up the hydraulic fluid.

Occasionally, apply a few drops of lubricating oil to the wheels and a few drops to the posts of the safety stands.

3 Clean electrical power tools

Keep power tools clean by brushing off any dust and wiping off excess oil or grease with a clean rag.

Inspect any electrical cables for dirt, oil or grease, and for any chafing or exposed wires.

With drills, inspect the chuck and lubricate it occasionally with machine oil.

4 Clean air powered tools

Apply a few drops of oil into the inlet of your air tools every day. Although these tools have no motor, they need to do regular lubrication of the internal parts to prevent wear.

5 Clean hoists and heavy machinery

Locate and checklist or maintenance record for each hoist or other major piece of equipment before carrying out cleaning activities.

Clean operating mechanisms and attachments of excess oil or grease.

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Handling and testing of workshop equipments and disposal of used engine oil

Objectives: At the end of this exercise you shall be able to
- **demonstrate safe handling of lifting equipments**
- **do the periodic testing of lifting equipments**
- **safety measures in disposal of used engine oil.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.

Equipments

- Air compressor - 1 No.
- Vehicle - 1 No.

Materials

- Oil - as reqd.
- Water - as reqd.
- Kerosene - as reqd.
- Cotton waste - as reqd.

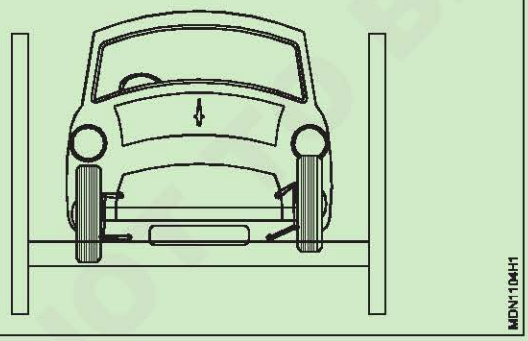
PROCEDURE

TASK 1 : **Demonstration safe handling of lifting equipments**

Check the test certificate.

The lifting equipment is subjected to statutory Testing and Certification. (Fig 1) the test calibration certificate should be attached to, or displayed near the lifting equipment that it refers to. Before using this equipment, make sure that the most recent inspection record is still within the prescribed time limit, and ensure that the certificate has not expired.

Fig 1



Example: M/s. ABCD.

Vehicle Hoist Service.

044-12345678.

Chennai - 78.

SERVICE.

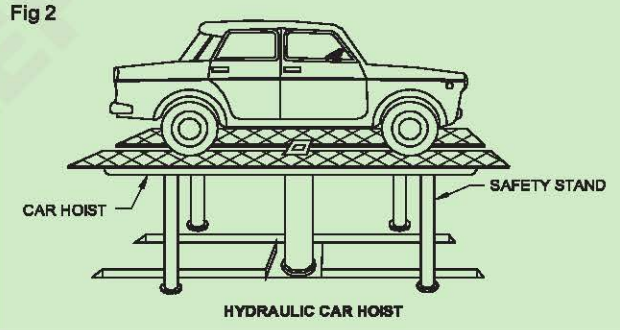
Date Serviced: 20/05/2018

Next Service : 19/05/2019

Check the equipment

1 Carry out regular periodic checks on the serviceability of all of the hydraulic lifting equipment. (Fig 2)

Fig 2



2 Refer to the manufacturer's handbook to find out how often they recommend maintenance tests and make sure that these occur.

3 Check whether the test equipment for its proper functioning.

4 Ensure that there are no leakage in the hose, control valves and oil pump

5 Before operating the lift, ensure that the car is correctly placed in the platform.

6 Check whether it is lifting properly.

7 And also check whether it is holds the oil or not.

Note : Vehicle hoist is not included in the equipments list. This practical can be given at any service station.

8 After the completion of the work, lower the ramp to its normal position.

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TASK 2 : **Safety measures in disposal of used engine oil**

1 Wear protective clothing, such as gloves, mask, shoes, apron etc.,

2 Do not spill any oil or grease on the ground.

3 Put your used motor oil in a clean plastic container with a tight lid. Never store used oil in a container that once held chemicals, food, or beverages.

4 Do not mix the oil with anything else, such as antifreeze, solvent, or paint.

5 Take used motor oil to a service station or other location that collects used motor oil for recycling.

Recycled used motor oil can be re-refined into new oil, processed into fuel oils and used as raw materials for the petroleum industry.

6 While storing used oil, meant for disposal keep them in a separate place with proper identification mark in the container. (Fig 1)

Never keep the used oil near the hot area or near flame.

While transporting ensure that there is no spillage of oil. (Fig 2)

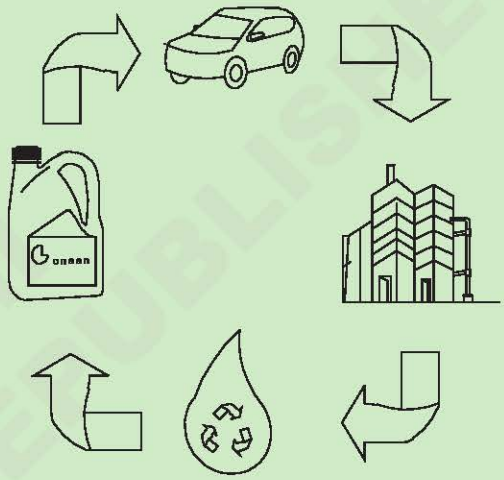
7 Maintain a record of oil disposed for reference and record as shown in Table below.

Fig 1



MDN1104J1

Fig 2



MDN1104J2

Table

Sl. No	Date	Qty per can (litre)	No of cans delivered	Total qty. disposed in litres	Remarks
1	Eg. 23 - 7 -18	2	05	100	
2	-	-	-	-	
3					
4					
5					

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Demonstrate occupational safety and first aid

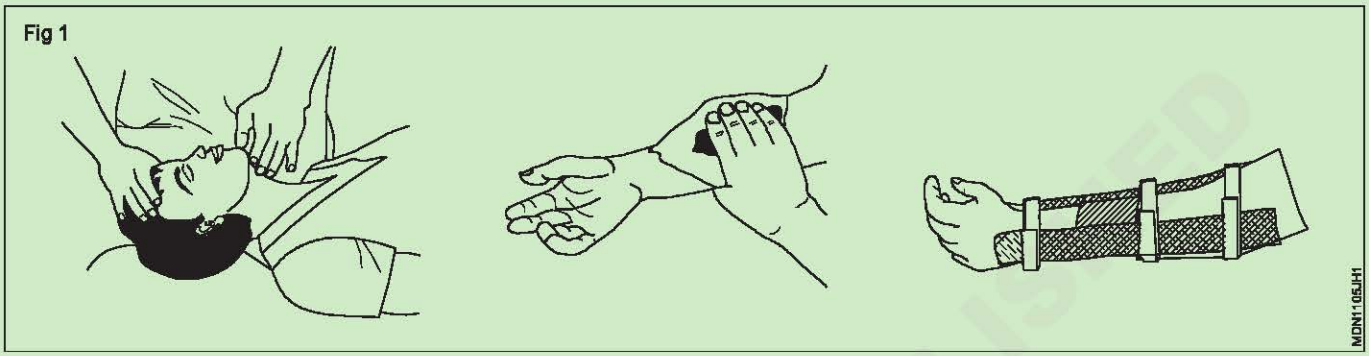
Objectives: At the end of this exercise you shall be able to

- **rescue breathing for an unconscious victim of different condition**
- **perform treatment for stopping of bleeding.**

PROCEDURE

TASK 1: **Prepare the victim to receive artificial respiration**

Fig 1



Assumption - For easy manageability, Instructor may arrange the trainees in group and ask each group to perform one method of resuscitation.

1 Loosen the tight clothing which may interfere with the victim's breathing.

2 Remove any foreign materials or false teeth from his mouth and keep the victim's mouth open.

3 Bring the victim safely to the level ground, taking necessary safety measures. (Fig 1)

4 Start artificial respiration immediately without delay. Do not waste too much time in loosening the clothes or trying to open the tightly closed mouth.

5 Avoid violent operations to prevent injury to the internal parts of the victim.

6 Send to a doctor immediately.

— — — — — — —

TASK 2 : **Resuscitate the victim by Nelson's arm - Lift back pressure method**

Nelson's arm - lift back pressure method must not be used in case there are injuries to the chest and belly.

1. Place the victim prone (that is face down) with his arms folded with the palms one over the other and the head resting on his cheek over the palms. Kneel on one or both knees near the victim's hand. Place your hands on the victim's back beyond the line of the armpits, with your fingers spread outwards and downwards, thumbs just touching each other as in(Fig 1).

2 Gently rock forward keeping your arms straight until they are nearly vertical, and steadily pressing the victim's back as shown in (Fig 2) to force the air out of the victim's lungs.

3 Synchronise the above movement of rocking backwards with your hands sliding downwards along the victim's arms, and grasp his upper arm just above the elbows as shown in (Fig 3). Continue to rock backwards.

Fig 1



4 As you rock back, gently raise and pull the victim's arms towards you as shown in (Fig 4) until you feel tension in his shoulders. To complete the cycle, lower the victim's arms and move your hands up to the initial position.

Fig 2

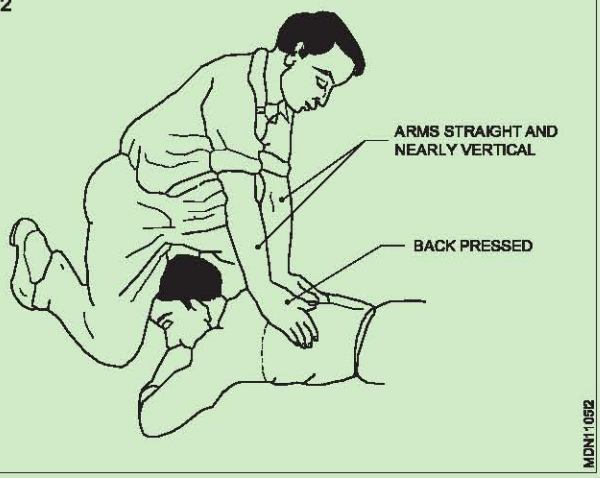
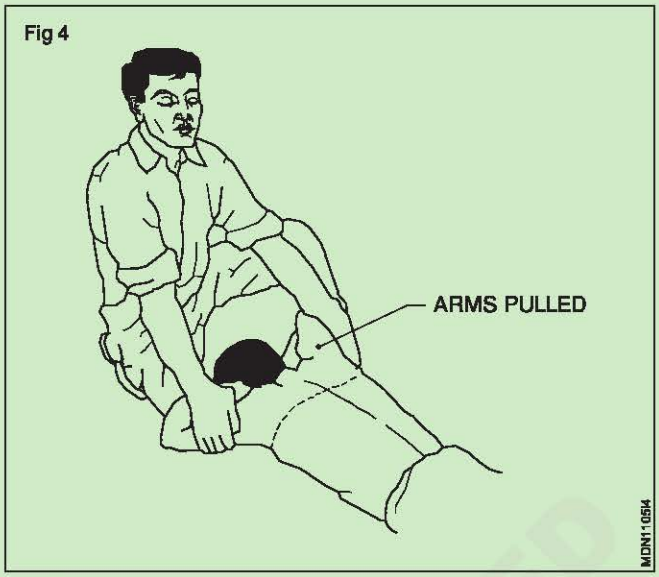


Fig 3



Fig 4



5 Continue artificial respiration till the victim begins to breathing naturally. Please note, in some cases, it may take hours.

6 When the victim revives, keep the victim warm with a blanket, wrapped up with hot water bottles or warm bricks; stimulate circulation by stroking the insides of the arms and legs towards the heart.

7 Keep him in the lying down position and do not let him exert himself.

Do not give him any stimulant until he is fully conscious.

TASK 3: **Do not use this method in case of injuries to victim on the chest and belly**

1 Lay the victim on his belly, one arm extended direct forward, the other arm bent at the elbow and with the face turned sideward and resting on the hand or forearm as shown in (Fig 1).

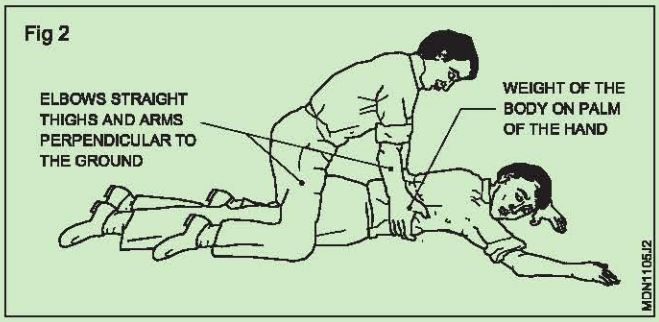
2 Kneel astride the victim, so that his thighs are between your knees and with your fingers and thumbs positioned as in (Fig 1).

3 With the arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the lower ribs of the victim to force the air out of the victim's lungs as shown in (Fig 2).

Fig 1



Fig 2

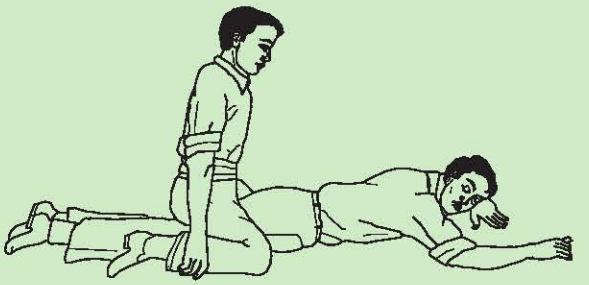


4 Now swing backward immediately removing all the pressure from the victim's body as shown in (Fig 3) thereby, allowing the lungs to fill with air.

5 After two seconds, swing forward again and repeat the cycle twelve to fifteen times a minute.

6 Continue artificial respiration till the victim begins to breathe naturally.

Fig 3



MDN1105J3

TASK 4 : **Resuscitate the victim by mouth-to-mouth method**

1 Lay the victim flat on his back and place a roll of clothing under his shoulders to ensure that his head is thrown well back. (Fig 1)

Fig 1



MDN1105U1

2 Tilt the victim's head back so that the chin points straight upward. (Fig 2)

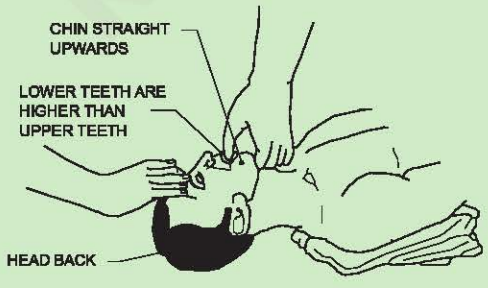
Fig 2



MDN1105U2

3 Grasp the victim's jaw as shown in (Fig 3), and raise it upward until the lower teeth are higher than the upper teeth; or place fingers on both sides of the jaw near the ear lobes and pull upward. Maintain the jaw position throughout the artificial respiration to prevent the tongue from blocking the air passage.

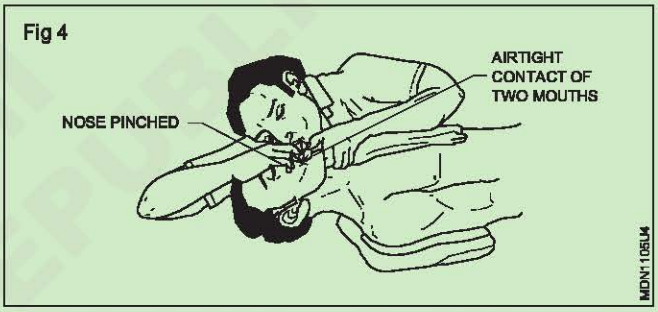
Fig 3



MDN1105U3

4 Take a deep breath and place your mouth over the victim's mouth as shown in (Fig 4) making airtight contact. Pinch the victim's nose shut with the thumb and forefinger. If you dislike direct contact, place a porous cloth between your mouth and the victim's. For an infant, place your mouth over his mouth and nose. (Fig 4)

Fig 4



MDN1105U4

5 Blow into the victim's mouth (gently in the case of an infant) until his chest rises. Remove your mouth and release the hold on the nose, to let him exhale, turning your head to hear the rushing out of air. The first 8 to 10 breathings should be as rapid as the victim responds, thereafter the rate should be slowed to about 12 times a minute (20 times for an infant).

If air cannot be blown in, check the position of the victim's head and jaw and recheck the mouth for obstructions, then try again more forcefully. If the chest still does not rise, turn the victim's face down and strike his back sharply to dislodge obstructions.

Sometimes air enters the victim's stomach as evidenced by a swelling stomach. Expel the air by gently pressing the stomach during the exhalation period.

TASK 5 : **Resuscitate the victim by Mouth-to-Nose method**

Use this method when the victim's mouth will not open, or has a blockage you cannot clear.

1 Use the fingers of one hand to keep the victim's lips firmly shut, seal your lips around the victim's nostrils and breathe into him. Check to see if the victim's chest is rising and falling. (Fig 1)

2 Repeat this exercise at the rate of 10 - 15 times per minute till the victim responds.

3 Continue this exercise till the arrival of the doctor.

Fig 1



MDN1105X1

TASK 6 : **Resuscitate a victim who is under cardiac arrest (CPR) cardio pulmanory.**

In cases where the heart has stopped beating, you must act immediately.

1 Check quickly whether the victim is under cardiac arrest.

Cardiac arrest could be ascertained by the absence of the cardiac pulse in the neck (Fig 1) blue colour around lips and widely dilated pupil of the eyes.

Fig 1



MDN1105Y1

2 Lay the victim on his back on a firm surface.

3 Kneel alongside facing the chest and locate the lower part of the breastbone. (Fig 2)

Fig 2



MDN1105Y2

4 Place the palm of one hand on the centre of the lower part of the breastbone, keeping your fingers off the ribs. Cover the palm with your other hand and lock your fingers together as shown in (Fig 3).

Fig 3



MDN1105Y3

5 Keeping your arms straight, press sharply down on the lower part of the breast bone; then release the pressure. (Fig 4)

Fig 4



MDN1105Y4

6 Repeat step 5, fifteen times at the rate of atleast once per second.

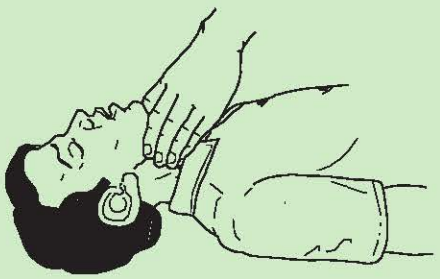
7 Check the cardiac pulse. (Fig 5)

8 Move back to the victim's mouth to give two breaths (mouth-to-mouth resuscitation). (Fig 6)

9 Continue with another 15 compressions of the heart followed by a further two breaths of mouth-to-mouth resuscitation, and so on, check the pulse at frequent intervals.

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Fig 5



MDN110575

Fig 6

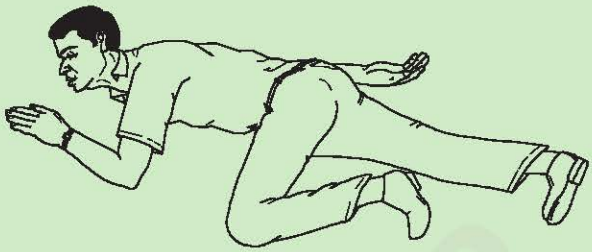


MDN110576

10 As soon as the heart beat returns, stop the compressions immediately but continue with mouth-to-much resuscitation until natural breathing is fully restored.

11 Place the victim in the recovery position as shown in (Fig 7). Keep him warm and get medical help quickly.

Fig 7



MDN110577

Other steps

1 Send for a doctor immediately.

2 Keep the victim warm with a blanket, wrapped up with hot water bottles or warm bricks; stimulate circulation by stroking the insides of the arms and legs towards the heart.

TASK 7 : **Treatment for bleeding victim**

1 Determine the location of the bleeding.

2 Elevate the injured area above the heart if possible.

3 Apply direct pressure to the bleeding area with sterile cloth.

4 Keep the pressure on for 5 seconds.

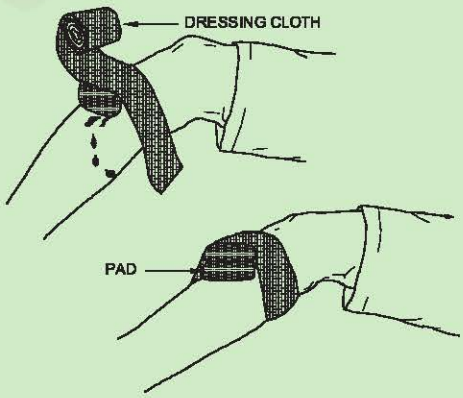
5 Check to see if the bleeding has stopped if not apply further pressure for 15 minutes.

6 Clean the wound.

7 Bandage the wound with pad of soft material. (Fig 1)

8 Advice victim to take treatment from doctor.

Fig 1



MDN110621

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Practice on fire safety

Objectives: At the end of this exercise you shall be able to
- **act as a leader of the group**
- **act as a member of the fire-fighting team.**

Requirements

Equipments

- Fire extinguishers (different type) - 1 No each.

PROCEDURE

General procedure to be adopted in the event of fire.

1 Raise an alarm. Follow the method written below for giving an alarm signals when fire breaks out.
   - by raising your voice and shouting Fire! Fire! to call the attention of others.
   - running towards fire alarm/bell to actuate it.
   - other means.

2 On receipt of the alarm signal.
   - stop working.
   - turn off all machinery and power.
   - switch off fans/air circulators/exhaust fans. (Better switch off the main)

3 If you are not involved in fighting the fire.
   - leave calmly using the emergency exit.
   - evacuate the premises.
   - assemble at a safe place along with the others.
   - check if anyone has gone to inform about the fire break to the concerned authority.
   - close the doors and windows, but do not lock or bolt.

4 If you are involved in fire fighting.
   - take instructions/give instructions for an organised way of fighting the fire.

   If taking instructions.
   - follow the instructions, and obey, if you can do so safety; do not risk getting trapped.

   If giving instructions.
   - assess the class of fire
   - send for sufficient assistance and inform the fire brigade
   - locate locally available suitable means to put out the fire
   - judge the magnitude of the fire, ensure emergency exit paths are clear of obstructions and then attempt to evacuate. (Remove explosive materials, substances that can serve as a ready fuel for fire within the vicinity of the fire break)
   - fight out the fire with assistance to put it out, by naming the person responsible for each activity.

5 Report the fire accident and the measures taken to put out the fire, to the authorities concerned.

Reporting all fires however small helps in the investigation of the cause of the fire. It helps to prevent the same kind of accident occurring again.

Note : Perform this exercise with the support of fire service station.

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Practice on fire extinguishers

Objectives: At the end of this exercise you shall be able to
- **select the fire extinguisher according to the type of fire**
- **operate the fire extinguisher**
- **extinguish the fire.**

Scan the QR code to view the video for this exercise

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.

Equipments

- Cut - Models of fire extinguisher - as reqd.
- Fire extinguisher (different type) - as reqd.

Materials

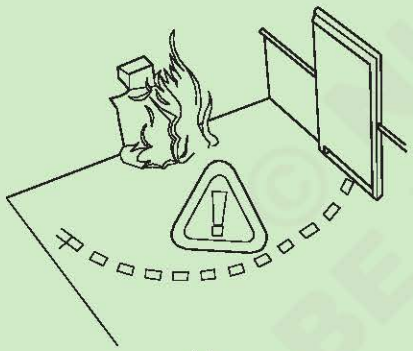
- Old tyre - as reqd.
- Wood, Paper, Cloth & Grease - as reqd.
- Gas and Liquified gas - as reqd.
- Metal and Electrical equipment - as reqd.

PROCEDURE

1 Alert people surrounding by shouting fire, fire, fire when you observe fire. (Fig 1a)

2 Inform Fire Service or arrange to inform immediately. (Fig 1b)

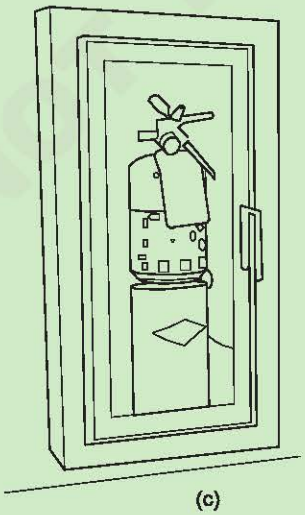
Fig 1



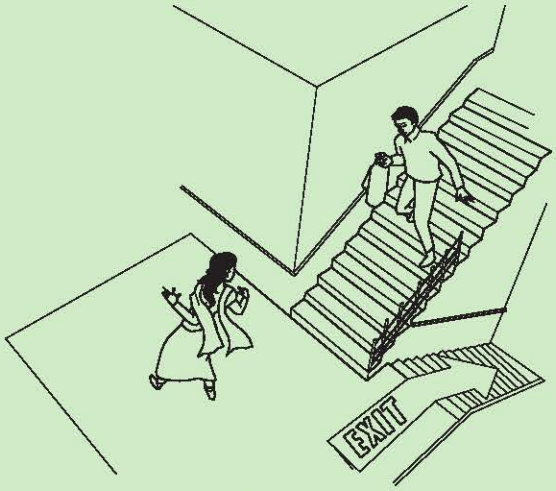
(a)



(b)



(c)



(d)

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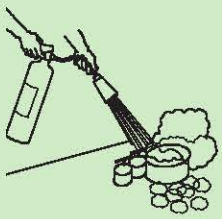
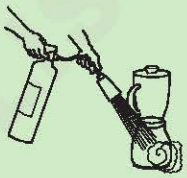
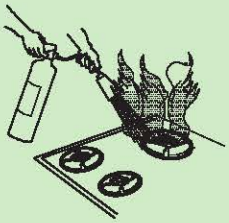
3 Open emergency exit and ask them to go away. (Fig 1c & 1d)

4 Put "Off" electrical power supply.

Do not allow people to go nearer to the fire

5 Analyze and identify the type of fire. Refer Table1.

Table1

Class 'A'	Wood, paper, cloth, solid material	
Class 'B'	Oil based fire (grease, gasoline, oil) & liquefiable solids	
Class 'C'	Gas and liquefied gases	
Class 'D'	Metals and electrical equipment	

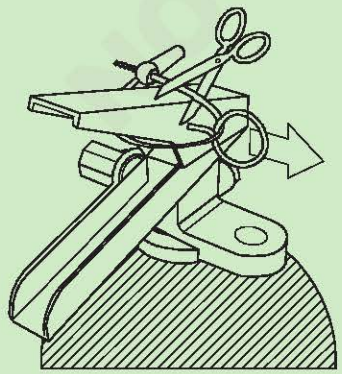
Assume the fire is 'B' type (flammable liquefiable solids)

6 Select CO_2 (carbon dioxide) fire extinguisher

7 Locate and pick up CO_2 fire extinguisher. Check for its expiry date.

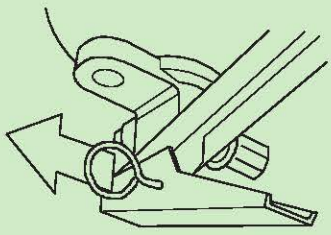
8 Break the seal. (Fig 2)

Fig 2



9 Pull the safety pin from the handle. (pin located at the top of the fire extinguisher) (Fig 3)

Fig 3



10 Aim the extinguisher nozzle or hose at the base of the fire. (this will remove the source of fuel fire) (Fig 4)

Keep your self low.

11 Squeeze the handle lever slowly to discharge the agent (Fig 5)

12 Sweep side to side approximately 15 cm over the fuel fire until the fire is put off.

Fire extinguishers are manufactured for use from the distance.

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Fig 4

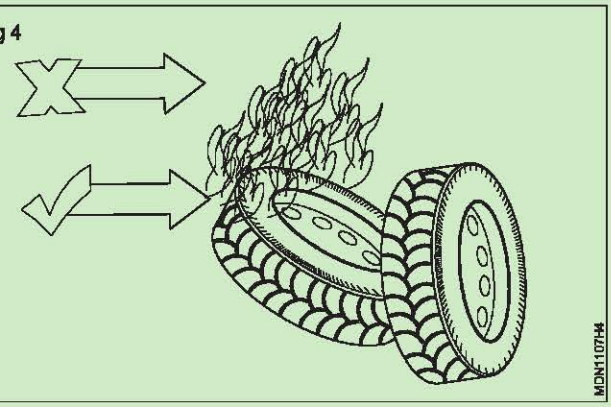
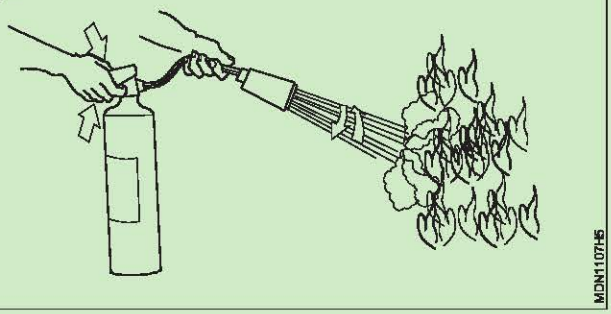


Fig 5



Caution

1 While putting off fire, the fire may flare up.

2 Do not be panic so long as it put off promptly

3 If the fire doesn't respond well after you have used up the fire extinguisher move away your self away from the fire point.

4 Do not attempt to put out a fire where it is emitting toxic smoke, leave it to the professionals.

5 Remember that your life is more important than properly. So don't place yourself or others at risk.

In order to remember the simple operation of fire extinguisher, remember;

"P.A.S.S" This will help to use fire extinguisher

P for pull.

A for aim.

S for squeeze.

S for sweep.

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Marking practice on the given job

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

- **draw lines on metallic surfaces by scribers**
- **draw parallel lines on metallic surfaces by jenny calipers**
- **draw parallel lines with a surface gauge supporting the job against the angle plate**
- **draw angles with a simple protractor and scriber**
- **bisect the angles with a divider**
- **draw circles with a divider**
- **draw curves and tangents with dividers steel rule and scribers**
- **register the profile by dot punching**
- **punch the centre of the circle with a centre punch and ball-peen hammer.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.

Equipments

- Scriber, Divider, 'V' groove - 1 No each
- Bevel Protractor - 1 No.
- Centre punch & Angle plate - 1 No each
- Surface gauge & Depth gauge - 1 No each
- Outside, Inside & Jenny caliper - 1 No each
- Surface plate - 1 No

Materials

- Chalk powder - as reqd.
- MS Plate - as reqd.

PROCEDURE

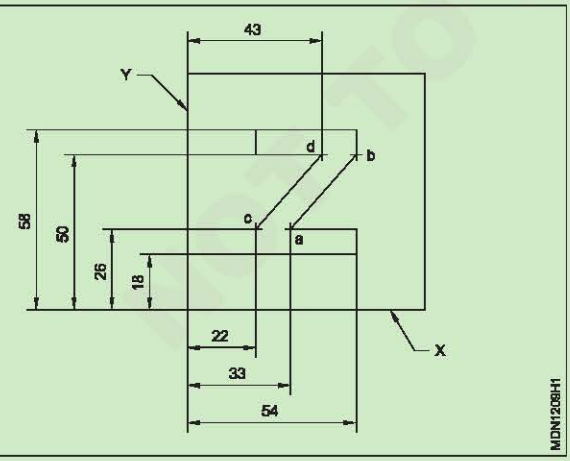
Marking 1

1 Check the raw material for its size and its squareness.

2 Apply copper sulphate solution on one side of the job and allow it to dry.

3 Scribe parallel lines to the edges 'x' and 'y' using a surface gauge. (Fig 1)

Fig 1

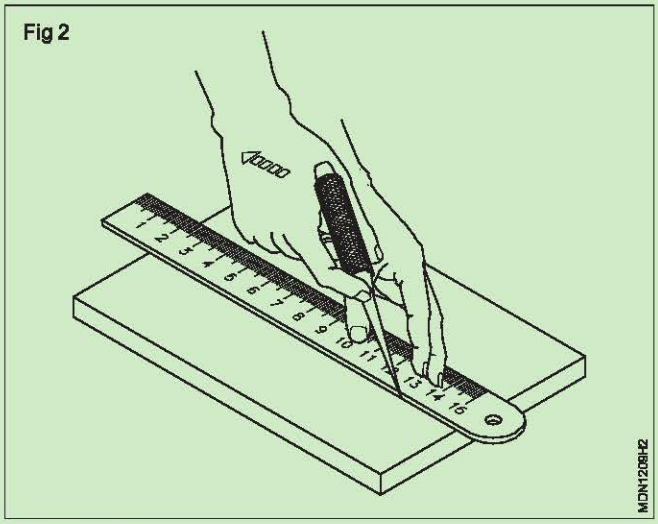


To avoid confusion, do not scribe the line longer than necessary.

4 Scribe two lines by joining points ab and cd, using a steel rule and scriber. (Fig 2)

5 Punch witness marks and complete 'Z' shape

Fig 2



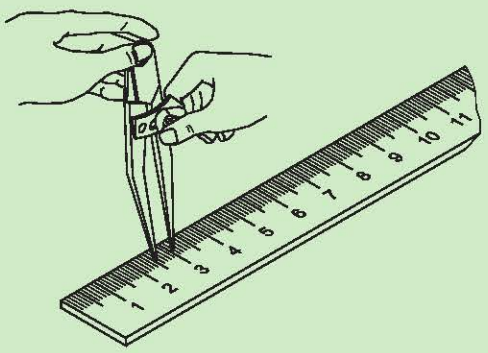
Marking 2

6 Apply the marking medium on the other side of the job and allow it to dry.

7 Mark the centre lines of three circles and one semicircle using the jenny caliper.

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Fig 3



MDN1208H3

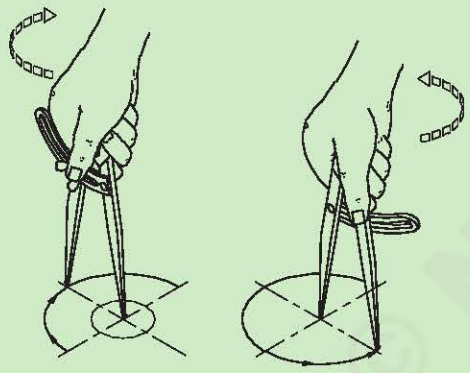
8 Punch all the four centres using a 30° prick punch. (Fig 5)

9 Open and set the divider to 5 mm. (Fig 3)

Make sure that both the legs of the divider are of equal length.

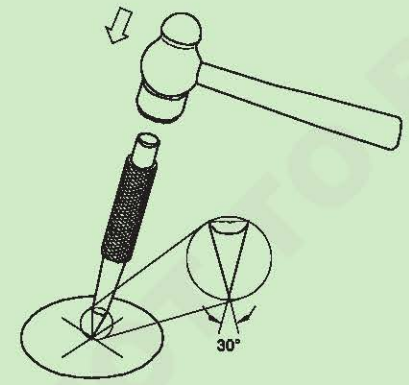
10 Draw two circles of ø10 using the divider. (Fig 4)

Fig 4



MDN1208H4

Fig 5



MDN1208H5

11 Set the divider and draw ø12 circle and R35 semicircle.

12 Punch witness marks on the circles and semicircles.

Reuse the same material for marking 3 and 4

Marking 3

13 File and finish one of the marked surfaces flat and deburr.

14 Apply copper sulphate solution on the finished side.

15 Butt the job against the angle plate.

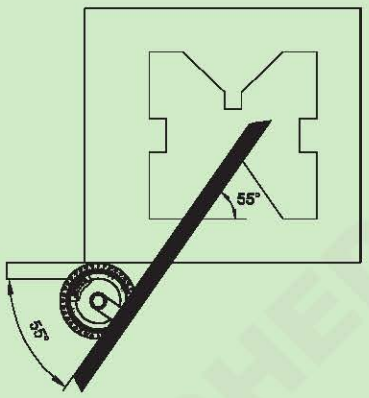
16 Mark all the parallel lines to the edges using the surface gauge.

17 Also mark the starting points of the Vee groove.

18 Set and lock the bevel protractor at 55°.

19 Butt the bevel protractor on to the edge of the job and mark one side of the Vee groove. (Fig 6)

Fig 6



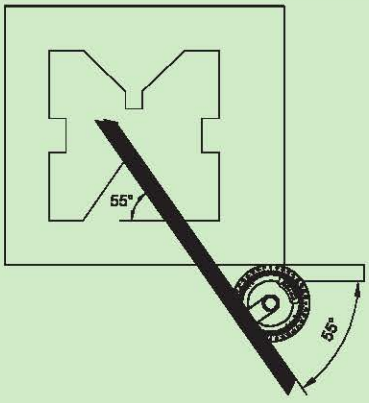
MDN1208H6

20 Continue the same procedure and complete the 44° Vee groove.

21 Complete the Vee block marking.

22 Bisect any two sides of the triangle formed by the 55° Vee groove, and get the centre and radius of the circle. (Fig 7)

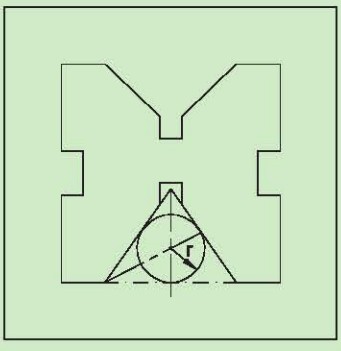
Fig 7



MDN1208H7

23 Draw the circle on the 55° Vee groove. (Fig 8)

Fig 8



MDN1208H8

24 Similarly draw the circle on the 44° Vee groove.

25 Punch witness marks.

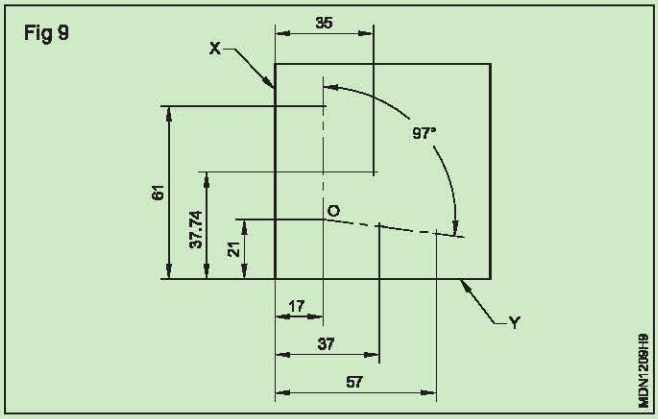
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Marking 4

26 File and finish the other surface flat, deburr and apply the marking medium.

27 Scribe the centre lines and parallel lines to the edges 'x' and 'y'. (Fig 9)

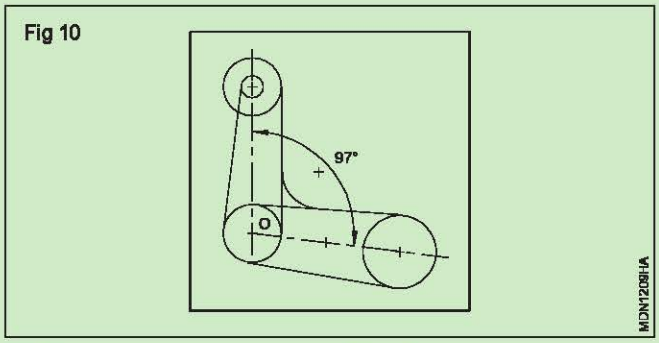
Fig 9



28 Set 97° on the bevel protractor.

29 Mark 97° line through point '0' and get the centres of the other two circles. (Fig 10)

Fig 10



30 Punch centre marks on all the four circles.

31 Draw all the four circles using a divider.

32 Draw R8, R8 and R10 curves a little more than the length required.

33 Draw two tangents close to the edges of the 'x' and 'y' circles using a steel rule and scriber. (Fig 10) and complete the marking as per shape given.

34 Punch witness marks.

Skill sequence

Marking parallel lines using surface gauge

Objectives: This shall help you to
- **mark parallel lines using a surface gauge**
- **set the surface gauge to any height dimension.**

Check the free movement of the scriber and other sliding units.

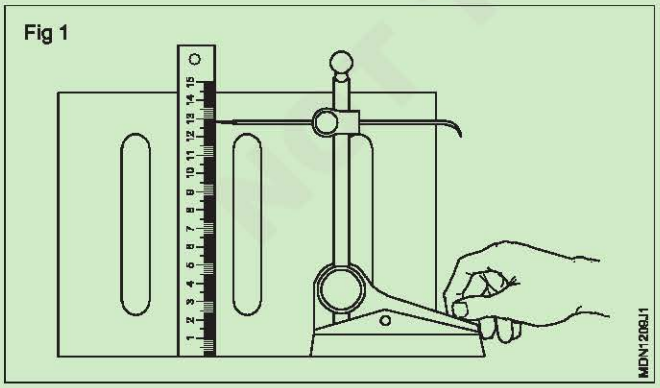
Clean the base of the surface gauge.

Keep the surface firmly on the surface plate.

Rest the steel rule against the angle plate and set the scriber to the size to be marked. (Fig 1)

Make sure that the job has no burrs and has been properly cleaned.

Fig 1

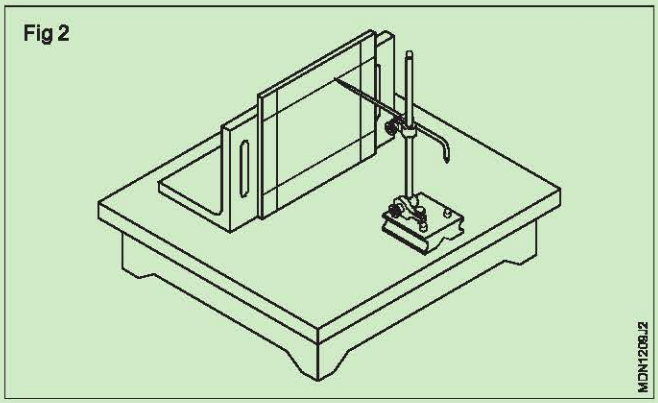


Apply a thin and even coating of the marking media.

Butt the job against the angle plate.

Hold the job in one hand and move the scriber point touching the surface across the work and mark. (Fig 2)

Fig 2



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Marking lines parallel to the edge of the job

Objective: At the end of the exercise you shall be able to;
- **mark parallel lines using a jenny caliper.**

Apply marking medium on the surface to be marked.

Set the jenny caliper to the size to be marked (i.e. dimension) with the help of a steel rule. (Fig 1)

Transfer the set dimension to the job. (Fig 2)

Incline slightly and move the jenny caliper with uniform speed and mark lines.

Make witness marks on the lines marked using a 60° prick punch. The witness marks should not be too close to one another.

Note to the instructor : Provide old exercise and models as much as possible to the trainees for acquiring measuring skills with simple measuring instruments.

Fig 1

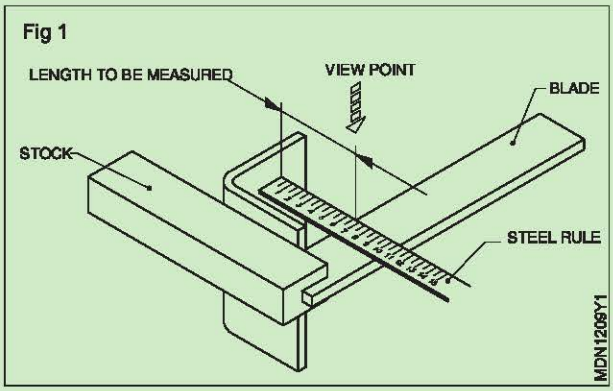


Fig 2

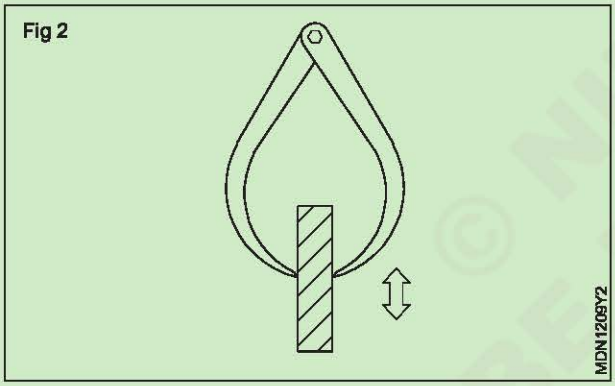


Fig 3

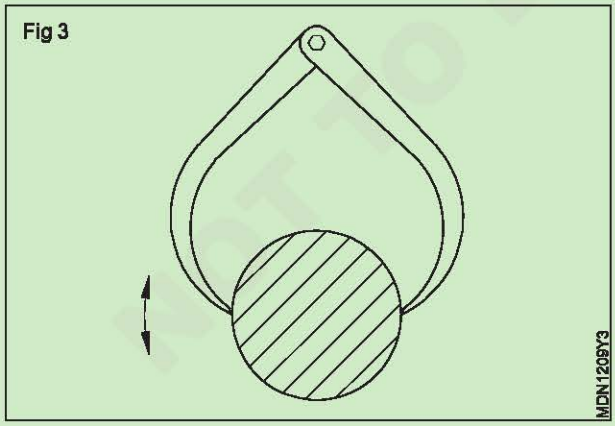


Fig 4

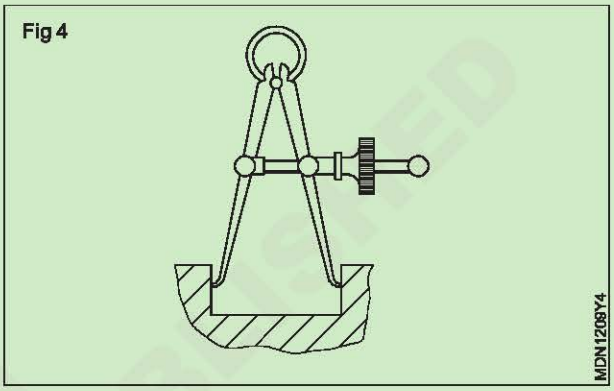


Fig 5

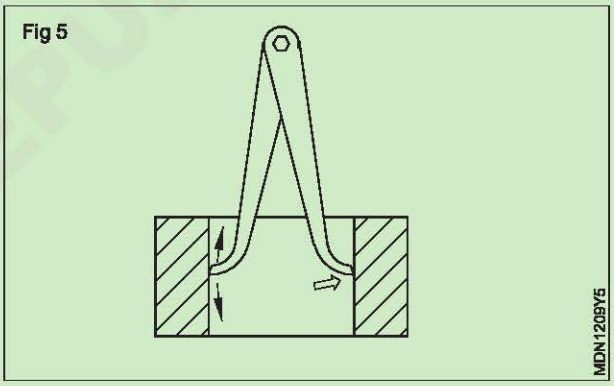
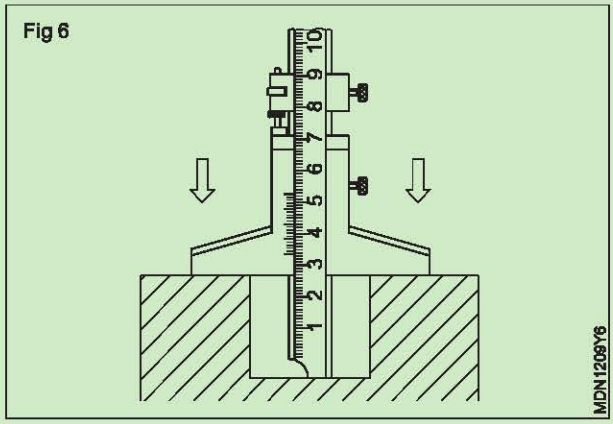


Fig 6



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Measure wheelbase of a vehicle

Objective: At the end of this exercise you shall be able to
- **measure the wheelbase of a vehicle.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.
- Measuring tape and plumb bob - 1 No each.

Equipments

- Vehicle - 1 No.

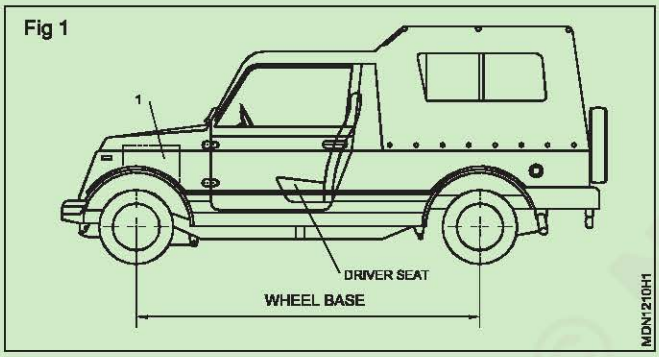
Materials

- Cotton waste - as reqd.

PROCEDURE

1 Place the vehicle on a plain ground (Fig 1)

Fig 1



2 Make the wheels straight ahead

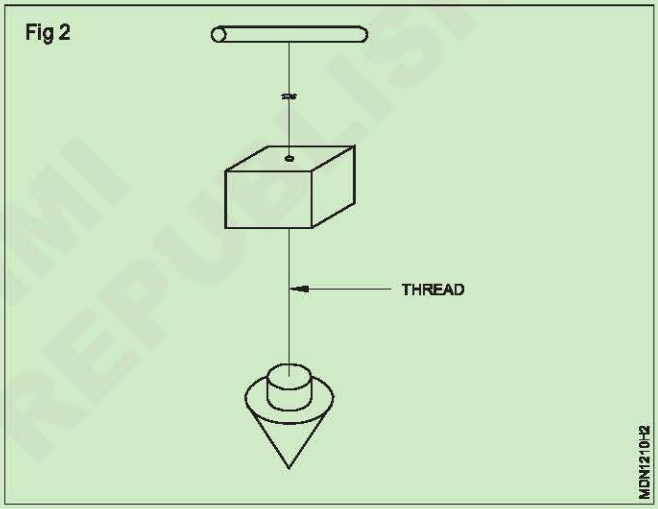
3 Apply the vehicle hand brake

4 Apply wheel chokes on front and rear wheels

5 Close all the doors

6 Use the plumb bob and mark the vehicle front wheel centre (from the side view of vehicle) on the ground. (Fig 2)

Fig 2



7 Similarly mark the vehicle rear wheel centre (from the same side view of the vehicle) on the ground

8 Measure the wheel base using measuring tape between the two markings

Skill sequence

Practice on use of tape and plumb bob

Objective: This shall help you to
- **measure wheel base front overhang and rear overhang.**

Select the correct measurement tape (Fig 4)

Select the proper length of measuring tape

Release the lock of the tape & pull it out for measurement

Front end of the tape should be coincide with the centre mark line on the ground

Keep the tape straight till the other end of the marked line

Note down the measurement line of the tape coincide with the marked line on the ground

Take the measurement & check with the manufacturer's specified wheel base data. (Fig 5)

Measure the distance between centre of front wheel so center of rear wheel, which wheels are in straight ahead position. This is wheel base. (Fig 3)

Measure the distance between center of from LH tyre to center of front RH tyre. This is wheel track. (Fig 3)

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Measure the distance between center of front wheel to the farthest point of the vehicle in front direction. This is front overhang. Measure the distance between center of rear wheel to the farthest point in the rear (normally rear bumper). This is rear overhang. (Fig 3)

Fig 4

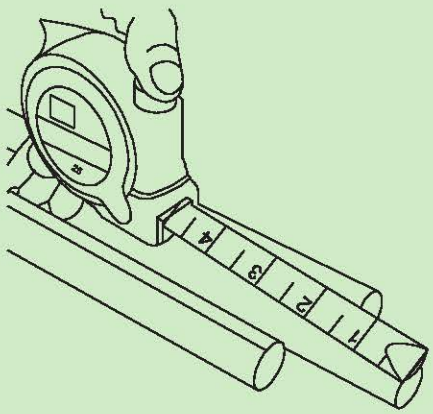


Fig 5

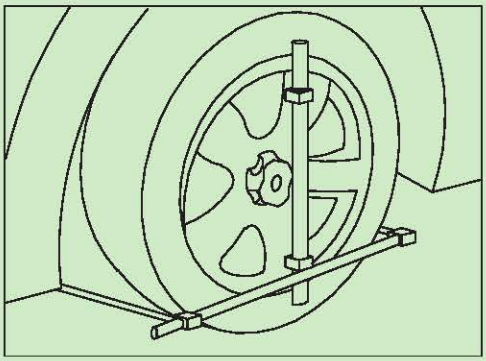
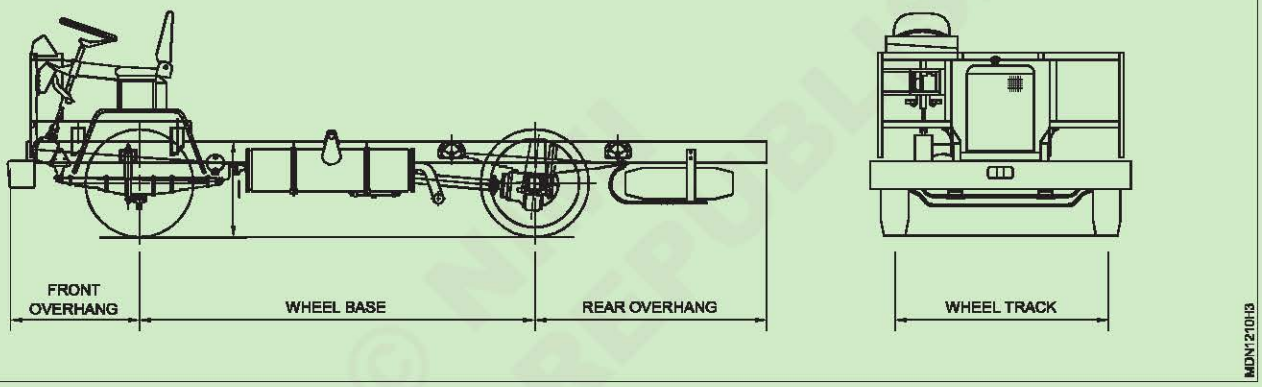


Fig 3



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Practice on removing wheel lug nuts

Objectives: At the end of this exercise you shall be able to
- **handle an air impact wrench**
- **loosen and tighten wheel nuts**
- **set the required torque.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.
- Air impact wrench - 1 set.

Equipments

- Vehicle - 1 No.
- Air Compressor unit - 1 No.

Materials

- Cotton waste - as reqd.
- Wheel nut - as reqd.

PROCEDURE

1 Park the vehicle on level ground.

2 Apply Hand Brake.

3 Close all the doors.

4 Put wheel chocks to all the wheels.

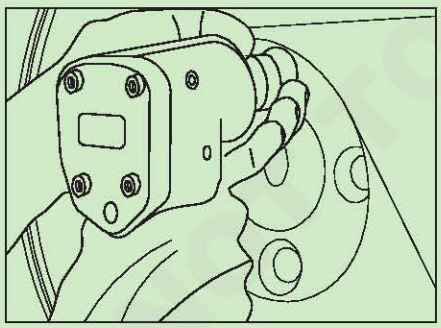
5 Remove the wheel cap.

6 Check the Air impact wrench is connected to the Air lines.

7 Select correct size of socket/special socket for wheel lug nut which can with-stand sudden impact force (six point Impact Socket).

8 Fit the socket on the Air-impact wrench. (Fig 1)

Fig 1



MDN1212H1

9 Set the direction of spin forward or backward with the help of wrench lever.

10 Set the torque by turning the valve to increase or decrease.

11 Insert impact socket on the wheel lug nut.

12 Trigger the switch of the impact wrench to loosen and remove the wheel lug nuts.

13 After removing all wheel nuts, place one or two nuts on the wheel bolt to avoid slipping of the wheel while jack up the vehicle for wheel removing.

Do not use an Impact wrench to tighten the wheel lug nuts

Wear ear protection device such as ear muffs and ear plugs

Wear safety glasses for eye protection

Apply a few drops of oil to inlet of the air impact wrench before using

Ensure there is no air-leakage on the line and adequate air pressure is available.

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Practice on handling workshop tools and power tools

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

- **identify screw driver for specific purpose and handle it**
- **identify spanner and wrenches for specific purpose and handle it**
- **identify pliers for specific purpose and handle it**
- **tightening locking devices**
- **make flare joints and fittings**
- **select the puller for removing gear and bearing from shaft.**

Scan the QR code to view the video for this exercise

Requirements

Tools / Instruments

• Trainee's tool kit	- 1 No.
• Screw driver	- 1 Set.
• Ring and D/E spanners	- 1 Set.
• Pliers	- 1 Set.

Equipments

• Pullers	- 1 No.
• Air compressor	- 1 No.
• Car washer	- 1 No.
• Jack mechanical and hydraulic	- 1 No.
• Hydraulic press	- 1 No.
• Flaring equipments	- 1 No.

Materials

• Kerosene	- as reqd.
• Cotton waste	- as reqd.
• Pipe	- as reqd.
• Steel wire	- as reqd.

PROCEDURE

TASK 1 : **Identify the screw driver for specific purpose**

Checking the condition of the fastener to be removed

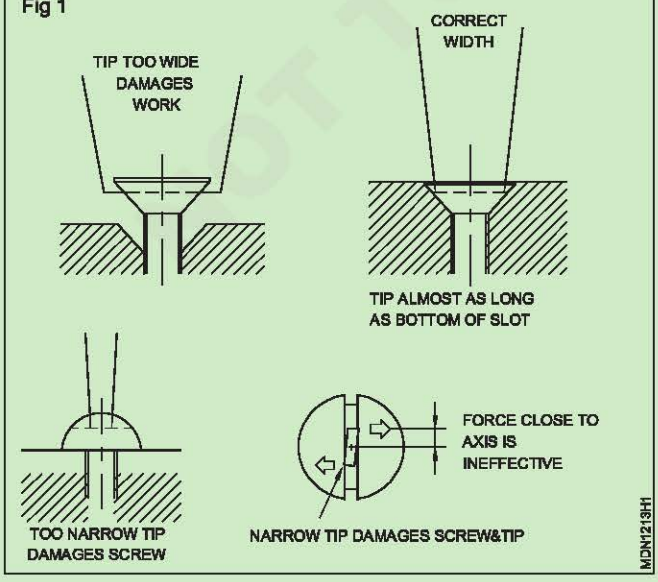
1 Clean the surface of the fastener to be removed by using kerosene, of banian cloth.

2 Check the cornering faces of the fastener for any wear or damage.

3 If it is found good, then proceed as follows

4 Select the correct size screwdriver to suit the screw slot. (Fig 1)

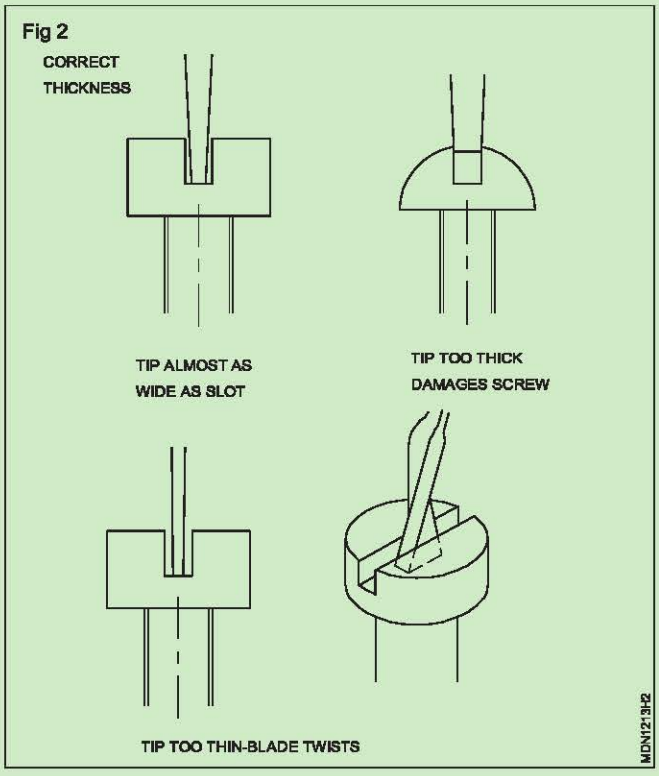
Fig 1



5 Select the longest suitable screwdriver with that size of tip. (Fig 2)

Make sure your hands and the handle are dry and not greasy.

Fig 2

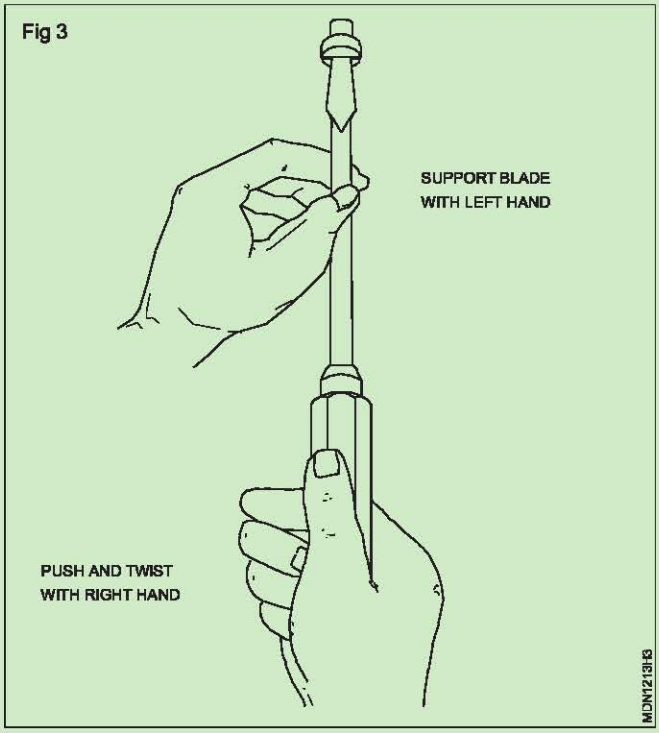


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6 Hold the screwdriver with its axis in line with the axis of the screw.

7 Guide the blade with the left hand. Apply a little pressure with the right hand to keep the tip in the slot. (Fig 3)

Fig 3



8 Twist firmly and steadily.

Keep the tip centered in the slot and the axis of the blade in line with the axis of the screw.

Always brace small works against the bench or other firm support before using a screw driver.

Never hold a small work in your hand while using a screw driver.

9 Turn large screws, use a screwdriver with a square blade. Apply extra twisting force with the aid of a close fitting spanner. (Fig. 4)

Never use pliers or toothed wrenches to apply twisting force to a screwdriver.

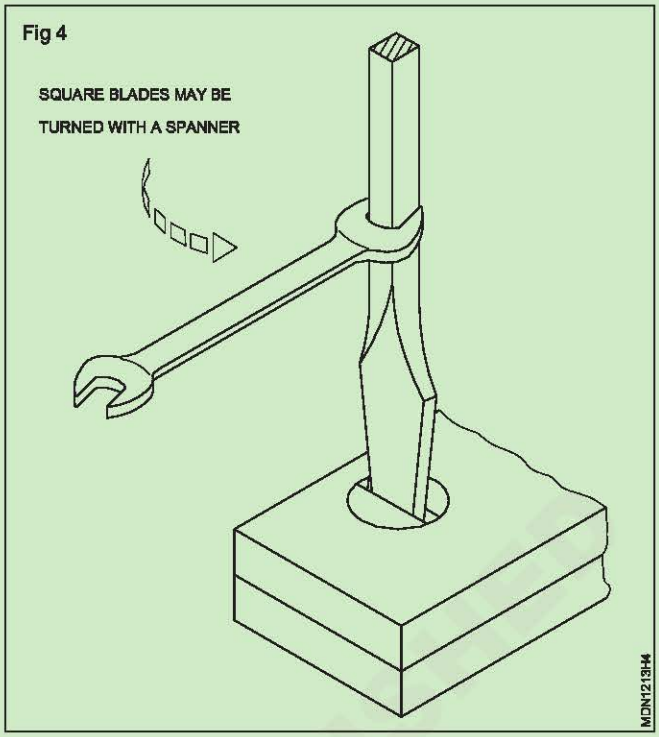
10 A Standard screwdriver blade should be ground to 9° so that the faces will be almost parallel with the sides of the screw slot. The end of the blade should be made as thick as the slot in the screw will permit.

Do not grind the blade to a chisel point, as it has a tendency to slip out of the screw slot.

11 Grind the width on both sides to an angle of 11°. The width should be equal to the diameter of the head.

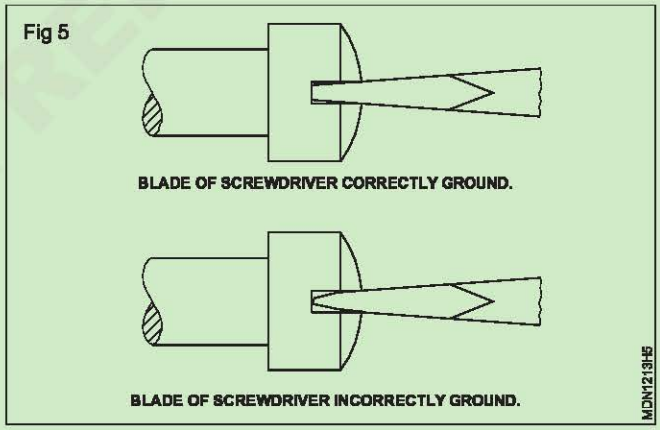
Never grind screwdrivers on a silicon carbide grinding wheel.

Fig 4



Standard screwdrivers (Fig 5) can be dressed by filing if they are worn out. Begin filing on the end of the tip. After dressing, the tip must be symmetrical about the axis of the blade. All corners must be square. The end must be at right angles to the axis in both planes.

Fig 5

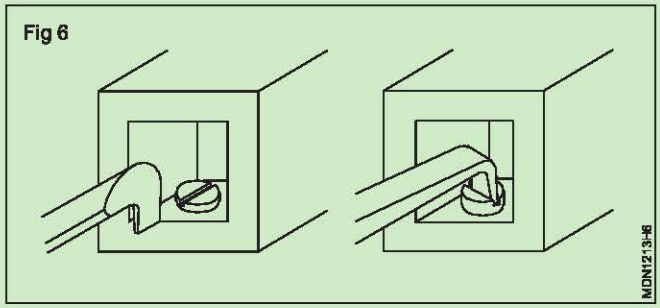


12 Use offset screw driver (Fig 6) in a restricted place.

13 Reverse the screwdriver after one end to get on quarter turn on .

14 Use the other end to get the next quarter turn and so on.

Fig 6

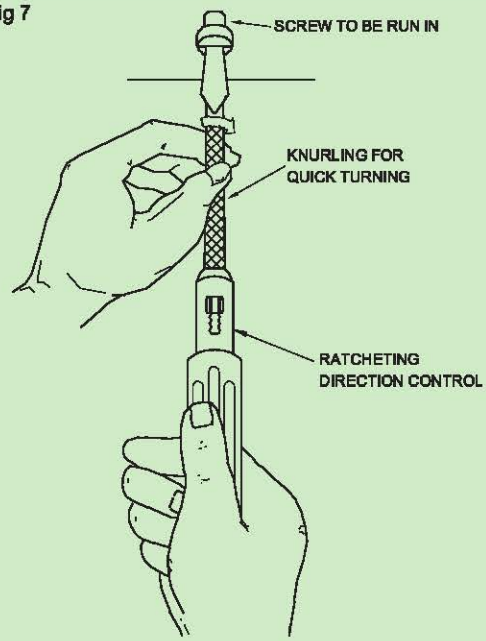


Keep pressing the tip into the slot as you turn.

15 Use ratchet screwdriver (Fig 7) for quick turning.

16 Keep the left hand on knurling, right hand on the ratchet head.

Fig 7



RATCHET SCREWDRIVER

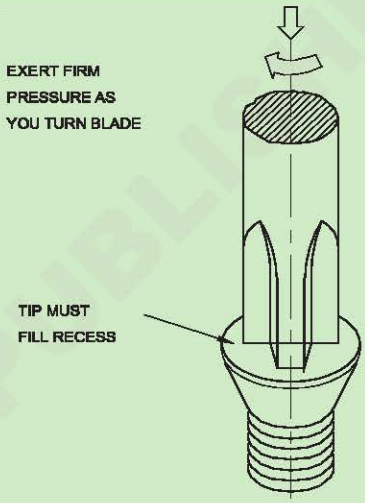
Change the direction of control depending on your movement.

Phillips (cross-recess) screwdrivers (Figs 8 &9)

Fig 8



Fig 9



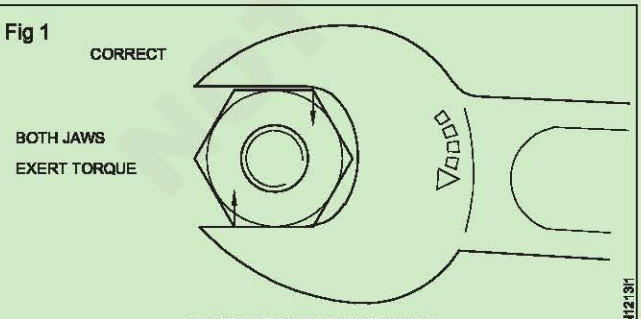
AXES OF SCREW AND THE SCREW DRIVER BE IN LINE

TASK 2 : **Identify spanner & wrenches for specific purpose**

Identifying the correct size of the tool

1 Determine the distance across the flats of a nut or bolt to be removed. (Fig 1)

Fig 1

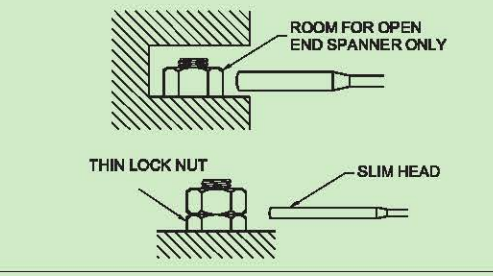


JAWS THRUST FULLY ON TO NUT

2 Decide the size of the spanner.

3 Choose the spanner that allows sufficient room without excess clearance for use. (Fig 2)

Fig 2



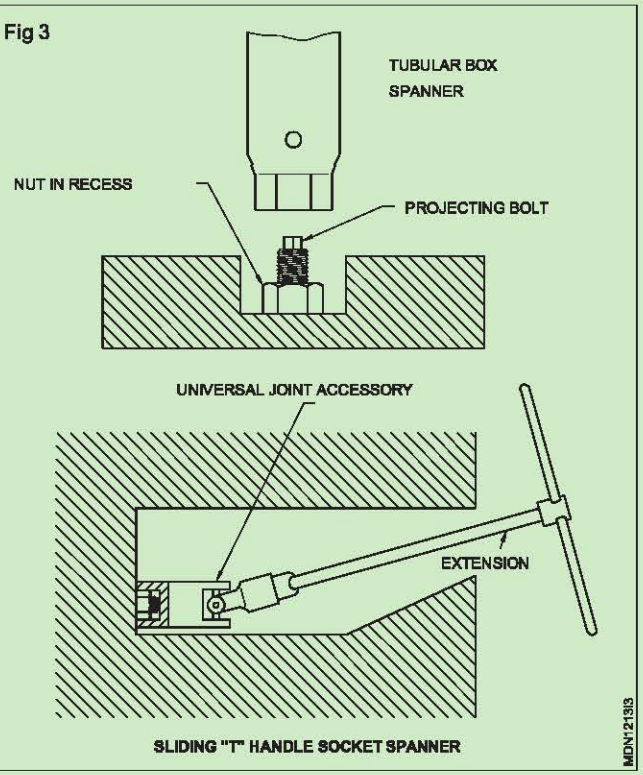
Handling the Tool excess clearance will cause slipping of spanner & fasteners corners gets damaged.

4 Select the correct size of the socket. (Fig 3)

5 Take a sliding offset handle and insert the drive attachment with square driving ends of a socket.

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Fig 3



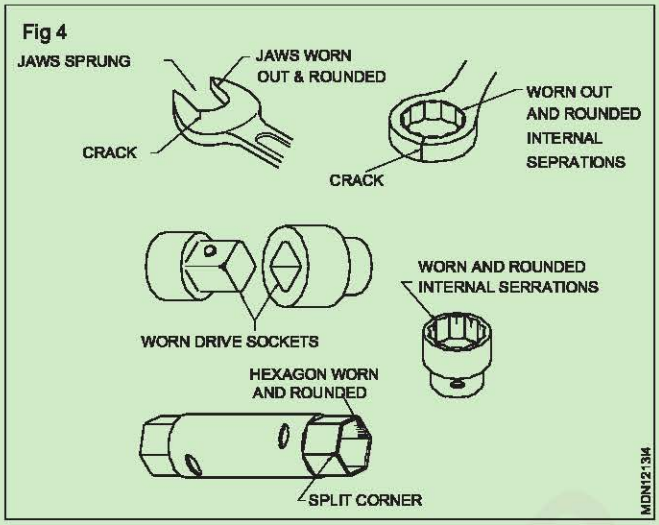
6 Insert the socket wrench on the bolt or nut and confirm whether it inserts fully.

7 Keep the position of the handle perpendicular to your forearm which enables you maximum leverage.

8 Pull the socket handle and drive out the nut/bolt head.

If the socket wrench is not usable for that particular fastener, then use ring spanner. (Fig 4)

Fig 4



9 Insert the ring spanner on the bolt or nut.

10 Keep the position of the shank perpendicular to your forearms which enables you maximum leverage.

11 Use D.E. Spanner where ring spanner is not suitable.

Always try to pull the spanner.

If you are forced to push the spanner, use the base of your hand and keep your hand open.

Use both hands for large spanner.

Keep yourself balanced and firm to avoid slipping.

TASK 3 : **Handling of Plier**

1 Select a component with lock wire to nut, which is to be removed.

2 Use the combination plier flat grip for untwist the lock wire.

3 After untwisting, pull the lock wire from the nut.

4 Remove the nut with proper spanner.

5 Select a brake pipe line to be removed from a junction.

6 Hold the brake pipe line with serrated pipe grip portion at combination pliers. (Fig 1)

7 Select proper size of proper double open end spanner & remove the union nut.

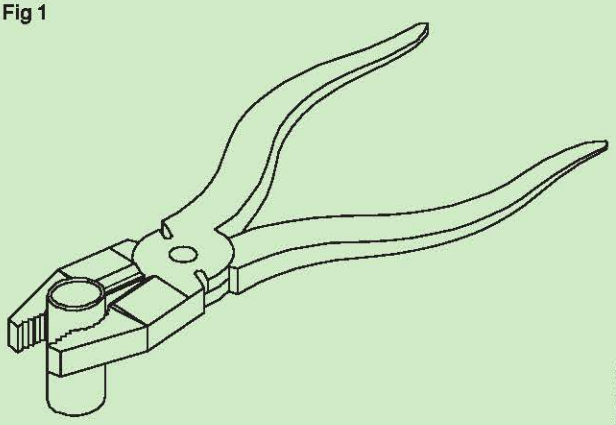
8 Select a 3 mm electrical wire to be cut.

9 Place the wire between joint cutters at the point which is to be cut. (Fig 2)

10 Press the handle to cut the wires.

11 Select a steel wire to be cut. (Fig 3)

Fig 1



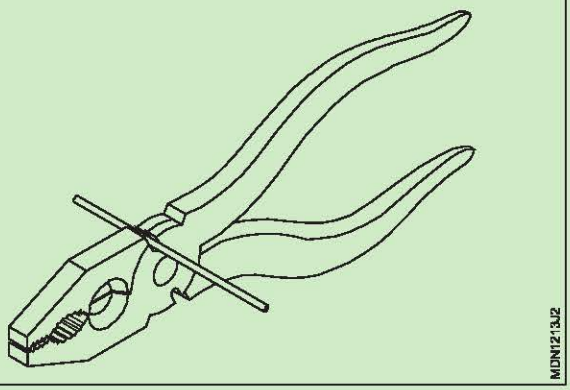
12 Place the steel wire in between side cutter.

13 Press the handle to cut the wire.

14 Select a nut with tab washer to be removed.

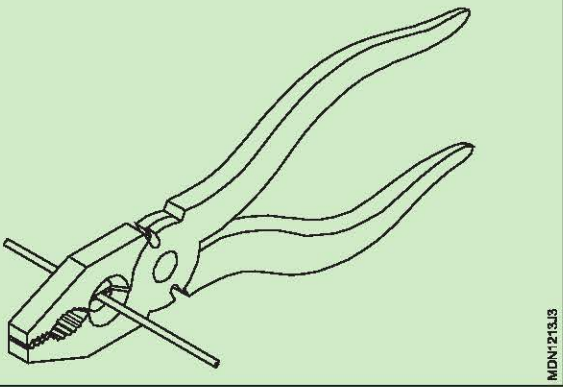
15 Unfold the tab washer with help of flat nose pliers. (Fig 4)

Fig 2



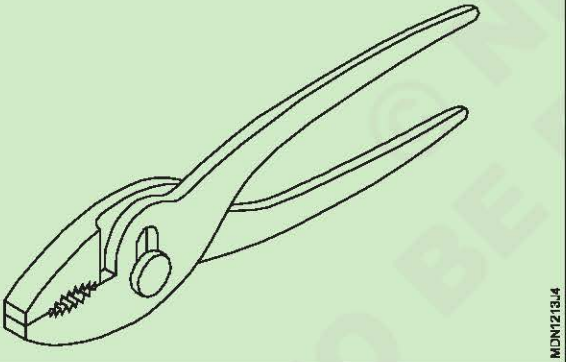
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Fig 3



MDN1213J3

Fig 4



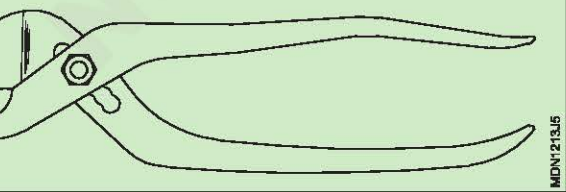
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16 Use a proper spanner to remove the nut.

17 Select a cylindrical component with nut.

18 Hold the cylindrical shaft with help of slip joint pliers jaws. (Fig 5)

Fig 5



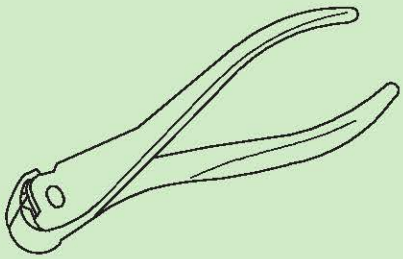
MDN1213J5

19 Remove the nut with proper spanner.

20 Select a wire to be trimmed.

21 Place the end of the wire to be trimmed by end cutting plier in between the cutting end. (Fig 6)

Fig 6



MDN1213J6

22 Apply pressure on handles to cut the wire.

23 Select the steel wire to be cut close to the component surface.

24 Cut the steel wire by slip joint multi gripplier applying pressure on the handles.

25 Use the cutting pliers to spread the cotter pin.

26 Select a stead with lock nut, from which lock nut has to be removed.

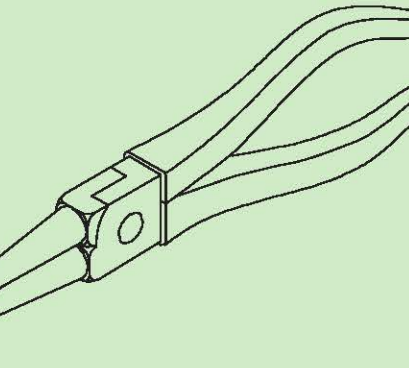
27 Hold the stead by locking pliers adjusting the screw in the handle lock with lever.

28 Use a proper spanner to remove the locking nut.

29 Select a wire which has to be converted into loop.

30 Hold the wire between the jaws. (Fig 7)

Fig 7



MDN1213J7

21 Form a loop by tuning the round nose pliers.

Skill Sequence

Tightening locking devices

Objective: This shall help you to
- **use different types of locking devices correctly.**

Split pin (Fig 1)

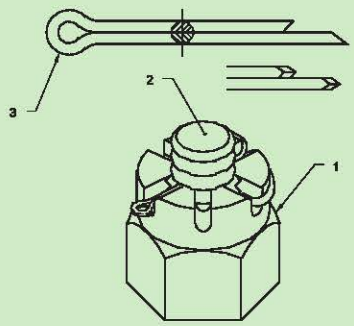
Tighten the nut (1) at the specified torque.

Check the bolt's (2) holes and nut's (1) slot alignment, if not aligned, align the hole by tightening the nut (1) slightly.

Insert a new suitable split pin (3) in the slot and hole. So that the loop on vertical plane.

Drive the split pin (3) fully inside with the help of a copper drift or rod and hammer.

Fig 1



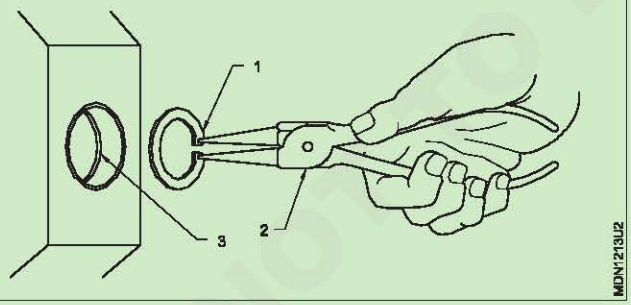
Spread open the long side of the split pin and bend it on the nut.

Inside circlip or snap ring (Fig 2)

Hold an internal circlip on hole face (1) with the help of an internal circlip plier (2).

Press the circlip (1) with the help of the plier (2) so that its diameter will be smaller than the hole diameter.

Fig 2



In this position insert the circlip in such a manner that it will sit squarely in the groove (3).

Take out the plier (2) after checking rotation of clip.

Outside circlip or snapping (Fig 3)

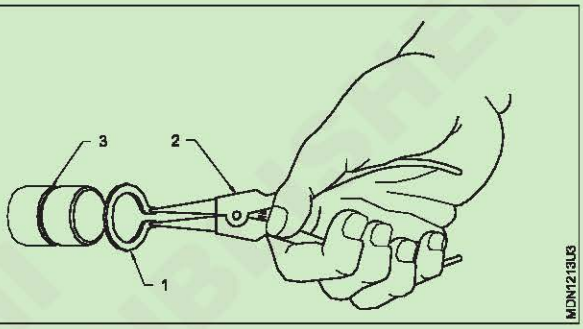
Hold an outside circlip shaft end (1) with the help of an external circlip plier (2).

Press the external circlip plier (2) so that the circlip (1) will enlarge in diameter.

While sliding, set it in the shaft groove (3). Ensure that the circlip sits squarely in groove (3) and rotate freely.

Take out the plier (2).

Fig 3



Wire ring hose clamp (Fig 4)

Clean the outside surface where the hose-pipe is to be set.

Apply grease inside the starting end surface for easy insertion.

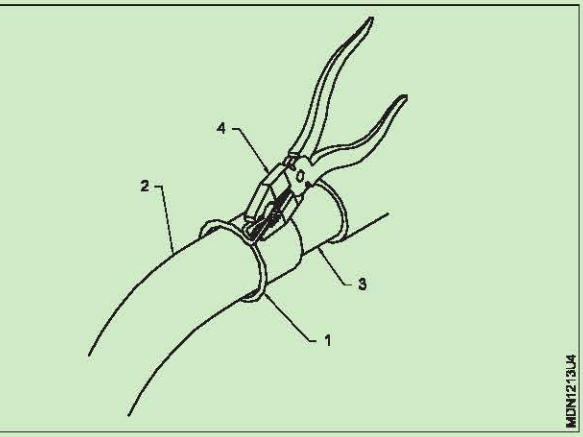
Set the wire spring hose clamp (1) on the hose-pipe (2).

Slide the hose-pipe (2) on the metal pipe (3).

Press the hose clamp (1) with the help of a plier (4) and slide it on the joint of the hose-pipe (2) and metal pipe (3).

Take out the plier (4)

Fig 4



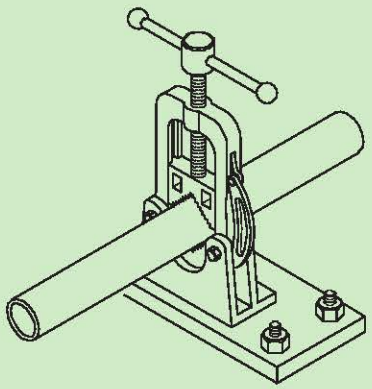
Handling of pipe flaring and cutting tools

Objective: This shall help you to
- **cut a G.I pipe using a pipe cutter.**

Measure the required length of pipe and mark it with chalk.

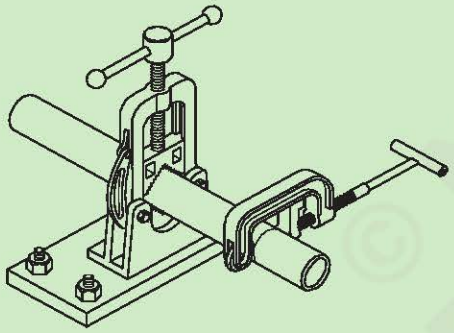
Keep the pipe in the pipe vice and tighten it. (Fig 1)

Fig 1



Fit the pipe cutter on the G.I. pipe (on the scribed line) and tighten the jacking screw so that the cutting wheel is touching the pipe. (Fig 2)

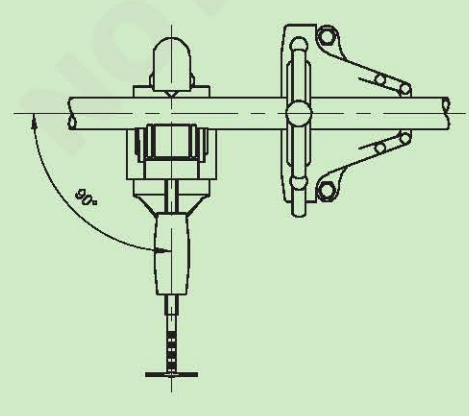
Fig 2



Ensure that the pipe is kept horizontal and parallel to the serrations such that the marking is visible at the top.

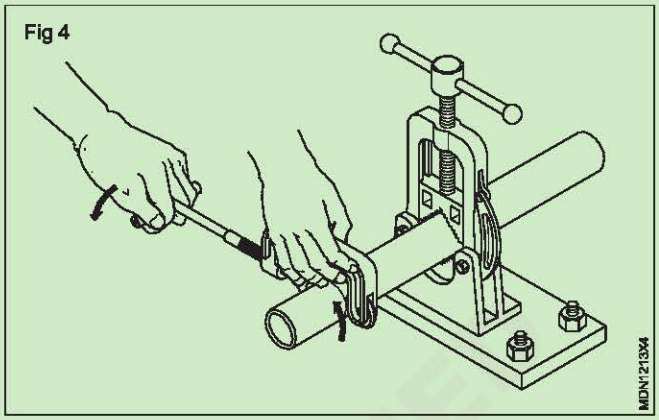
Rotate one or two turns to ensure that the cutting wheel is sitting exactly on the scribed line at 90° to the pipe. (Fig 3)

Fig 3



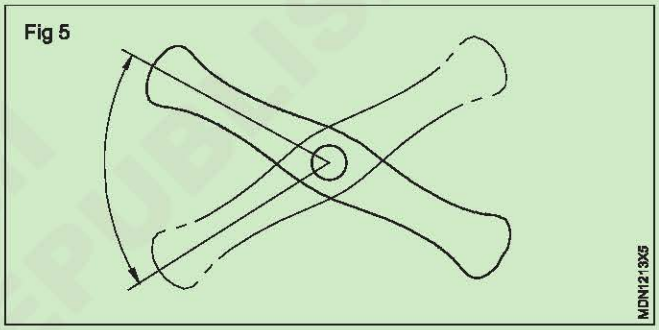
Rotate the pipe cutter around the pipe. (Fig 4)

Fig 4



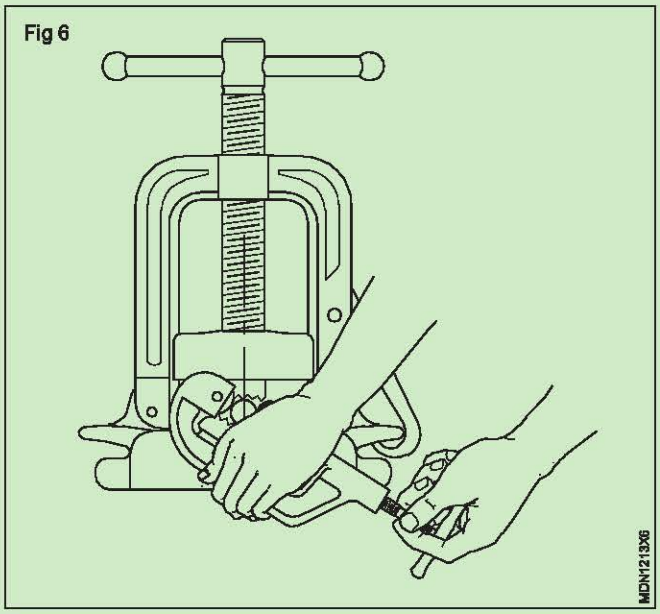
After two or three turns use the jacking screw to apply pressure on the cutting wheel. (Fig 5)

Fig 5



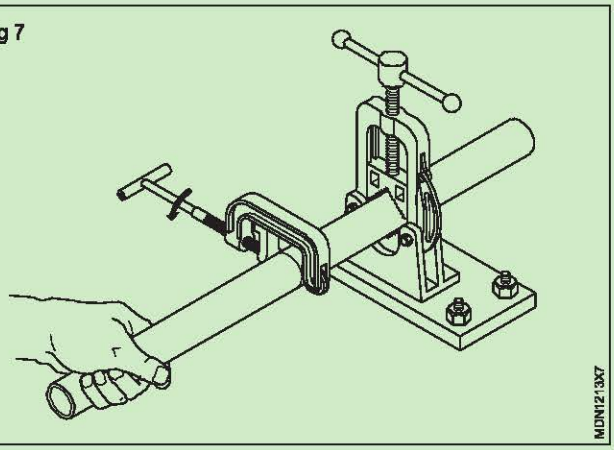
Keep rotating the pipe cutter around the pipe. Increase the pressure to the cutter by repeating the cycle until the pipe is cut through. (Fig 6)

Fig 6



Support the pipe with your left hand so that the free end of the pipe does not fall. (Fig 7)

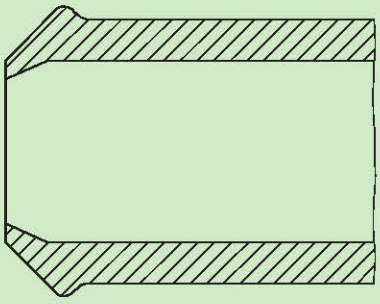
Fig 7



MDN1213X7

The cut portion of the pipe will appear as shown in Fig 8.

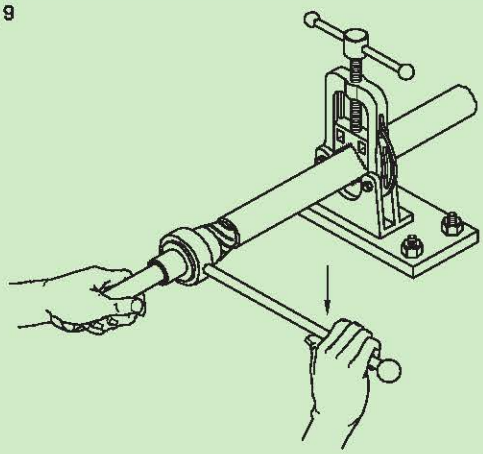
Fig 8



MDN121330B

Remove burrs using a pipe reamer. (Fig 9)

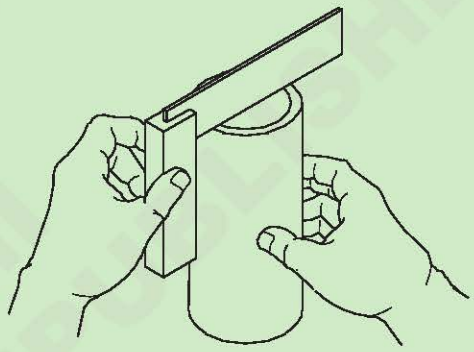
Fig 9



MDN121333G

Check that the pipe ends are square. (Fig 10)

Fig 10



MDN12133XA

Make flare joints and test them with flare fittings

Objectives: This shall help you to
- **flare the end of pipe**
- **joint flare nut with flare fitting and test it.**

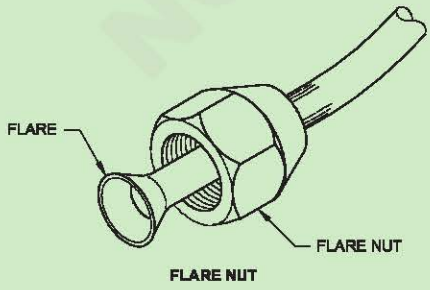
Flaring

Brake line pipes / Fuel pipe lines / Air conditioner pipe lines are sometimes jointed to fittings by making a flared connection.

The end of the pipe is opened out to form a cone (Fig 1).

Always place the special flare nut on the pipe first before flaring.

Fig 1



FLARE NUT

MDN1213Y1

Examine the pipe flaring tool. Make sure that you understand how it works before starting to flare the end of a pipe.

Make sure that the end of the pipe is free of rough edges before flaring

Place the pipe in the tool (Fig 2). Make sure that you have.

a Place the flare nut on the pipe

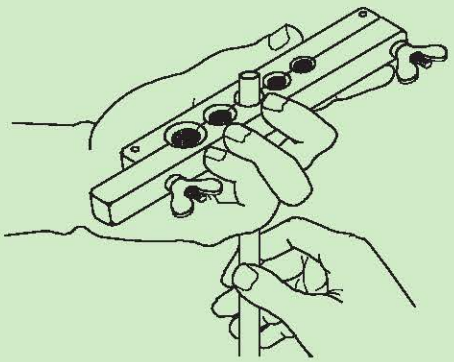
b Choose the correct size hole in the flaring tool to fit the pipe; (there are 5 holes to fit different sizes of pipe.)

If the pipe is 1/4 inch (6mm) in diameter, position the pipe so that the end is at least 2 mm above the top of the flaring block (Fig 3). (This distance is calculated as "pipe diameter divided by 3"; i this case, 6mm divided by 3= 2 mm).

Tighten the nuts at each end of the flaring block (see drawing).

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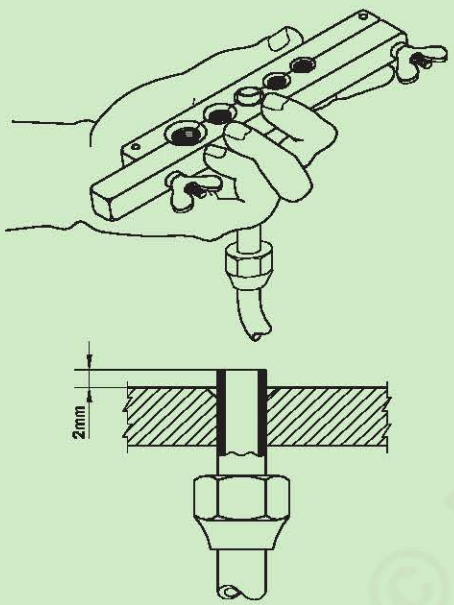
Fig 2



MDN1213Y2

Fit the yoke to the flaring block (Fig 3)

Fig 3

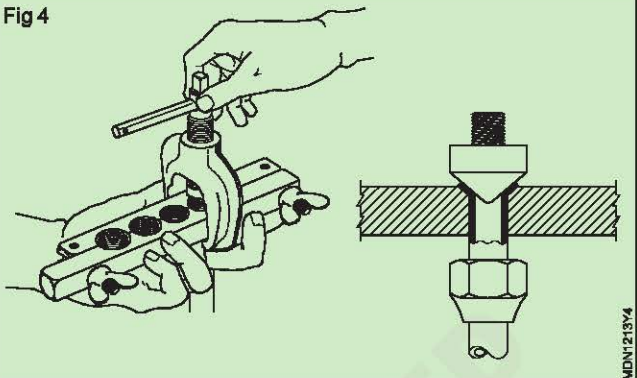


MDN1213Y3

Oil the cone and slowly screw it into the end of the pipe.

The end of the pipe will be formed into a flare (Fig 4).

Fig 4



MDN1213Y4

Unscrew & remove the flaring block remove the flared pipe from the block.

Examine the flare. If it has cracked, the cone was screwed down too quickly.

Make sure that the flare is the correct size. It should just fit inside the flare nut. If it is too loose, cut off the flare and start again

Use 3 mm instead of 2 mm. Repeat until the flare is the correct size for the flare nut - not too loose and not too tight.

Observation Table 1

Sl. No.	Skills	Remarks
1	Checking flaring	Cracked/uneven/too small/too long/incorrect
2	Number of attempts	One/two/three
Note : Repeat the steps to the sizes of copper tube		

Joining with flare fittings

Put thread seal tape on the thread

Push back the flare nut and place the flared tube on the fitting, then tighten the flare nut using adjustable wrench or suitable double end spanner.

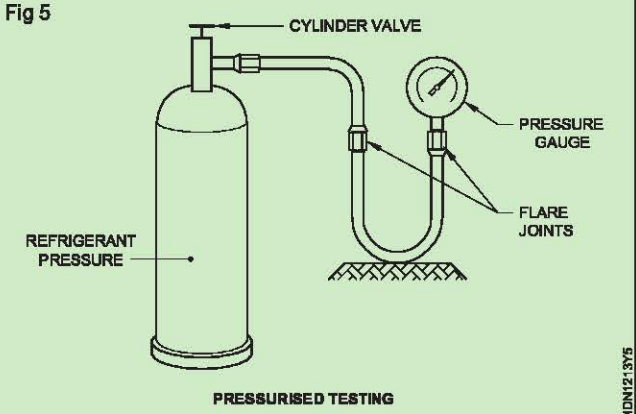
Tighten the one end of the tube to the cylinder with the flare nut. (Fig 5)

Connect a pressure gauge at the other end of the tube with flare nut.

Do not give more pressure while tightening since this will spoil flare.

Make sure that they should not be loose in the tube.

Fig 5



MDN1213Y5

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Observation Table 2

Sl. No.	Skills	Remarks
1	Selection of correct fittings	Correct/not correct
2	Joining method	Excellent/good/fair
3	Time taken	Less/very less/more

The pressure will be shown in the pressure gauge.

Then close the cylinder valve. Major leaks will make noise and that nut needs to be tightened.

If there is no leak, the pressure in the pressure gauge will remain constant.

If it decreases, check the joints with soap solution foam. Leak will bubble, then tight the joints. If it stands still then there is no leak.

Observation Table 3

Sl. No.	Skills	Remarks
1	Selection of tools	Excellent/Good/Average
2	Detecting leak and arresting	Excellent/Good/Average

Handling of puller, gear and bearing

Objectives: This shall help you to

- **select, install to use a puller for removing gear from shaft**
- **select install to use of puller for removing bearing from shaft.**

Identify the object to be removed, i.e. Gear / Bearing.

Determine the size of the Gear / Bearing to be removed.

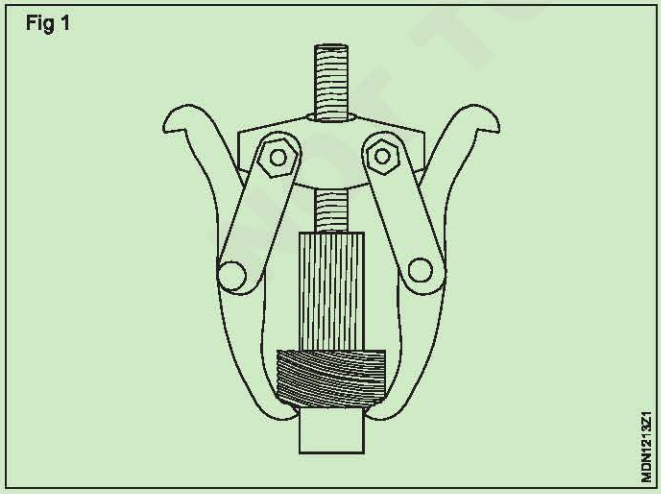
Choose a puller according to Gear / Bearing i.e, 2 or 3 Jaw & External or Internal Jaw puller.

Unscrew the forcing screw of the puller to the optimum length.

Split open the jaw of the puller.

Position the jaws of the puller over gear as shown in the diagram. (Fig 1)

Fig 1



Position the tip of forcing screw on the shaft, as shown in the diagram. (Fig 2)

Tighten the forcing screw till the forcing screw end touches the shaft.

Check the puller is not going to slip of from the center of shaft & readjust if necessary.

Tighten the forcing screw till the gear comes all of the shaft.

Warnings

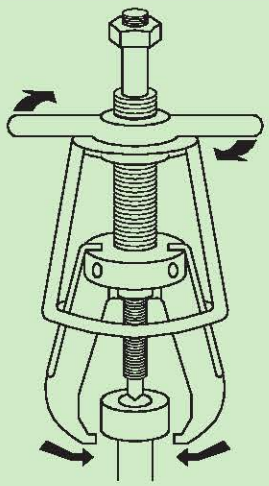
Always wear proper personal protective gear (i.e gloves, safety glasses)

Never use a tool to strike the puller. Hitting the puller may cause if to break.

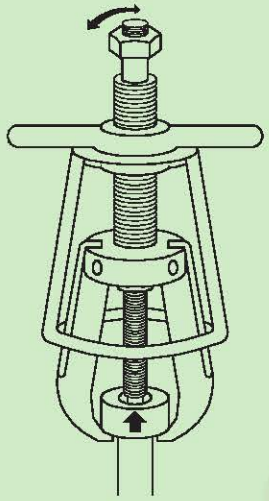
Applying heat to the puller may damage it.

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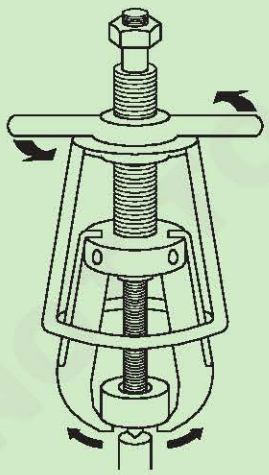
Fig 2



(A)



(B)



(C)

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Practice on measuring outside diameters

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

- **measure cam height using outside micrometer**
- **measure camshaft journal diameter using outside micrometer**
- **measure crankshaft journal diameter using outside micrometer**
- **measure valve stem diameter using outside micrometer**
- **measure piston pin and piston skirt diameter using outside micrometer.**

Scan the QR code to view the video for this exercise

Requirements

Tools/Instruments

- Outside micrometer (0 - 25mm) - 1 No.

Equipments

- Work bench - 1 No.
- V blocks - 1 Pair

Materials

- Camshaft - 1 No.
- Crankshaft - 1 No.
- Valve - 1 Set.
- Piston - 1 Set.
- Piston pin - 1 Set.
- Cotton waste - as reqd
- Kerosene - as reqd

PROCEDURE

TASK 1 : **Check the cam height**

1 Check the camshaft visually for cracks.

2 Clean the camshaft using a small brush with recommended cleaning solvent.

3 Clear sludge and gum deposit.

4 Blow out the passages with compressed air. With the help of micrometer, measure the reading.

5 Before taking the measurement, ensure that micrometer is adjusted for zero setting.

6 Record the main scale reading and thimble reading.

7 Check the cam shaft at 2 or 3 places on the table and arrive at the observed value.

Measuring on cam height, camshaft journal dia, crankshaft journal dia, valve stem dia, piston diameter, and piston pin dia with outside micrometers.

8 Using a micrometer, measure the cam lobe height and record the results in a table 1 below (Fig 1)

Fig 1

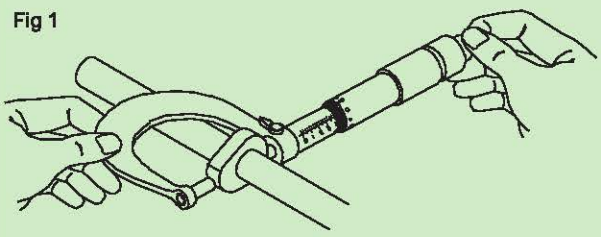


Table 1

Component Name	Main scale Reading	Coinciding Thimble scale (div)	Least count	Result
	(a)	(b)	(c)	R = a + (b x c)
Cam lob height			0.01	

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TASK 2 : **Check the cam shaft journal diameter**

1 Inspect the journal diameter of the camshaft and record the results in a table 2 below. (Fig 2)

Fig 2

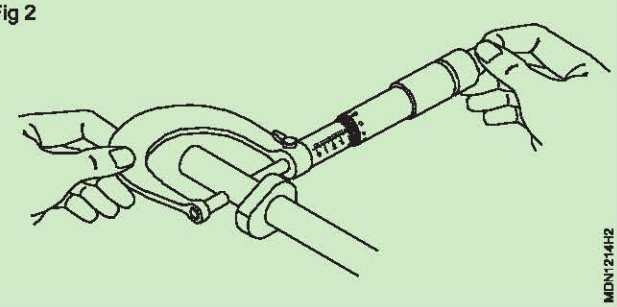


Table 2

Component Name	Main scale Reading	Coinciding Thimble scale (div)	Least count	Result
	(a)	(b)	(c)	R = a + (b x c)
Cam shaft journal diameter			0.01	

TASK 3 : **Check the crankshaft journal diameter**

1 Use a micrometer to measure crankshaft journal diameter at two places, 180° apart and at two points along its length. Record the result in a Table 3.

2 Put the bearing caps at their respective places with the same bolts.

3 Clean the crankshaft using a small brush with the recommended cleaning solvent.

4 Clear sludge and gum deposits from the drilled oil passages in the crankshaft by the wire brush.

5 Blow out the passages with compressed air

With the help of a micrometer, measure the journal diameter at '1' '2' '3' & '4'. The difference in reading between '1' & '3' and '2' & '4' will give the ovality. (Fig 1)

6 Measure the oil clearance between the crankshaft main journal and the bearing shell.

Fig 1

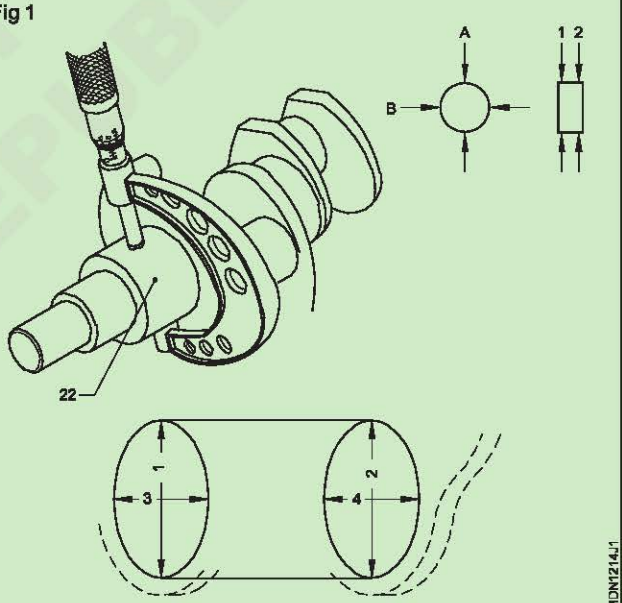


Table 3

Component Name	Main scale Reading	Coinciding Thimble scale (div)	Least count	Result
	(a)	(b)	(c)	R = a + (b x c)
Crank shaft journal Diameter			0.01	

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TASK 4 : **Check the diameter of the valve stem**

1 Use a micrometer to measure the diameter of the valve stem and record the results in a table 4 below. (Fig 1)

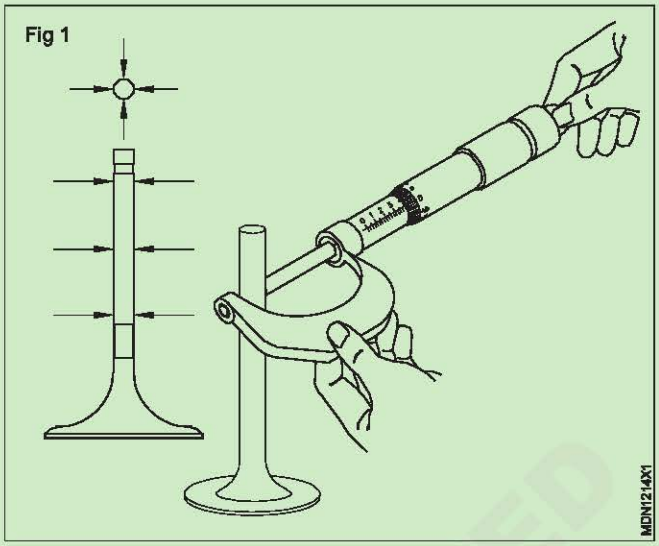


Table 4

Component Name	Main scale Reading	Coinciding Thimble scale (div)	Least count	Result
	(a)	(b)	(c)	R = a + (b x c)
Valve stem diameter			0.01	

— — — — — — —

TASK 5 : **Check the piston and piston pin (Fig 5 & Fig 6)**

1 Use a micrometer to measure the piston diameter at right angles to the piston pin center line, and at a position 52 mm (2.05 in.) from the top of the piston head and record the results in a table 5 below. (Fig 1)

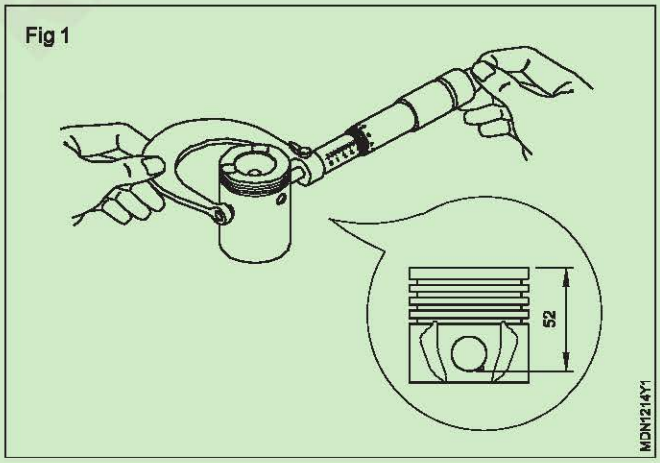


Table 5

Component Name	Main scale Reading	Coinciding Thimble scale (div)	Least count	Result
	(a)	(b)	(c)	R = a + (b x c)
Piston diameter			0.01	

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2 Use a micrometer to measure the external diameter of the piston pin and record the results. (Fig 2)

Fig 2

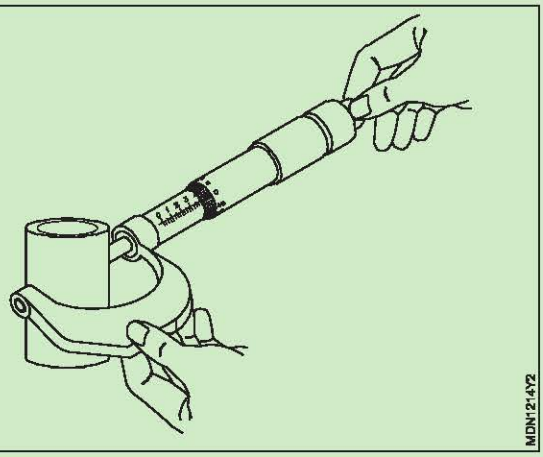


Table 6

Component Name	Main scale Reading	Coinciding Thimble scale (div)	Least count	Result
	(a)	(b)	(c)	R = a + (b x c)
Piston pin diameter			0.01	

— — — — — — —

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Practice on measuring cylinder bore

Objectives: At the end of this exercise you shall be able to
- **clean the cylinder bore**
- **measure the cylinder bore diameter, wear/ovality/taperness with a micrometer and bore dial gauge.**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.
- Bore diagauge - 1 No.

Equipments

- Engine block - 1 No.

Materials

- Banian cloth - as reqd.
- Cotton waste - as reqd.
- Paper - 1 No.
- Pencil - 1 No.

PROCEDURE.

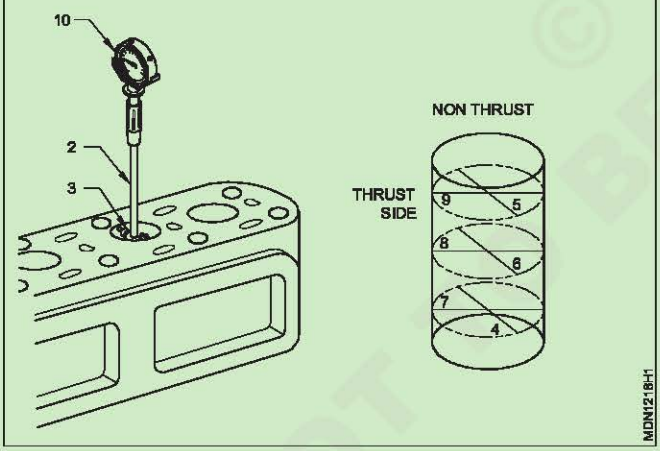
Checking taper ovality of cylinder bore (Fig 1)

Clean cylinder bore with a piece of cloth.

Measure inside diameter of the bore with an inside micro meter

Select the correct size of extension rod (1) which is more than measuring range.

Fig 1



Assemble the extension rod on the stem of the dial test indicator (2) and with the help of 75-100mm outside micrometer set "0".

Press the spring loaded plunger end (3).

Tilt the bore gauge and insert into the bore, check gauge parallel to measuring spindle note the needle returning point.

Take measurement at (5) with the bore gauge and note down the reading.

Take another reading at 6 & 4 note down the reading.

Repeat above at three places (9, 8 & 7).

The difference in measurement between (9) & (5), (8) & (6) and (7) & (4) is ovality. The difference in measurement between (9) and (8), (8) and (7), and (9) and (7) is taper.

Note down maximum ovality and taper. If any one of them is more than the specified limit, recommend for reboring/ replacement of liner.

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Practice on measuring run out and end play of crank shaft

Objectives: At the end of this exercise you shall be able to
- **check wear of crank shaft**
- **check end play of crank shaft**

Requirements

Tools / Instruments

- Trainee's tool kit - 1 No.
- Out side micrometer - 1 No.
- Feeler gauge - 1 No.
- Dial indicator - 1 No.
- Magnetic base - 1 No.

Equipments

- Diesel Engine - 1 No.
- Work bench - 1 No.

Materials

- Banian cloth - as reqd.
- Cotton waste - as reqd.
- Crank shaft - 1 No.
- Valve guide - 1 No.
- Fly wheel - 1 No.

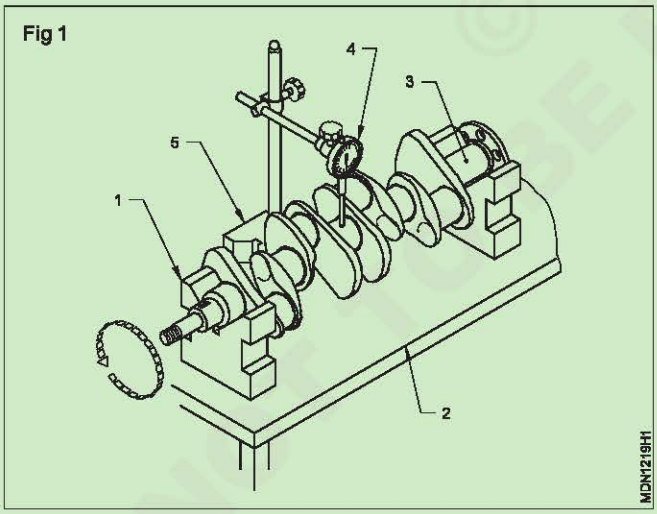
PROCEDURE

TASK 1 : **Check wear of crank shaft (Fig 1)**

Place two 'V' blocks (1) on the surface table (2).

Place the 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 over hang more than 1/ 10th of its total length

Fig 1



Place the dial indicator with the magnetic base (5) on the surface table.

Bring the dial indicator (4) at the centre of the shaft (3)

Push the dial indicator's (4) needle on the shaft so that the needle shows some deflection.

Adjust the indicator's needle to 'O' position by rotating the dial.

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.

Repeat the above steps at three places, so as to cover the complete length of the shaft (3).

Note down the maximum wear at all the places.

Replace the shaft, if the maximum bend at any one or more places is found more than the limit specified by the manufacturer.

TASK 2 : **Checking crankshaft end play (Fig 1)**

Fix the magnetic base (10) on the cylinder block (11) or on inspection table.

Set the dial gauge (12) on the crankshaft flange (13)

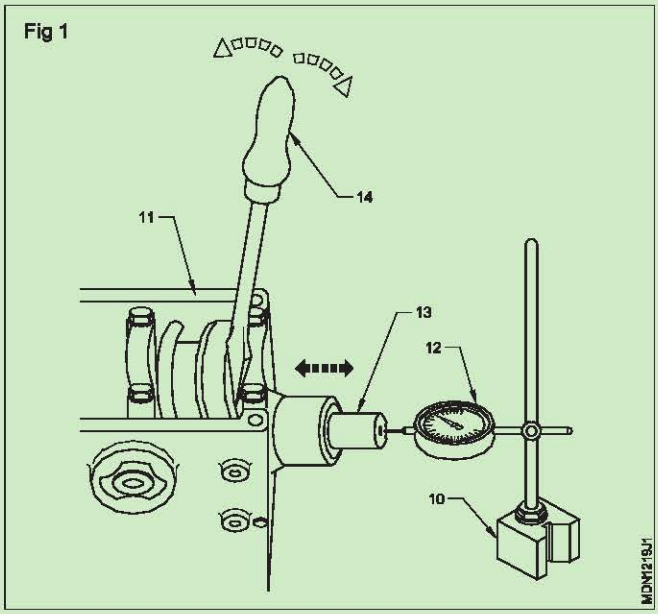
Set the dial gauge for 'O' (zero).

By using the lever (14) move the crankshaft forward and backward.

Note down the crankshaft end play and compare with the manufacturer's specifications.

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Fig 1



TASK 3 : **Check the wear of valve guides**

Place the dial indicator with a magnetic base on the face of the cylinder head (Fig 1).

Fig 1

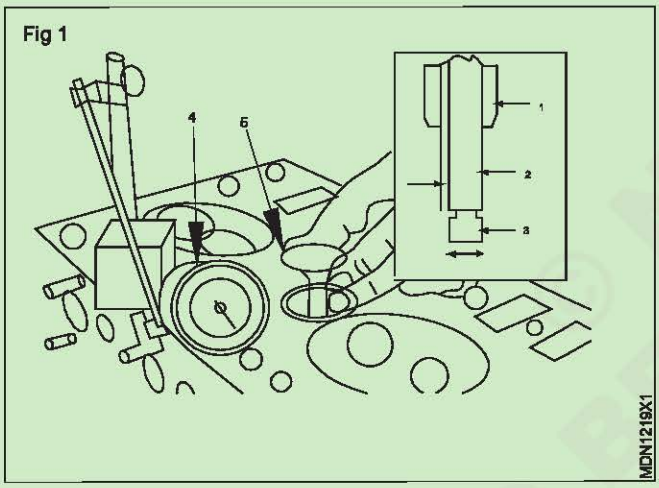
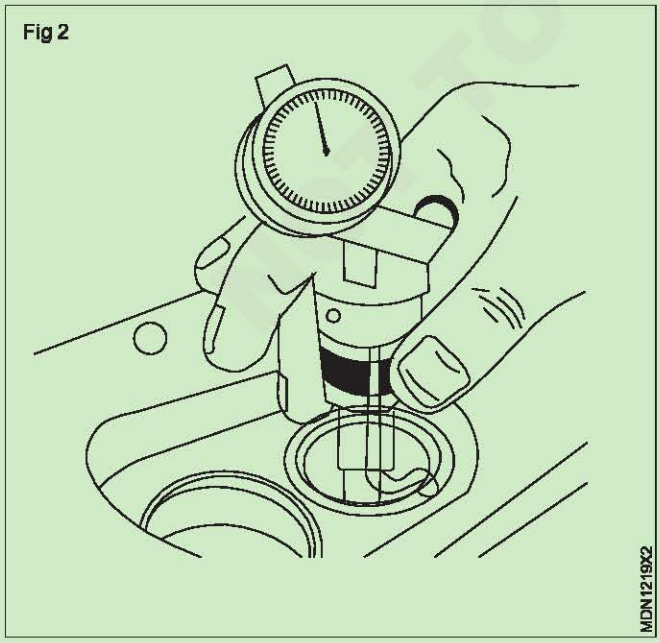


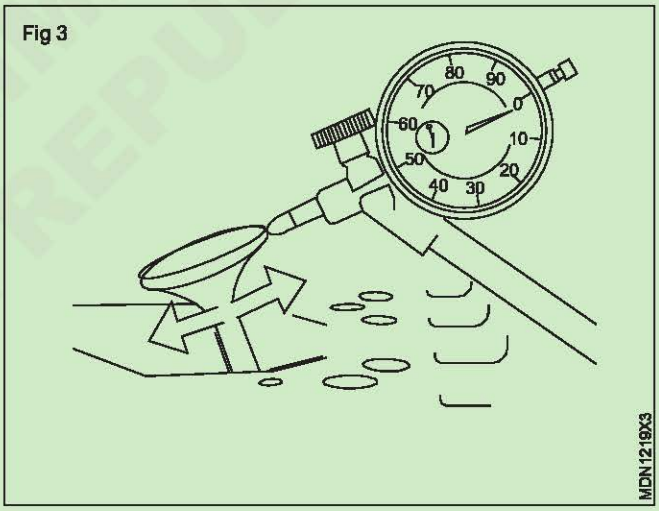
Fig 2



1 Set the position of the needle of the dial indicator to zero (Fig 2).

2 Move the valve in a radial direction away from the dial indicator as far as possible (Fig 3).

Fig 3



3 Position the contact point of the dial indicator on the edge of the valve head (Fig 3).

4 Move the valve in a radial direction towards the dial indicator as far as possible (Fig 3).

5 Note the distance of movement on the dial indicator.

If the distances is greater than the maximum clearance of the valve in the valve guide, replace the valve guide. This is called service wear.

Note : All lubricant must be removed from the outside of the inlet and exhaust valve guides before the valve seal is installed. Do not cut valve seat before the valve guide is installed.

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Practice on measuring cylinder head flatness

Objective: At the end of this exercise you shall be able to
- **check flatness of surface by straight edge and feeler gauge.**

Requirements

Tools/Instruments

• Trainee's tools kit	- 1 No.
• Straight edge	- 1 No.
• Long leaf feeler gauge	- 1 No.

Equipments

• Work table	- 1 No.

Materials

• Cylinder head	- 1 No.
• Banian cloth	- as reqd.
• Cotton waste	- as reqd.

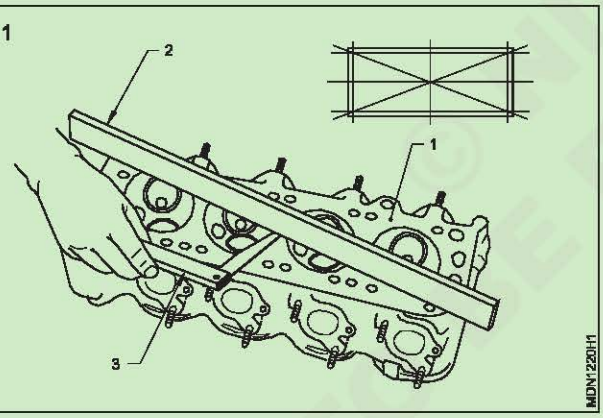
PROCEDURE

Check engine head flatness by feeler gauge

1 Clean the cylinder head surface to be checked. (Fig 1)

2 Place cylinder head (1) on a plain surface, so that surface, to be checked, faces upward.

Fig 1



3 Keep the straight edge (2) on surface and press the straight edge at the centre with your left hand.

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

5 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.

6 Repeat the above steps in 4 directions and note down the maximum face out in all the 4 directions.

7 Recommend for resurfacing/replacement of parts (1) if maximum face-out in any one or more directions is more than the limit specified by the manufacturer.

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Measuring piston ring end gap and piston to cylinder clearance

Objectives: At the end of this exercise you shall be able to
- **check the piston ring end gap**
- **check piston to cylinder wall clearance.**

Requirements

Tools/Instruments

- Trainee's tools kit - 1 No.
- Feeler gauge - 1 No.

Equipments

- Diesel engine - 1 No.
- Work table - 1 No.

Materials

- Piston - 1 No
- Piston rings - 1 No.
- Engine block with liner - 1 No.
- Banian cloth - 1 No.
- Cotton waste - 1 No.

PROCEDURE

Check end gap of piston ring and piston to cylinder wall clearance with the feeler gauge (Fig 1)

1 Clean the cylinder bore (1) thoroughly.

2 Insert the piston ring inside the cylinder bore squarely.

3 Use a bore piston to place the piston ring square in the liner/bore.

4 Insert feeler gauge and measure the piston ring end gap (4).

5 Remove the piston ring and clean the cylinder bore.

6 Insert the piston without piston ring inside the cylinder bore. (Fig 1)

7 Insert long leaf feeler gauge between piston and cylinder bore.

If it is tight, reduce the thickness of feeler gauge and verify with the bore piston.

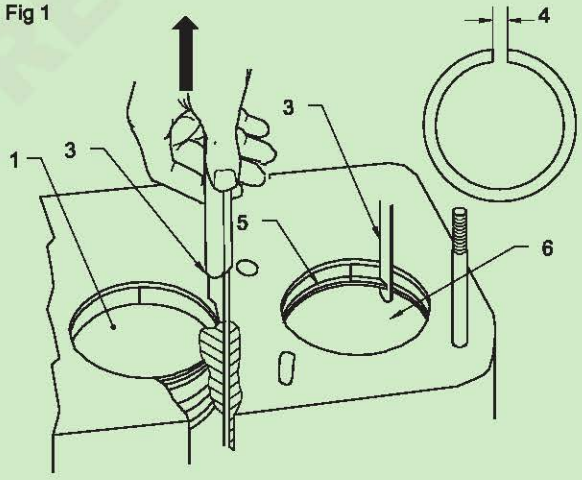
If the bore piston moves very free, increase the feeler gauge thickness.

8 Calculate the thickness of feeler gauge, which allows movement of piston with a slight pressure.

This thickness is the piston to cylinder wall clearance match the same with the company specification.

9 Remove the piston from the cylinder bore.

Fig 1



Perform engine vacuum test

Objective: At the end of this exercise you shall be able to
- **perform the engine vacuum test.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 Set.
- Vacuum gauge - 1 No.

Equipments

- Running Engine Petrol / Diesel - 1 Set.

Materials

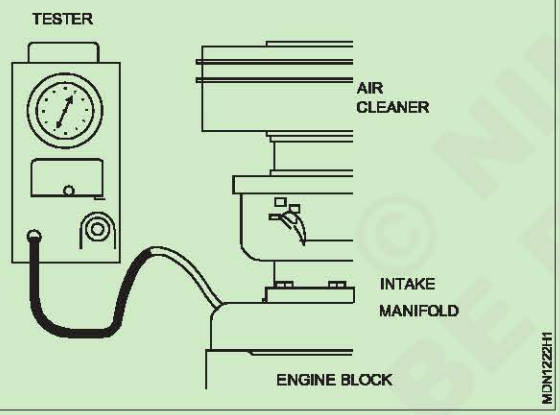
- Rubber hose - as reqd.
- Cotton waste - as reqd.
- Paper A4 sheet - 1 Sheet.
- Pencil/Pen - 1 No.

PROCEDURE

1 Warm up the given engine.

2 Connect the vacuum gauge to the intake manifold (disconnect vacuum booster if used) (Fig 1).

Fig 1



3 Read the vacuum gauge reading at idle speed, normal speed & high speed.

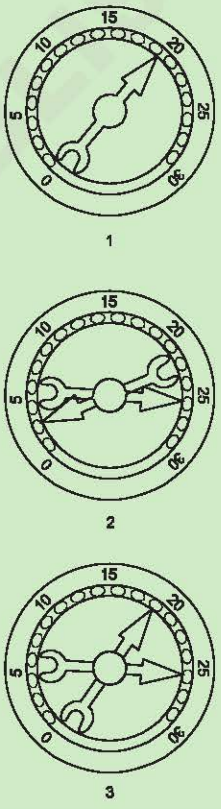
List the reading (measurement) one by one.

Adjust the gauge damper until needle moves easily without excessive flutter.

Normal reading: needle between 15 and 22 in holding steady. (Fig 2)

Intake leak: A low, steady reading can be caused by an air intake manifold or carburetor mounting flange gasket leak.

Fig 2



Blown head gasket: A regular drop of fair magnitude can be caused by a blown head gasket or warped head or the block surface.

Deduct 1 inch for each 1,000 feet of elevation.

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Check tyre air pressure

Objective: At the end of this exercise you shall be able to
- **check existing tyre pressure on a vehicle.**

Requirements

Tools/Instruments

• Trainee's tools kit	- 1 No.
• Tyre pressure gauge	- 1 No.
• Air pressure inflating unit	- 1 No.
• Air valve remover	- 1 No.

Equipments

• Running vehicle	- 1 No.

Materials

• Cotton waste	- as reqd.
• Air valve	- as reqd.
• Valve cap	- as reqd.

PROCEDURE

1 Remove valve cap / clean the valve externally.

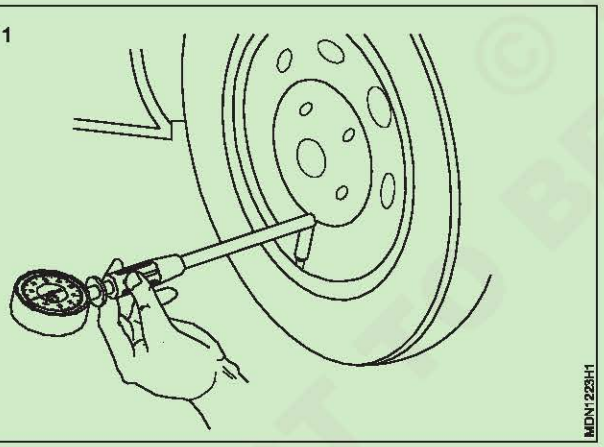
2 Insert tyre pressure gauge & take the reading. (Fig 1)

3 Compare with the recommended pressure.

4 Check if tyre needs inflation or deflation.

5 If it is to be inflated, insert the air inflator & watch the tyre pressure reading in the gauge.

Fig 1



Some equipments have the facility to preset the air pressure. Once the preset pressure is achieved, it automatically drips.

6 Check if the air valve is leaking.

7 If there is no leak, replace the cap.

Caution

1 **Never check tyre pressure, when tyre is hot after a long run.**

2 **Ensure there is sufficient air in Air tank and free from contamination like water, oil, dust etc.**

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Removing broken stud/bolt

Objective: At the end of this exercise you shall be able to
- **remove the broken stud below the surface using the ezy-out (stud extractor).**

Requirements

Tools/Instruments

- Trainee's tools kit - 1 No.
- Tap wrench - 1 Set.
- Stud extractor - 1 Set.

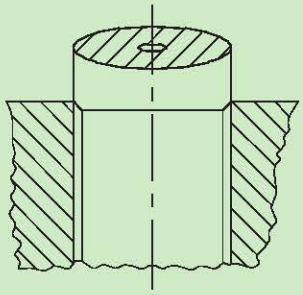
Materials

- Cylinder block with broken stud - 1 No.
- Cotton waste - as reqd.

PROCEDURE

1 File flat on the top surface of the stud. (Fig 1)

Fig 1

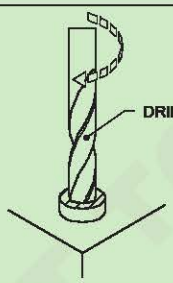


2 Locate the centre and centre punch it.

3 Select the ezy-out and the recommended drill size from Table 1.

4 Drill a hole on the centre punch mark. (Fig 2)

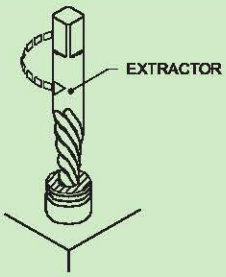
Fig 2



5 Check the hole is perpendicular.

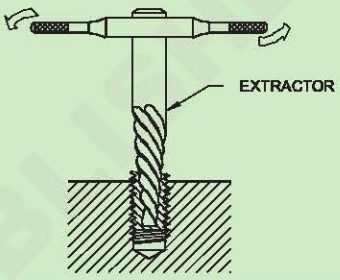
6 Set the ezy-out (stud extractor) on the drilled hole. (Fig 3)

Fig 3



7 Turn it anticlockwise by a tap wrench. (Fig 4)

Fig 4



As the ezy-out penetrates into the stud, the grip increases and gradually the broken stud portion unscrews.

8 Replace a new stud in position after lubricating the threads.

9 File two sides of the studs flat above the surface.

10 Use a wrench and unscrew to remove the broken stud out. (Fig 4)

Table 1

Recommended drill and Ezy-out size for the extraction of broken stud and bolt.

Suitable for screw size	Drill size to be used	Ezy-out No. to be used
1/8" to 1/4" (3 to 6 mm)	5/64" (2 mm)	1
Over 1/4" to 5/16" (6 to 8 mm)	7/64" (2.8 mm)	2
Over 5/16" to 7/16" (8 to 11 mm)	5/32" (4 mm)	3
Over 7/16" to 9/16" (11 to 14 mm)	1/4" (6.3 mm)	4
Over 9/16" to 3/4" (14 to 19 mm)	17/64" (6.7mm)	5

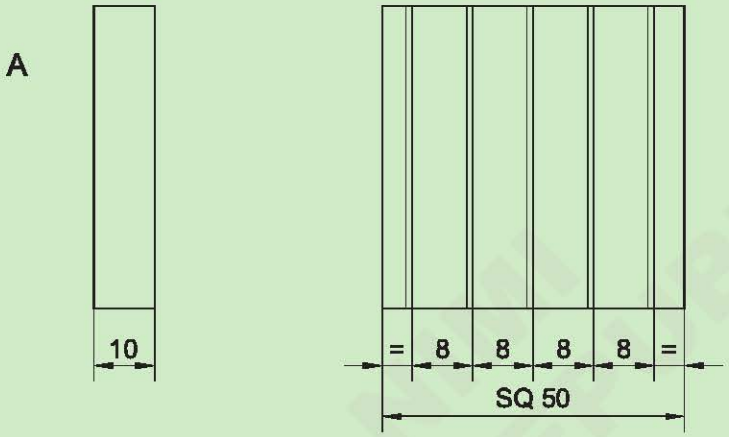
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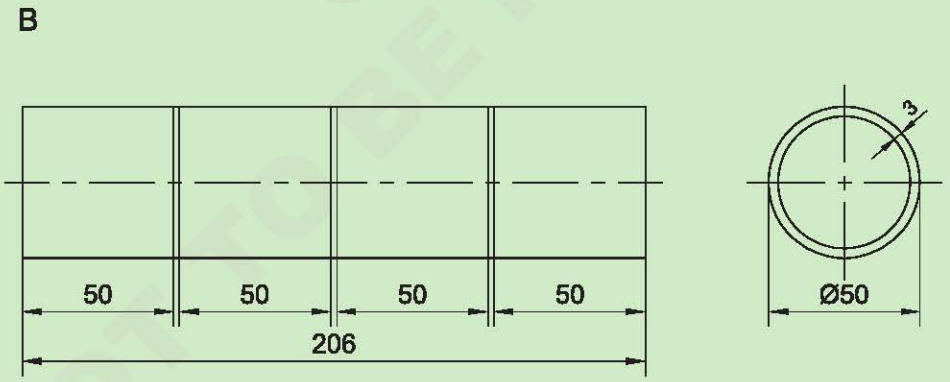
Exercise 1.3.20

Practice on using various cutting tools

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

- **cut a mild steel flat along a straight line using a hack saw**
- **flat filing practice along with flatness checking**
- **cut the given M.S sheet into two pieces along its length using chisel**
- **sharpening of chisel in grinder**
- **sharpening of center punch in grinder**
- **safety precaution in grinding tools.**





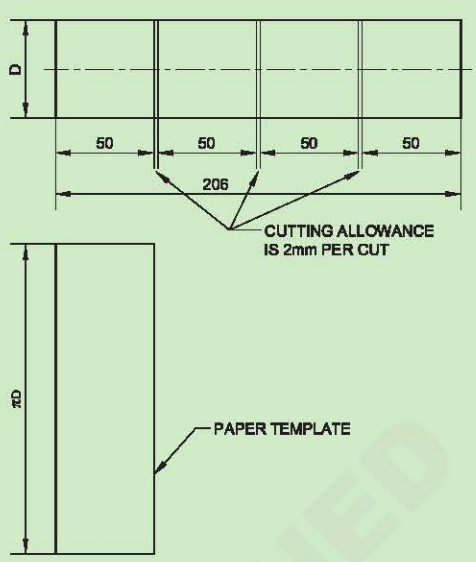
1	Ø50 x 3 - 206		Fe 310		B	
1	50 ISF 10 - 50		Fe 310		A	1.04
NO.OFF	STOCK SIZE	SEMI PRODUCT	MATERIAL	PROJECT NO.	PART NO.	EX. NO.
SCALE NTS	HACK SAWING				TOLERANCE ±0.5	TIME 5h
					CODE NO. MDN1327E1	

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Job Sequence

- Check the size of the given M.S flat Job.
- Apply copper sulphate solution and allow it to dry
- Layout lines as per drawing using a scriber taking measurement from the edge and punch mark the lines using a dot punch and hammer.
- Cut by hacksaw along the lines.
- Remove burrs, if any by filing.
- Mark lines as per drawing using a paper template and punch mark the line. (Fig 1)

Fig 1



Skill Sequence

Holding the workpiece

Objectives: This shall help you to
- **holding the work piece**
- **fixing of hacksaw blades.**

Holding the workpiece: Position the metal to be cut according to the cross-section i.e a plate, a pipe or a channel for hacksawing.

As far as possible the job is held so as to be cut on the flat side rather than the edge or the corner. This reduces the blade breakages. (Fig 1 to 3)

Fig 1

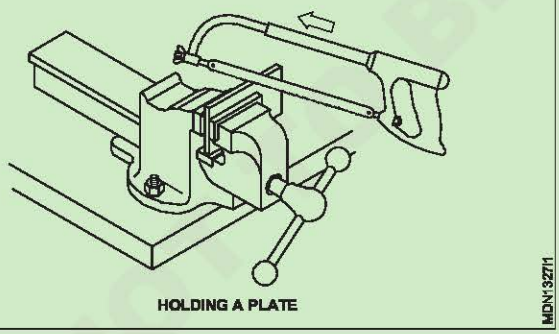


Fig 3

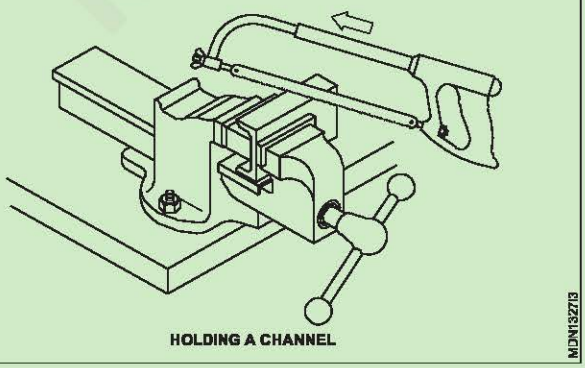
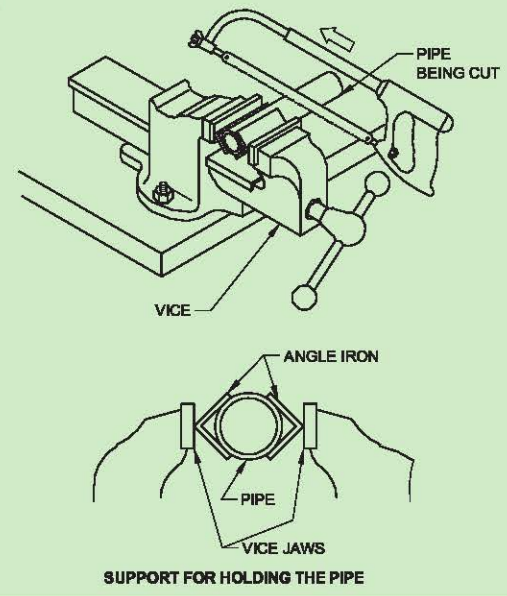


Fig 2



The selection of the blade depends on the shape and hardness of the material to be cut.

Pitch selection: For soft materials such as bronze, brass soft steel, cast iron etc. use a 1.8 mm pitch blade. (Fig 4)

For steel use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 5)

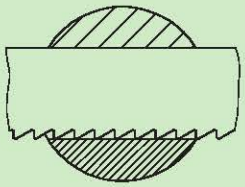
For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 6)

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Fixing of Hacksaw Blades: The teeth of the hacksaw blade should point in the direction of the cut and away from the handle. (Fig 7)

The blade should be held straight, and correctly tightened before starting.

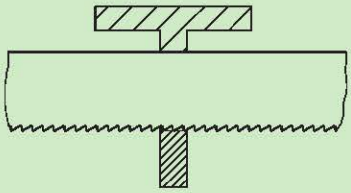
Fig 4



MORE CHIP CLEARANCE

MDN132714

Fig 5



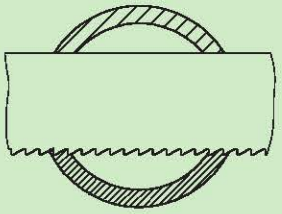
TWO OR MORE TEETH ON SECTION

MDN132715

While starting the cut make a small notch. (Fig 2) (Notch means a small groove on the job surface.)

The cutting movement should be steady and the full length of the blade should be used.

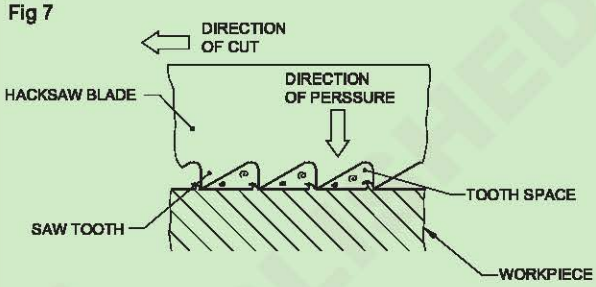
Fig 6



TWO OR MORE TEETH ON SECTION

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Fig 7



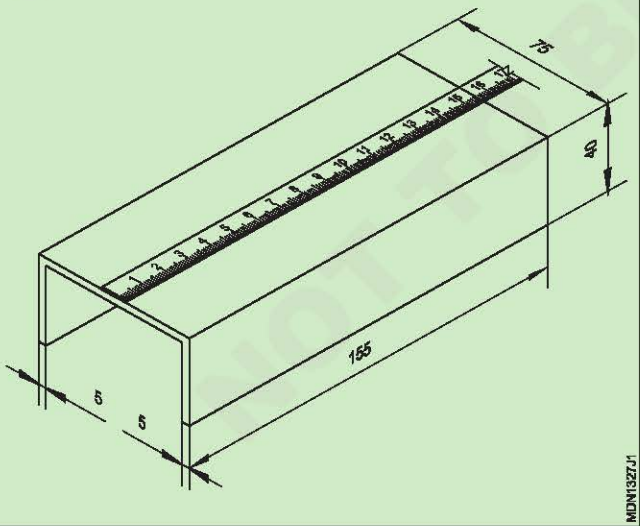
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Filing and hacksawing

Objectives: This shall help you to
- **file M.S channel**
- **cutting pipe by hacksaw.**

Check the material size 155 x 75 x 40 mm equal angle MS channel. (Fig 1)

Fig 1

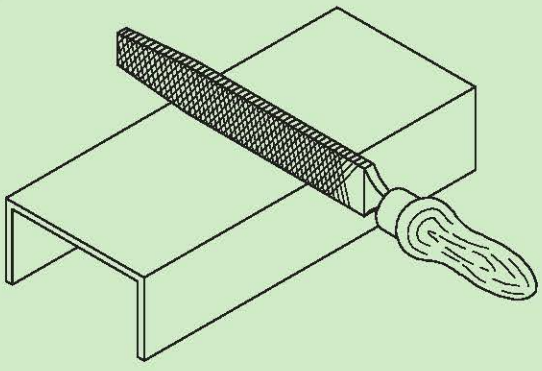


MDN132731

Remove all the rust from all the surfaces by the edge of file, clean by cotton waste. (Fig 2)

Hold the file handle with thumb will be placed firmly to grip the file, left leg will be in forward direction right leg will 300 mm from the front leg. Also check the height of your vice should be on the level of your elbow as in Fig 3.

Fig 2



MDN1327J2

Hold the job in bench vice grip firmly from width of the channel. (Fig 4)

Place file on the job and start filing while file will go in forward direction develop pressure on job, at return stroke release (Fig 5) the pressure and changes the place file and go for next area. (Fig 6) Like that complete operation and check flatness with the help of trysquare blade.

Open the job and start on (A) side filing as directed previously. Check the squareness along with (B). (Fig 7)

Open the job and start on (D) (Fig 6) side filing as directed previously. Check the squareness along with (A). (Fig 8)

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Fig 3

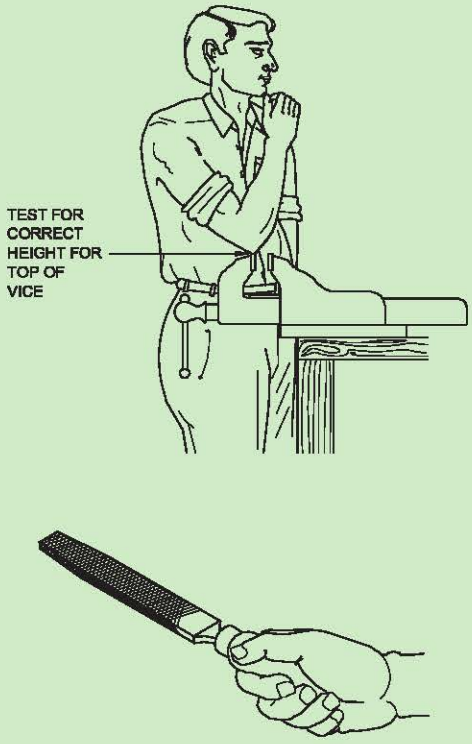


Fig 4

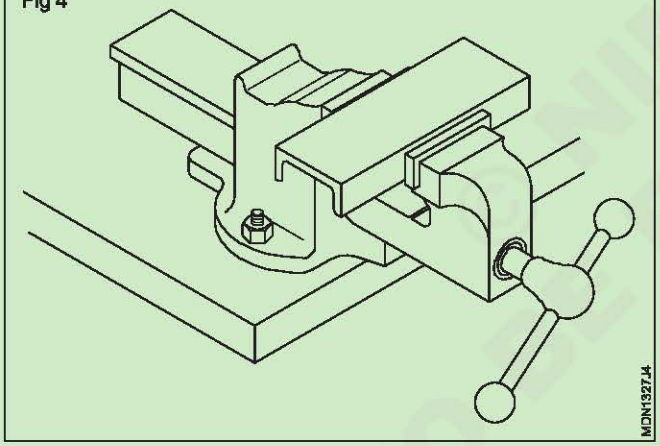
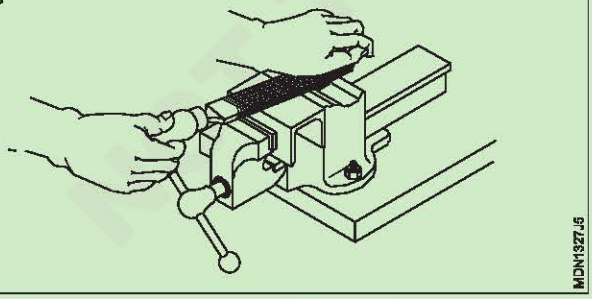


Fig 5



Open the job and start on (C) side filing as directed previously. Check the squareness along with (A,B&D). (Fig 9)

Open the job and start on (F) side filing as directed previously. Check the squareness along with (AB&D) (Fig 10)

Fig 6

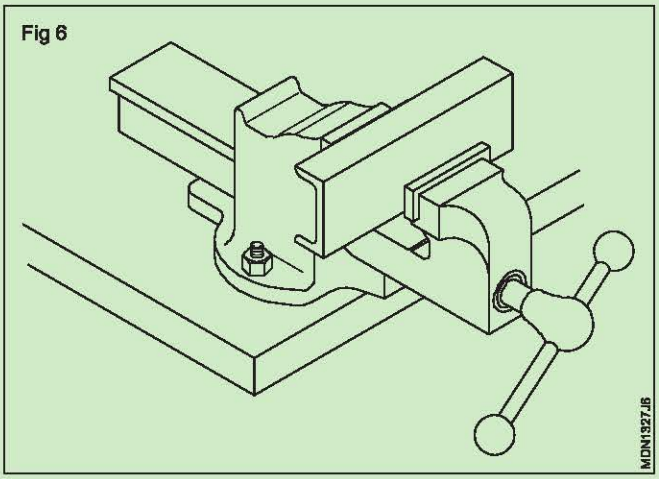


Fig 7

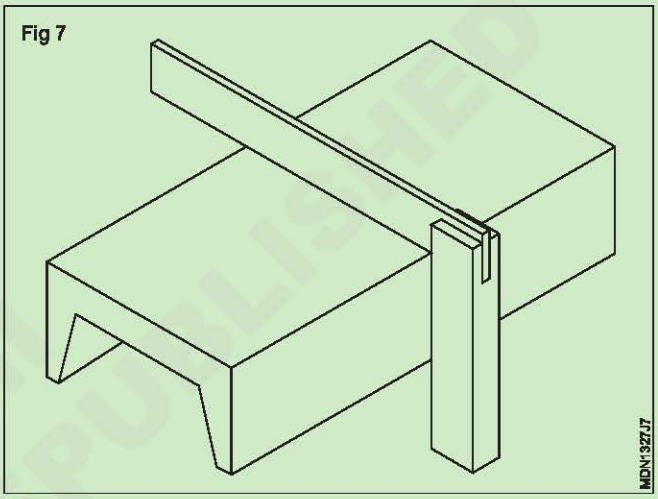
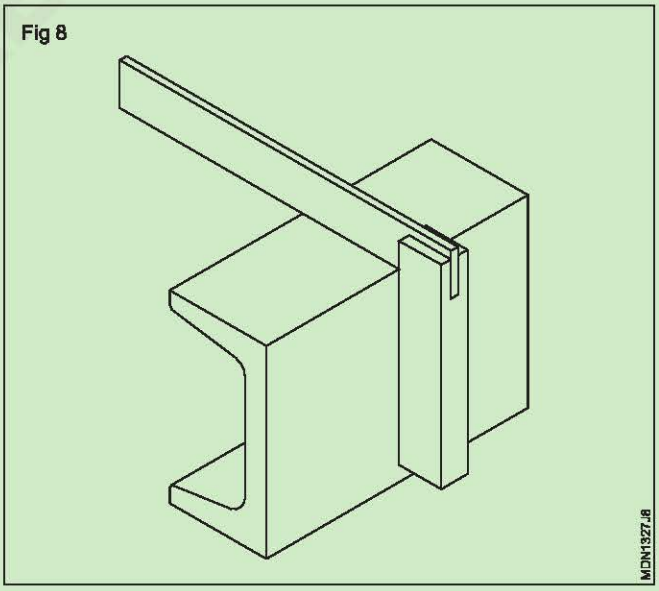


Fig 8



Apply pressure only during the forward stroke. (Fig 11)

At least two to three teeth should be in contact with the work while cutting. Select fine pitch blade i.e 0.8 or 1 mm pitch for thin work and for cutting pipes. (Fig 12a)

Turn and change the position of the pipe while hacksawing (Fig 12b)

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Fig 9

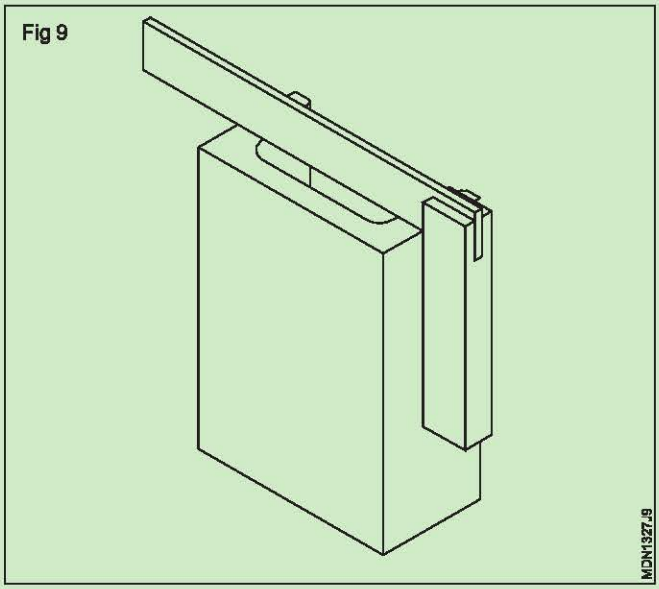


Fig 10

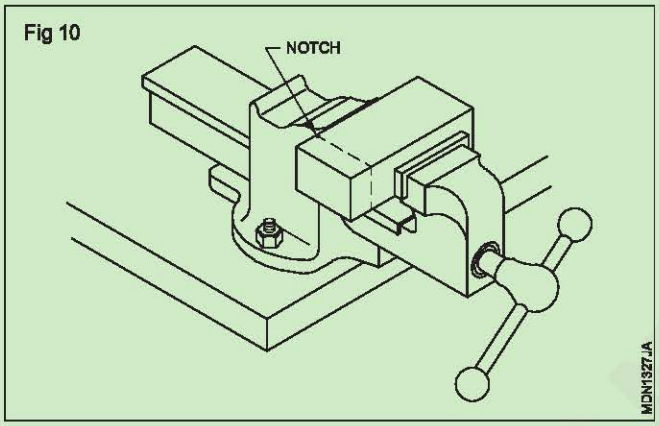
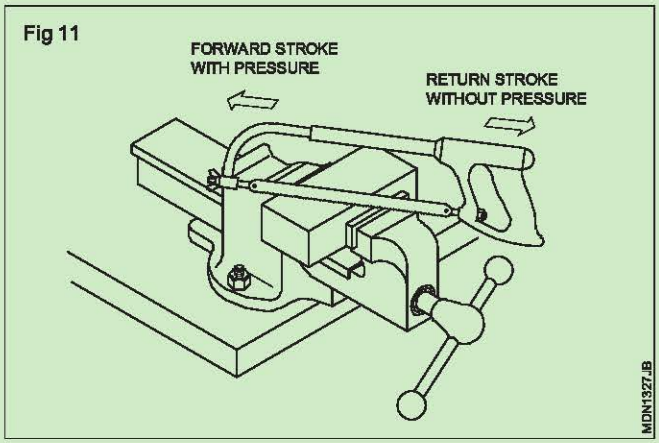


Fig 11

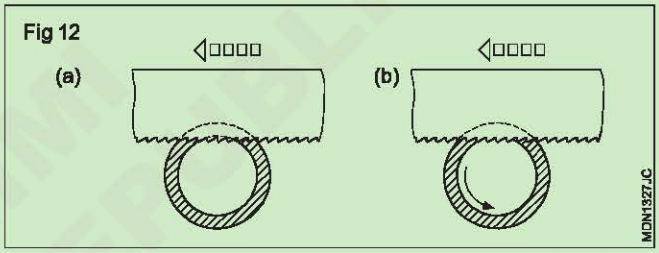


While cutting pipes by hacksawing a paper template is made and wrapped over the pipe to get the line of cut marked on the circumference of the pipe.

Normally, a coolant is not necessary while hacksawing.

Do not move the blade too fast. While finishing a cut, slow down to avoid breakage of the blade and injury to yourself and others.

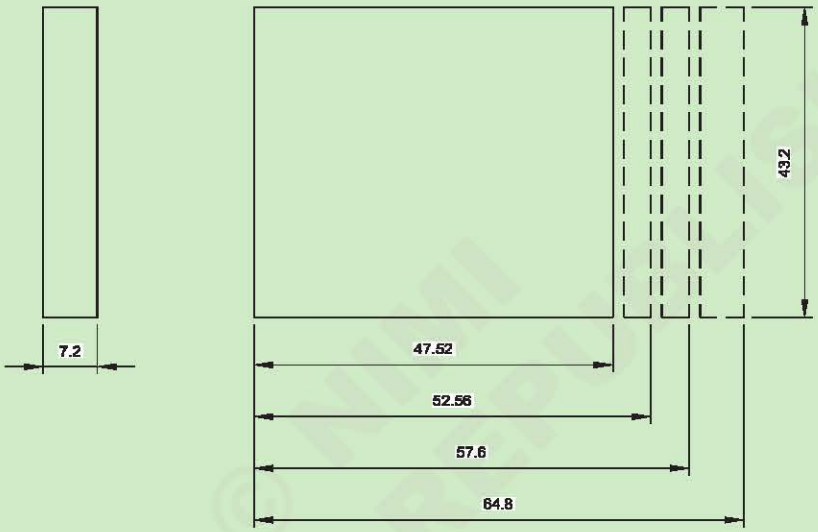
Fig 12



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Practice on hacksawing and filing

Objectives: At the end of this exercise you shall be able to
- **mark straight lines using a scribing block**
- **cut on marked lines using a hacksaw blade.**



1		From exercise 2	Fe 310			
NO.OFF	STOCK SIZE	SEMI PRODUCT	MATERIAL	PROJECT NO.	PART NO.	EX. NO1.3.08.
SCALE NTS	HACK SAWING				TOLERANCE ±0.5	TIME 5h
					CODE NO. MDN1328E1	

Job Sequence

- Check the raw material for its size.
- File flat and square to finish the block 55 x 10 x 80.
- Mark centre lines for the holes as per drawing.
- Drill a pilot hole for concave profile.
- Saw cut to remove the excess metal for the profile.
- File with flat file the two sides.

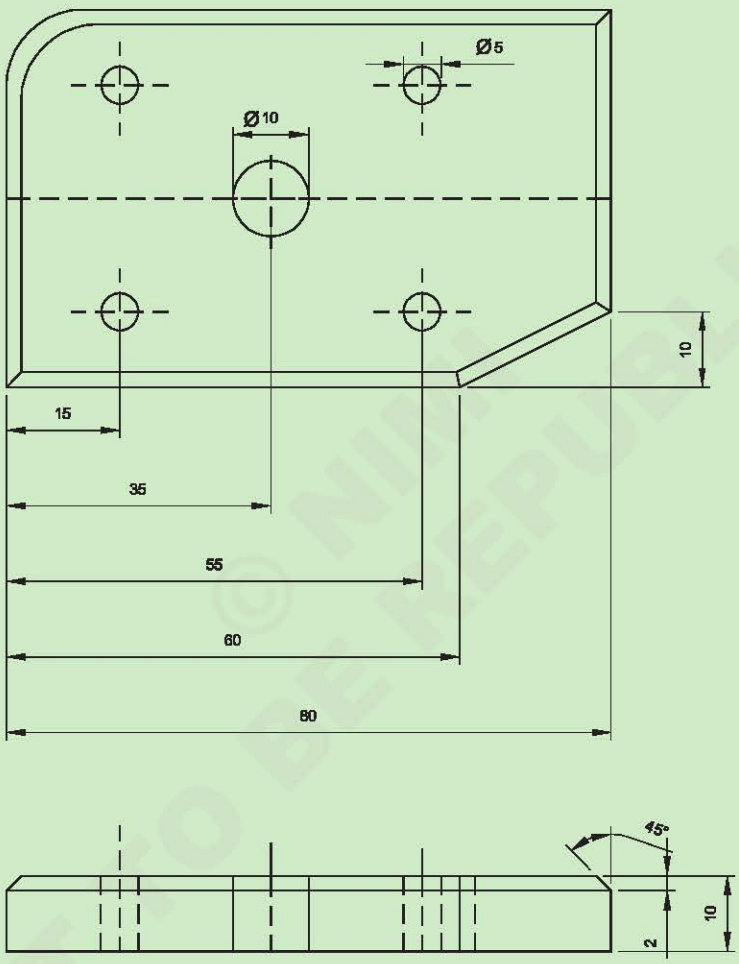
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Exercise 1.3.22

Practice on marking and drilling

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

- **file surfaces flat within + 0.5 mm**
- **file angular surfaces**
- **chamfer edges by filing**
- **file concave surfaces**
- **file convex surfaces**
- **drill through holes.**



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1	65ISF12x85		Fe 310			
NO.OFF	STOCK SIZE	SEMI PRODUCT	MATERIAL	PROJECT NO.	PART NO.	
SCALE NTS	DRILLING AND FILING RADIUS				DEVIATIONS ±0.1	
					CODE NO. MDN1331E1	

Job Sequence

- Check the raw material for its size.
- File flat the top face first.
- File the two adjacent sides flat and square to each other as well as with top surface.
- Mark the dimension as per the drawing file and finish the block.
- Mark horizontal, vertical angular curved lines as per the drawing using scriber block and dividers.
- Fix the M.S. plate in a vice.
- File the radius and angle.
- Locate the centres for holes to be drilled.
- Drill ϕ5mm and 10mm through holes as per drawing.
- File with knife edge file to finish the surface.

Skill Sequence

Drilling through hole

Objective : This shall help you to
- **drill through hole to the required size.**

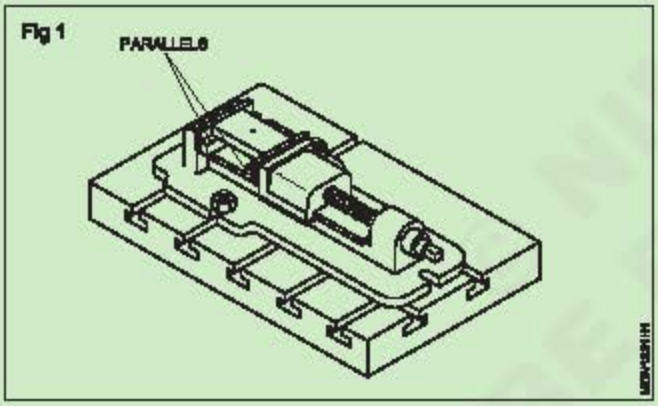
Method of drilling

Check the given raw material for its size.

Mark and locate the centres for the hole to be drilled.

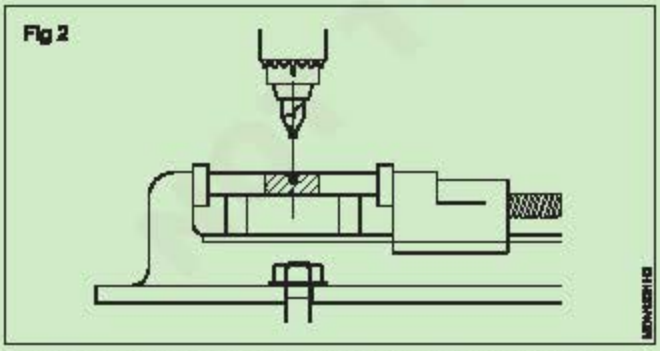
Mount the job in the machine vice on the parallels and clamp it securely to the drill-press-table. (Fig 1)

Fig 1



Set the work table (Fig 2) in such a manner that a drill can be fixed and removed without disturbing the vice or the job.

Fig 2



Fix the centre drill on the drilling machine spindle and align with the centre mark on the job.

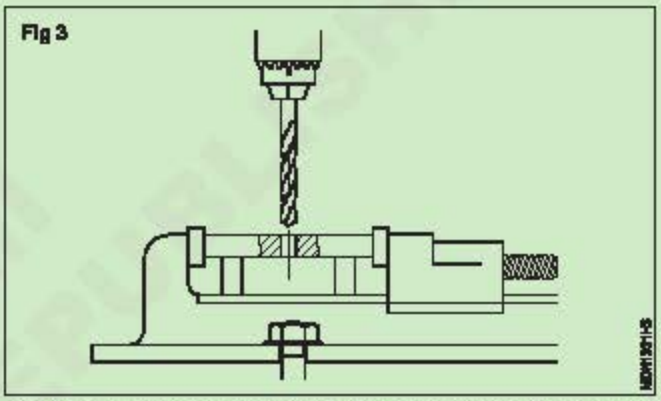
Spot the hole location with a centre drill.

Remove the centre drill and fix 8 mm drill for pilot hole.

Start the drilling machine.

Feed the drill and drill through hole. (Fig 3)

Fig 3



Set the spindle speed of the drilling machine to the nearest calculating r.p.m.

$$V = \frac{\pi d \times n}{1000}$$

Remove drill from the machine without disturbing the set up.

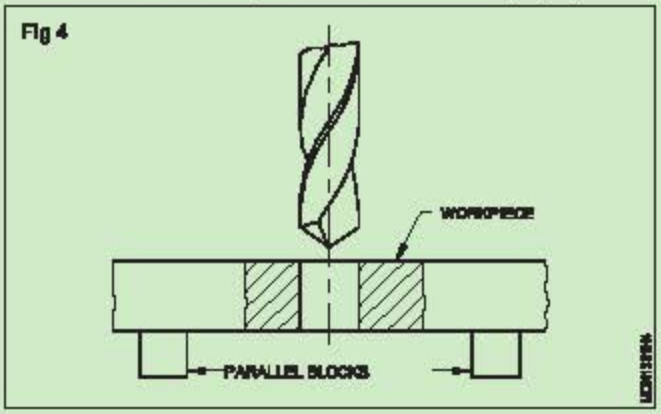
Fix 14.5 mm drill and drill through hole.

Use cutting fluid, while drilling.

Release the drill frequently from the hole for the chips to be flushed out by the cutting fluid.

Remove the drill and job from the machine. (Fig 4)

Fig 4



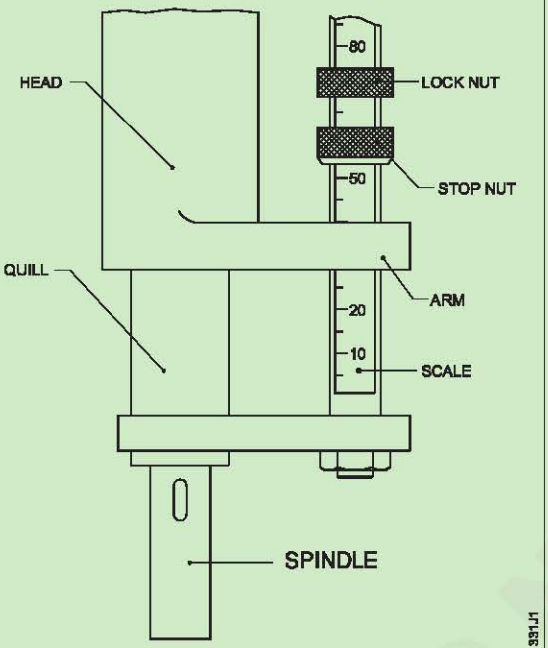
Drilling blind holes

Objective : This shall help you to
- **drill blind holes to the required depth using the depth stops.**

Method of controlling depth of blind holes

While drilling blind holes, it is necessary to control the feed of the drill. Most machines are provided with a depth stop arrangement by which the downward movement of the spindle can be controlled. (Fig 1)

Fig 1



Most depth stop arrangements will have graduations by which the advancement of the spindle can be observed.

Generally the blind hole depth tolerances are given up to 0.5 mm accuracy.

Setting for drilling blind holes

For blind hole-depth setting, first the work is held on the machine and the hole is located correctly.

The drill is started, and it drills until the full diameter is formed. Note down the initial reading at this point. (Fig 2)

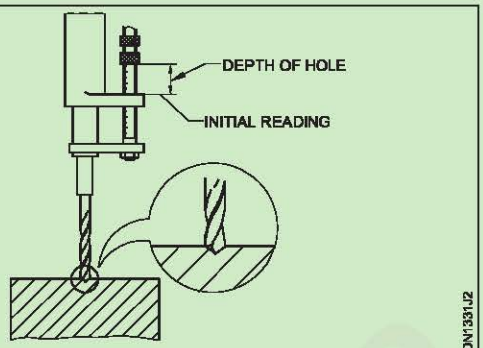
Add the initial reading to the depth of the blind hole to be drilled.

Initial Reading + Depth of Hole = Setting

Adjust the stop next to the required setting, using the scale.

Tighten the lock nut to prevent the setting from being disturbed.

Fig 2

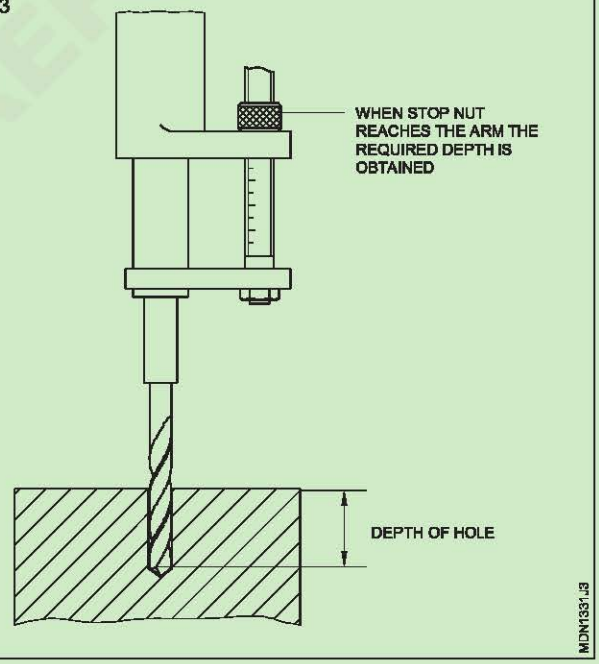


Start the machine and feed the drill. When the stop nut reaches the arm the blind hole is drilled to the required depth. (Fig 3)

While drilling, release the drill frequently from the hole for the chips to be flushed out by the cutting fluid.

Do not drill on a light component without clamping. If not clamped, the job will rotate along with drill.

Fig 3



Following the safety precautions while using drilling machine

Objectives: This shall help you to
- **follow personal safety**
- **follow drilling machine safety**
- **follow job safety**
- **follow drill bit safety.**

Wear a dress suitable for work

Ensure that the spindle head and table is locked properly.

The workpiece and the drill should be rigidly held.

Switch off power when not in use.

Clean and oil the machine after use.

Use a brush to clean the chips and swarf.

Select proper cutting speed according to material.

Select proper cutting fluid according to material.

Remove the workpiece only after getting cooled or with a tong.

While fixing the drill in a socket or sleeve, the tang portion should align in the slot. (Fig 1 & 2) This will facilitate the removal of drill or sleeve from the machine spindle.

Fig 1

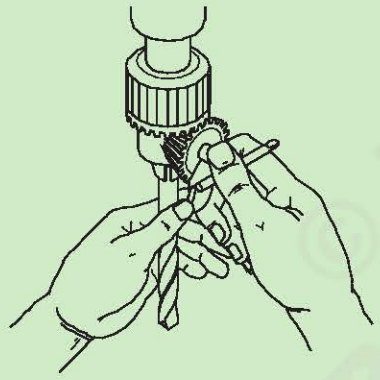
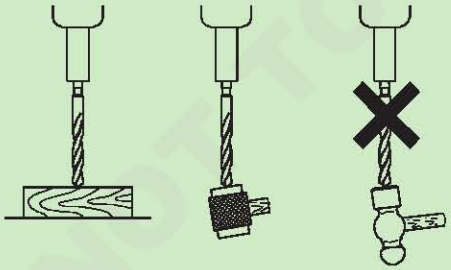


Fig 2



Ensure the belt safeguard properly placed before drilling (Fig 3)

Before drilling ensure that drill point tip properly sits on the punched marking of the job (Fig 4)

While removing the drill from the sockets/sleeves, don't allow it to fall on the table or jobs. (Fig 5)

Use a drift to remove drills and sockets from the machine spindle. (Fig 6)

Fig 3

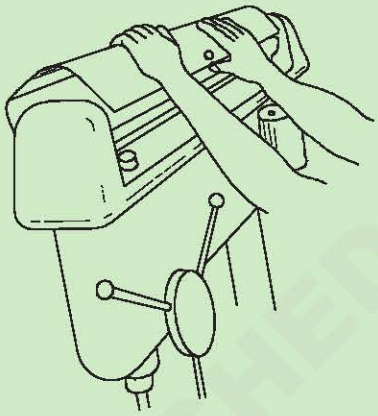


Fig 4

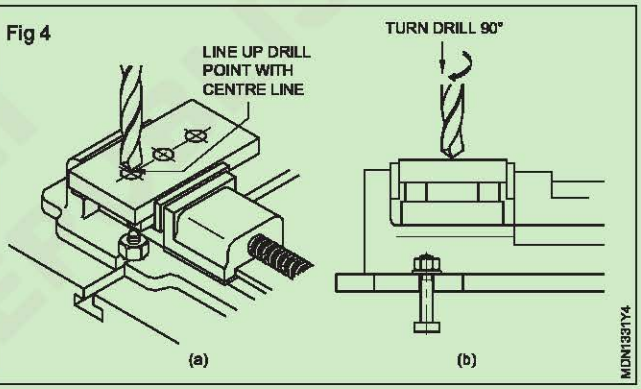


Fig 5

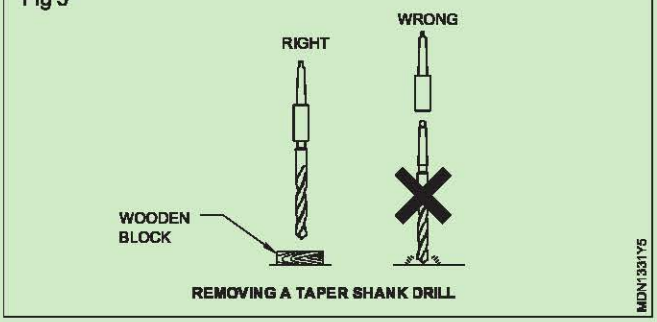
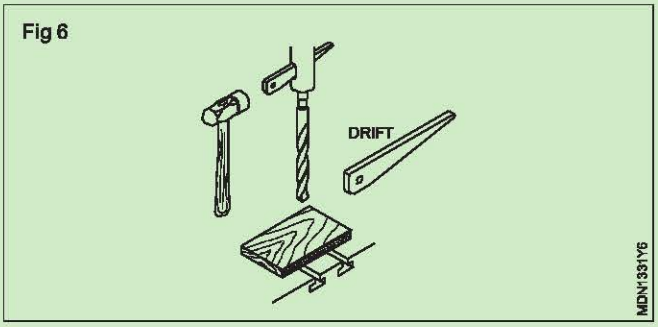


Fig 6



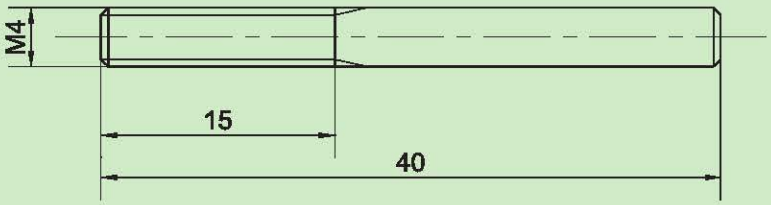
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Practice on forming internal and external threads

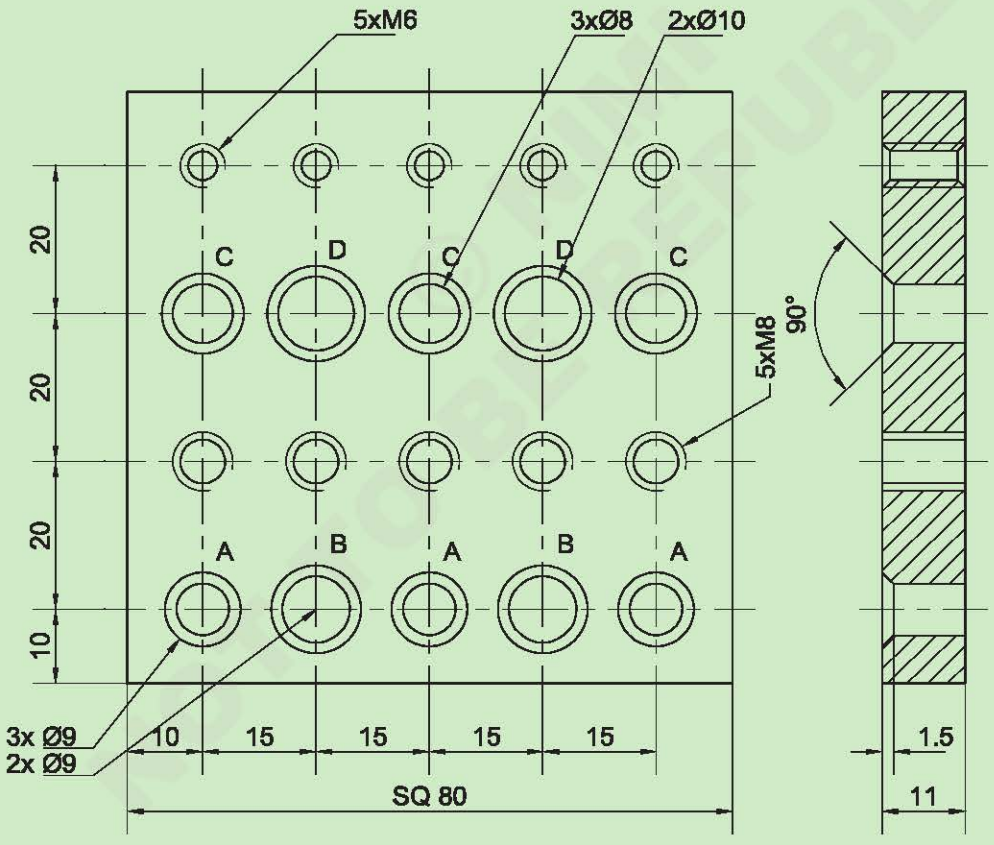
Objectives: At the end of this exercise you shall be able to

- **file surfaces flat within ± 0.5 mm**
- **file angular surfaces**
- **chamfer edges by filing**
- **file concave surfaces**
- **file convex surfaces**
- **drill through holes.**

1



2



NO.OFF	STOCK SIZE	SEMI-PRODUCT	MATERIAL	PROJECT NO.	PART NO.	Ex.No.
1	5x45		Fe310		1	1.3.14
1	90ISF12x85	-	Fe310		2	1.3.14

SCALE 1:1

CUTTING INTERNAL THREADINGS

DEVIATIONS ±0.1

CODE NO. MDN1332E1

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Job Sequence

- Check the raw material for its size.
- File and finish the plate 80 x 11 x 80 within + 0.2 mm.
- Locate centres for holes to be drilled, tapped and countersunk.
- Centre punch the centres.
- Drill five, ø5 mm tapping drill size holes for M6 tapping.
- Drill five, ø6.8 mm tapping drill size holes for M8 tapping.
- Drill four ø 8 mm through holes as per drawing. Enlarge by drilling ø10 mm the 2nd and 4th hole of the second row.
- Drill five ø7 mm through holes as per drawing.
- Enlarge the 2nd and 4th holes by drilling ø9 mm on the 4th row
- Countersink ø 8 and ø 10 holes with 90° countersink as per standard. (Refer to the table.)
- Countersink ø7 and ø 9 mm holes with 120° countersink as per 5 standard. (Refer to the table.)
- Cut M6 internal thread in the four ø 5 mm drilled holes.
- Countersink 120° all the four ø 6.8 mm holes on both sides as per drawing.
- Cut M8 internal threads in all the five ø 6.8 mm drilled holes with M8 taps.
- Check M6 and M8 tapped holes with the supplied M6 and M8 screws, respectively.
- Hold cylindrical blank on vice.
- Cut M4 external thread using M4 dies on part 2.

Skill Sequence

Internal threading of through holes using hand taps

Objectives: This shall help you to
- **determine the tap drill sizes for internal threading**
- **cut internal threads using hand taps.**

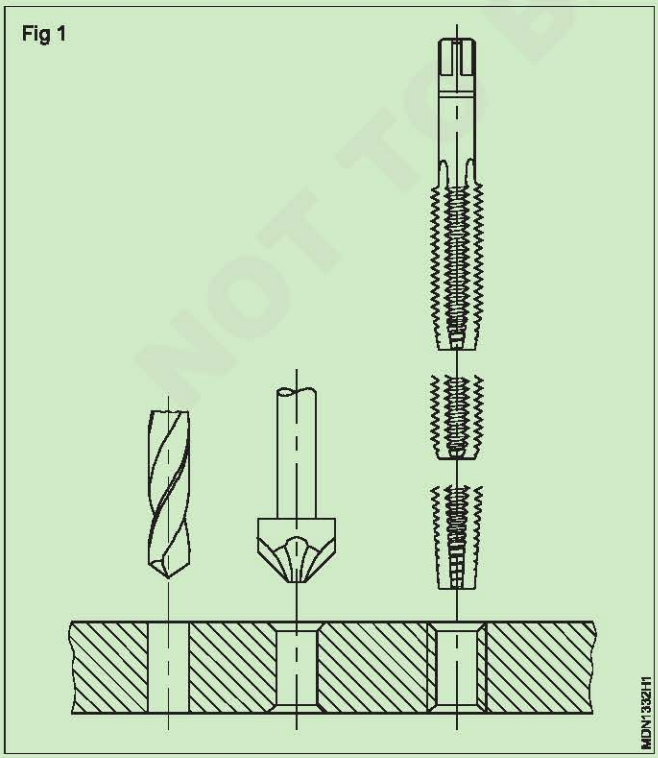
Determining the tap drill size

For cutting internal threads, it is necessary to determine the size of the hole (tap drill size). This can be calculated using a formula or can be chosen from the table of tap drill sizes.

Drill the hole to the required tap drill size.

Do not forget to give the chamfer required for aligning and starting the tap. (Fig 1)

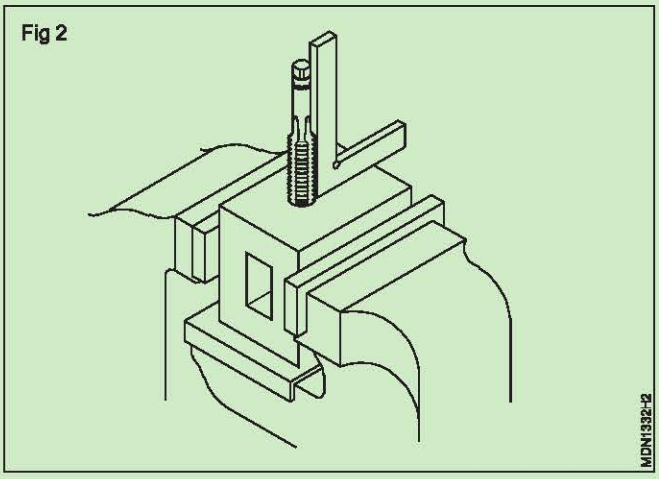
Fig 1



Hold the work firmly and horizontally in the vice. The top surfaces should be slightly above the level of the vice jaws.

This will help in using a try square without any obstruction while aligning the tap. (Fig 2)

Fig 2



Use soft jaws while holding the finished surface on a vice.

Fix the first tap (Taper tap) in the wrench.

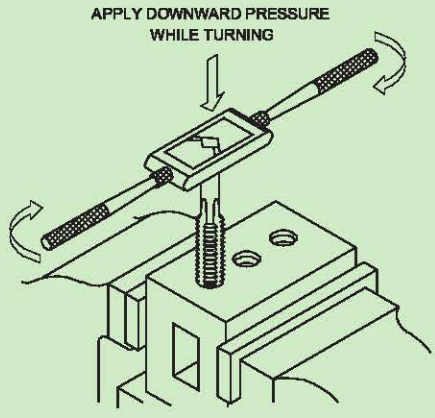
Too small a wrench will need a greater force to turn the tap. Very large and heavy tap wrenches will not give the feel required to turn the tap slowly as it cuts.

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Position the tap in the chamfered hole vertically by ensuring the wrench is in the horizontal plane.

Exert steady downward pressure and turn the tap wrench slowly in a clockwise direction to start the thread. Hold the tap wrench close to the centre. (Fig 3)

Fig 3



When you are sure of starting of the thread, remove the tap wrench without disturbing the tap alignment.

Check and make sure the tap is vertical, use a small try square for help. Place the try square in two positions, 90° to each other. (Fig 4 & 5)

Fig 4

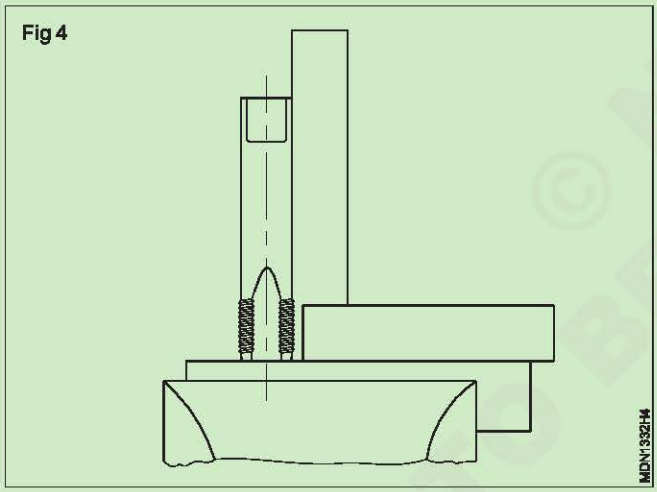
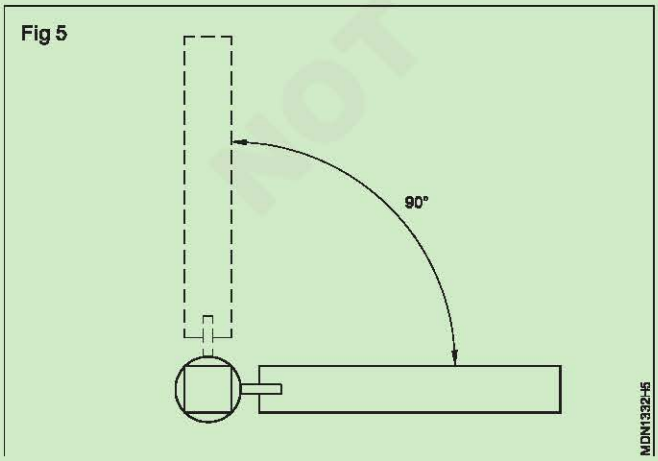


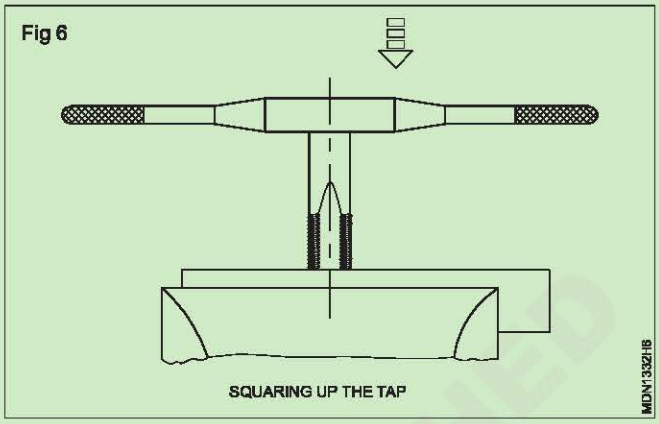
Fig 5



Make corrections, if necessary. This is done by exerting slightly more pressure on the opposite side of the tap inclination. (Fig 6)

Never apply side pressure without giving a turning motion to the tap.

Fig 6



Check the tap alignment again with a try square.

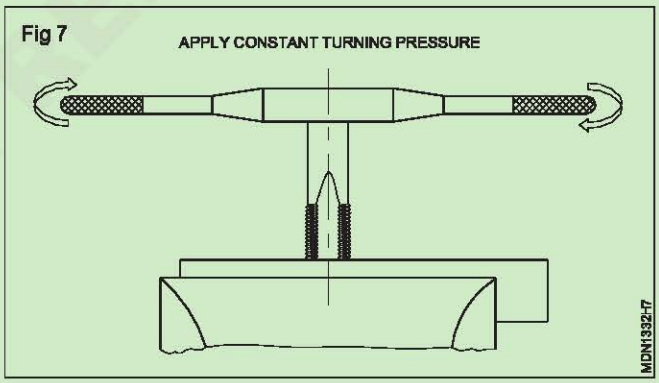
Fit the tap wrench, and tighten without disturbing the tap alignment.

Make one or two turns and check the alignment.

The tap alignment should be corrected within the first few turns.

After the tap is positioned vertically, turn the wrench lightly by holding the ends of the wrench handles without exerting any downward pressure. (Fig 7)

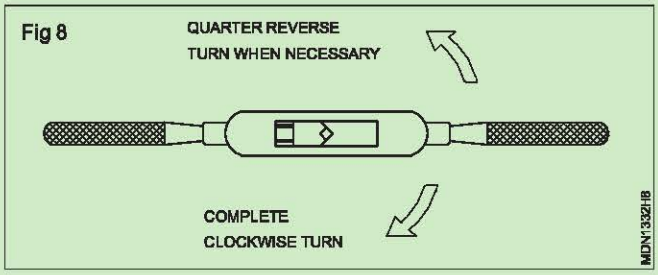
Fig 7



While turning the wrench, the movement should be well balanced. Any extra pressure on one side will spoil the tap alignment and can also cause breakage of the tap.

Continue cutting the thread. Turn backwards frequently, about quarter turn to break the chip. Stop and turn backward also when some obstruction to movement is felt. (Fig 8)

Fig 8



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Use a cutting fluid while cutting the thread.

Cut the thread until the tap is fully inside the hole being threaded.

Finish and clean up using intermediate and plug tap. The intermediate and plug tap will not cut any thread if the tap has entered the hole fully.

Remove chips from the work with a brush.

Check the threaded hole with a matching screw.

Clean the tap with a brush, and place it back on the stand.

Internal threading blind holes using hand taps

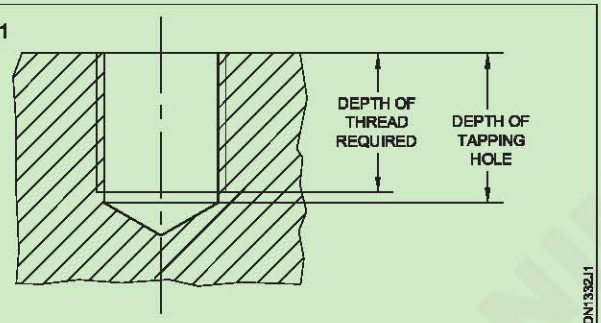
Objective: This shall help you to
- **cut internal threads in blind holes.**

Drilling a blind hole

Determine the tapping drill size using the table for tapping drill sizes.

Drill a blind hole (Fig 1) using the depth stop arrangement. The depth of the tapping hole should be slightly more than the depth of the required thread.

Fig 1



Procedure for threading

Remove metal chips, if any, from the blind hole by turning it upside down and slightly tapping it on a wooden surface.

Do not clear chips by blowing as it can cause injury to your eyes.

Screw a matching nut on the first tap to act as a depth stop. (Fig 2)

Thread the blind hole until the nut touches the plate surface.

Remove the chips from the hole frequently, using a flattened and bent wire.

Finish tapping the hole with intermediate and bottoming tap. Set nut to control the depth of thread. (Fig 3)

Fig 2

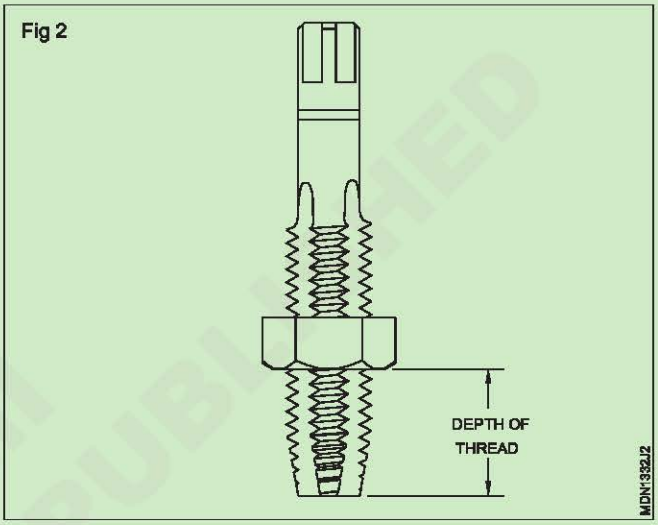
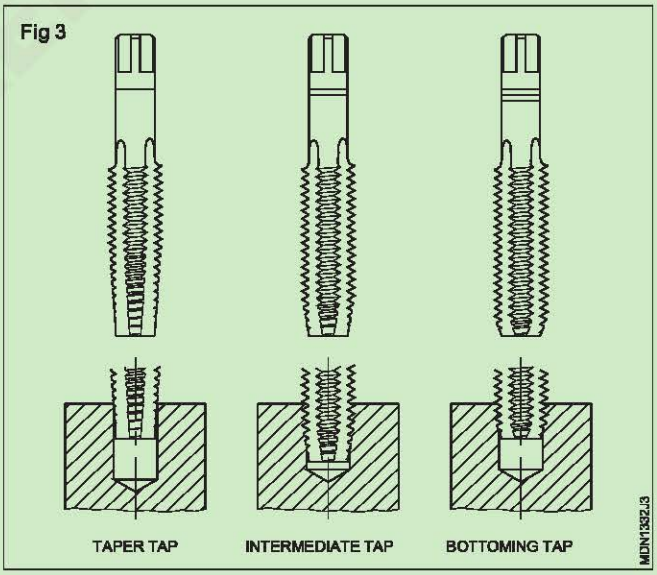


Fig 3



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External threading using dies

Objective: This shall help you to
- **external threading using dies.**

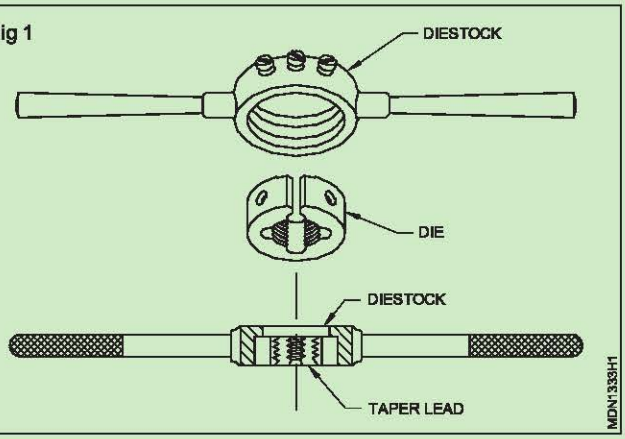
External threading using dies

Check blank size

Blank size = thread size - 0.1 x pitch of thread

Fix the die in the die stock and place the leading side of the die opposite to the step of the die stock. (Fig 1)

Fig 1



Use false jaws for ensuring a good grip in the vice.

Project the blank above the vice-just the required thread length only.

Place the leading side of the die on the chamfer of the work. (Fig 2 & Fig 3)

Fig 2

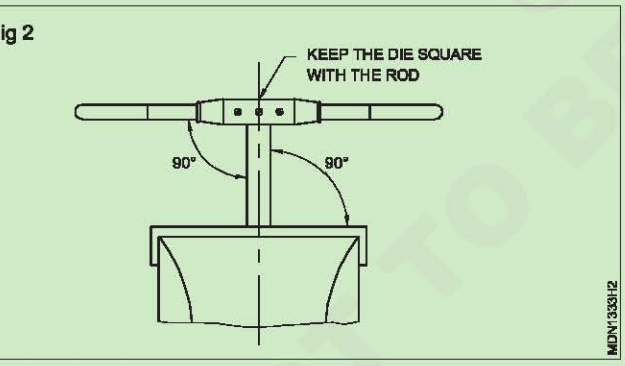
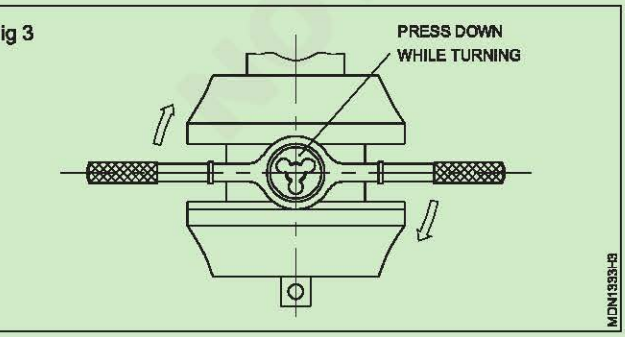


Fig 3



Make sure that the die is fully open by tightening the centre screw of the die stock. (Fig 4 & Fig 5)

Fig 4

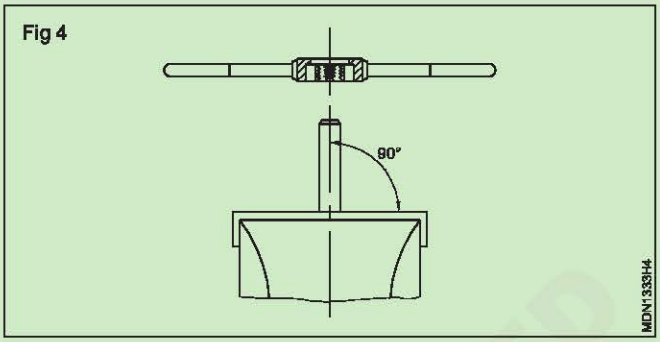
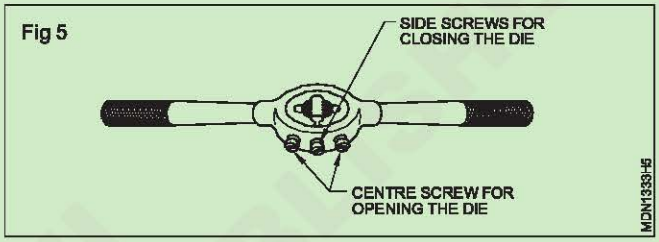


Fig 5



Start the die, square to the bolt centre line.

Apply pressure on the die stock evenly and turn in the clockwise direction to advance the die on the bolt blank.

Cut slowly and reverse the die for a short distance in order to break the chips.

Use a cutting lubricant.

Increase the depth of the cut gradually by adjusting the outer screws.

Check the thread with a matching nut.

Repeat the cutting until the nut matches.

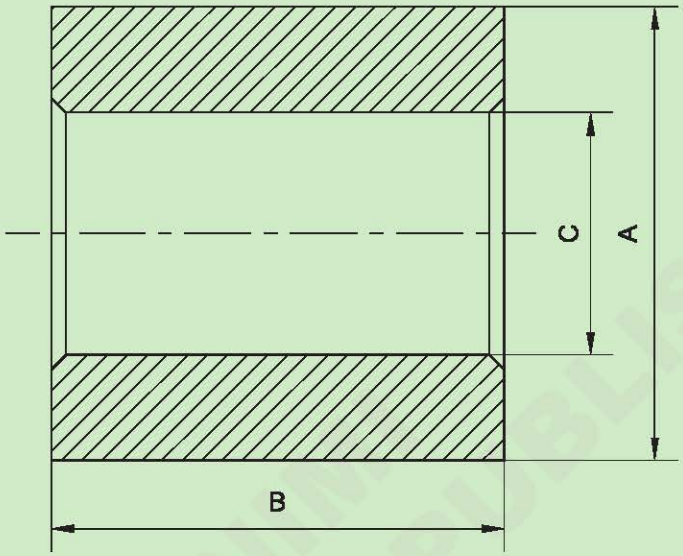
Too much depth of cut at one time will spoil the threads. It can also spoil the die.

Clean the die frequently to prevent the chips from clogging and spoiling the thread.

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Practice on reaming a hole

Objectives: At the end of this exercise you shall be able to
- **ream through hole with a hand reamer**
- **check the reamed hole by using a plug gauge.**



A			
B			
C			

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1	-	-	Fe310	-	-	1.3.15
NO.OFF	STOCK SIZE		SEMI-PRODUCT	MATERIAL	PROJECT NO.	PART NO.	Ex No.
SCALE 1:1	REAMING				DEVIATIONS ±0.1	
					CODE NO. MDN1333E1	

Job Sequence

- Hold the job in a vice.
- Select the correct type and size of reamer
- Hold the reamer in tap wrench
- Ream the hole by using sufficient coolant.
- Give uniform hand feed while reaming.
- Check the hole with a 'Go' and 'No-Go' plug gauge.

Skill sequence

Reaming drilled holes using hand reamers

Objective: This shall help you to
• ream through holes within limits and check reamed holes with cylindrical pins.

Determining the drill size for reaming

Use the formula,

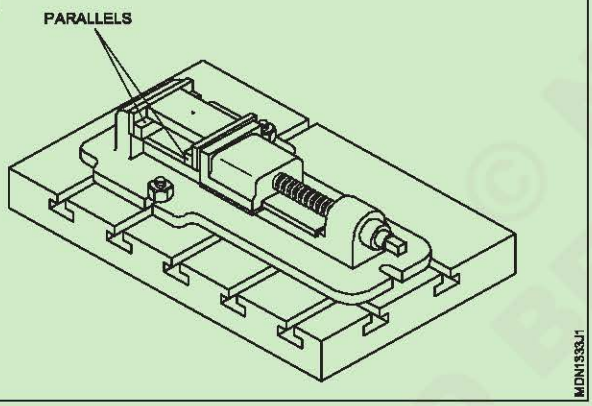
Drill diameter = reamed hole size. (undersize + oversize) [Refer to the table for the recommended undersizes in related theory on drill sizes for reaming. (See table 1.)]

Procedure for hand reaming

Drill holes for reaming as per the sizes determined.

Place the work on parallels while setting on the machine vice. (Fig 1)

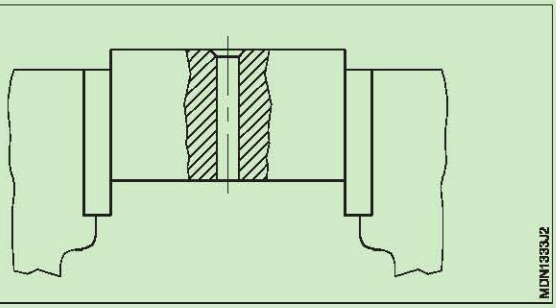
Fig 1



Chamfer the hole ends slightly. This removes burrs, and will also help to align the reamer vertically. Fix the work in the bench vice. Use vice clamps to protect the finished surfaces. Ensure that the job is horizontal. (Fig 2)

Fix the tap wrench on the square end and place the reamer vertically in the hole. Check the alignment with a try square. Make corrections, if necessary. Turn the tap wrench in a clockwise direction applying a slight downward pressure at the same time. Apply pressure evenly at both ends of the tap wrench.

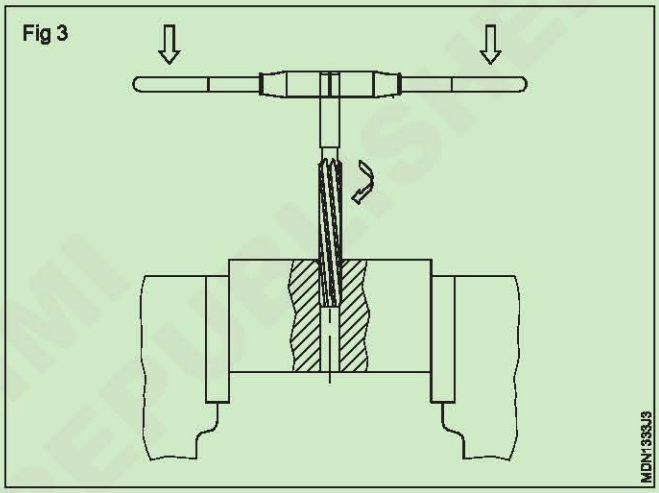
Fig 2



Apply cutting fluid.

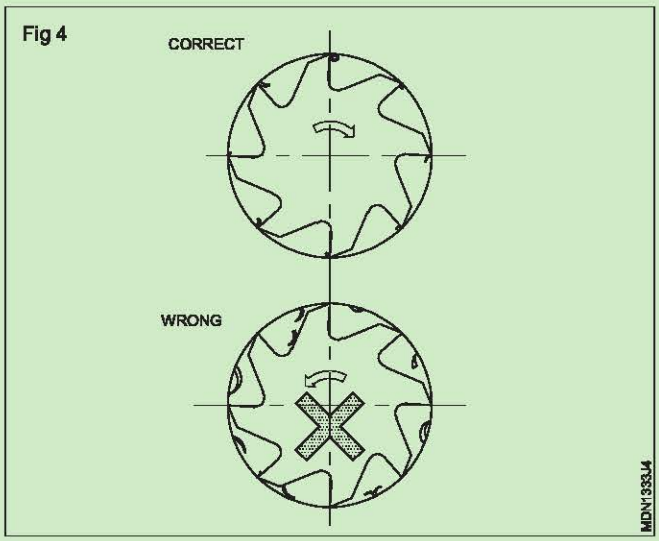
Turn the tap wrench steadily and slowly, maintaining the downward pressure. (Fig 3)

Fig 3



Do not turn in the reverse direction for it will scratch the reamed hole. (Fig 4)

Fig 4

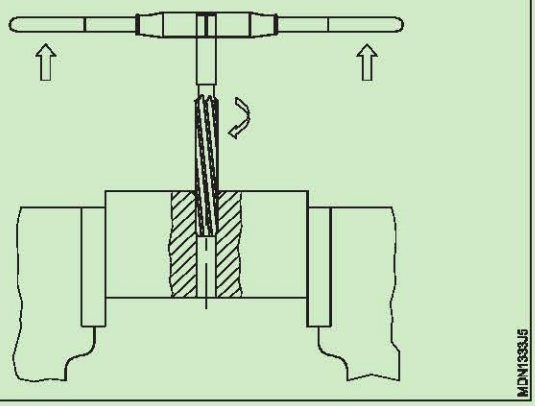


Ream the hole through. Ensure that the taper lead length of the reamer comes out well and clear from the bottom of the work.

Do not allow the end of the reamer to the strike on the vice.

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Fig 5



Remove the reamer with an upward pull until the reamer is clear of the hole. (Fig 5)

Remove the burrs from the bottom of the reamed hole.

Clean the hole. Check the accuracy with the cylindrical pins supplied.

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Practice on soldering wires

Objective: At the end of this exercise you shall be able to
- **prepare crimping joints with connectors**
- **solder the cable lugs by using blow lamp**
- **solder the cables using soldering iron.**

Requirements

Tools/Instruments

• Trainee's tool kit	- 1 No.
• Crimping plier	- 1 No.
• Blow lamp	- 1 No.
• Tong	- 1 No.
• Combination plier	- 1 No.

Materials

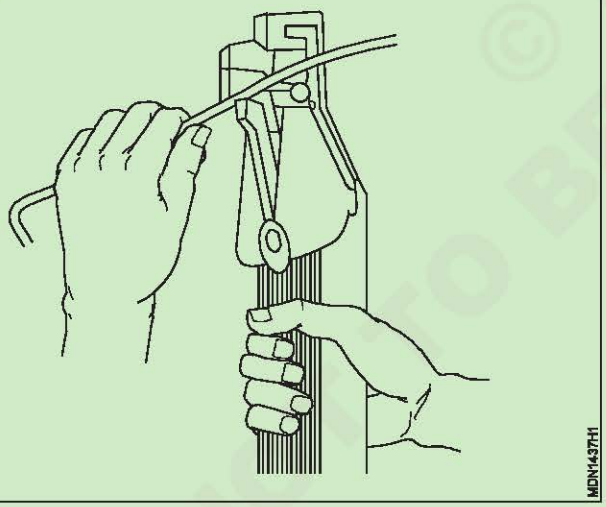
• Cotton waste	- as reqd.
• Wooden plank	- as reqd.
• Solder	- as reqd.
• Brick	- as reqd.
• Insulating sleeve	- as reqd.
• Flux	- as reqd.
• Lug socket	- as reqd.
• Cloth/Cotton tape	- as reqd.
• Grade sandpaper	- as reqd.
• Copper and Aluminium conductors	- as reqd.

PROCEDURE

TASK 1 : **Prepare the crimping joints with connector**

1 Strip off the required length of insulation from the cable that suits the terminal size. (Fig 1)

Fig 1



Be sure hot to cut or damage the wire core, & use correct size wire stripper blade. (Fig 2)

2 Twist the strands of the wire slightly clockwise.(Fig 3)

3 Clamp the spade connector with the crimping pliers in the matching position of the jaws. (Use a suitable spade connector and crimping plier.) (Fig 4)

4 Insert the wire far enough in the connector.

5 Apply slight pressure to create a light impression on the connector.

Fig 2

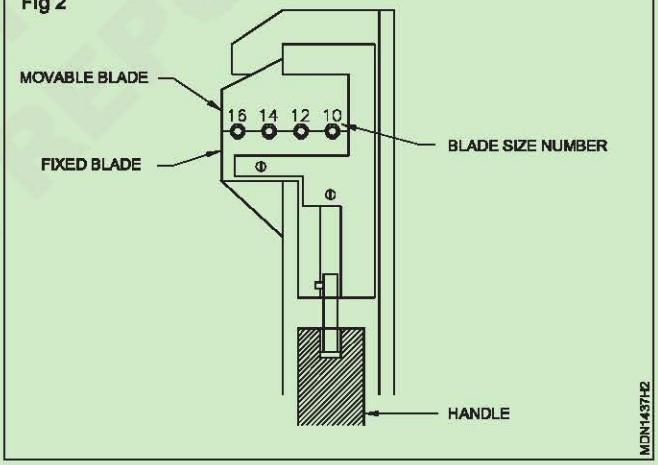
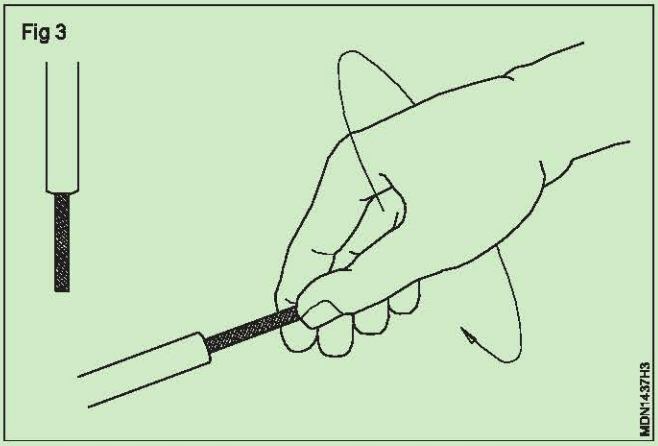


Fig 3

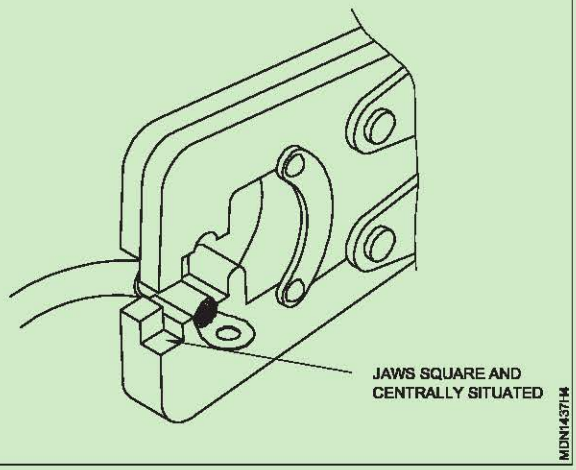


6 Check whether the connector is located in the middle of the band of the connector, and, if necessary, make final adjustments.

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7 Apply sufficient pressure in the handle to press the connector fully. (Fig 5)

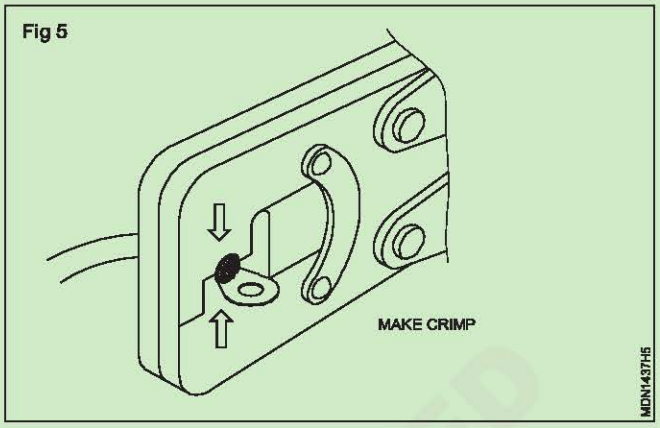
Fig 4



8 Check whether the prepared crimping joint is firm by pulling the cable and connector.

9 Repeat the crimping of connectors for various sizes of copper and aluminium conductors of different lengths.

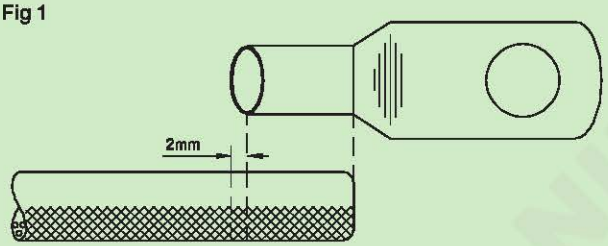
Fig 5



TASK 2 : **Solder the cable lugs by using blow lamp**

1 Solder a lug to a copper conductor. (Fig 1)

Fig 1

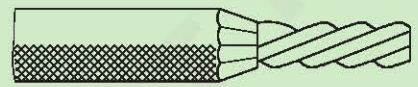


2 Clean the inner surface of the cable lug using 00 grade sandpaper.

3 Put the cable lug to one end of the cable and mark the cable according to the depth of the cable lug. Add about 2 mm to the marking.

4 Remove the insulation from the cable and clean the strands. (Avoid damage to the strands of the cable while skinning.) (Fig 2)

Fig 2



5 Wrap a cloth/cotton tape on the insulation of the cable to a length of 30 mm and wet it with water. (Use minimum water to wet the cloth/tape. Do not allow water to drip). (Fig 3)

6 Light the blowlamp and let it emit a blue flame. (Fig 4)

Fig 3

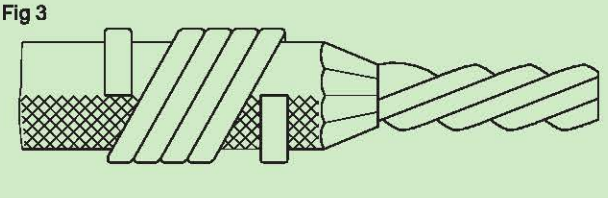
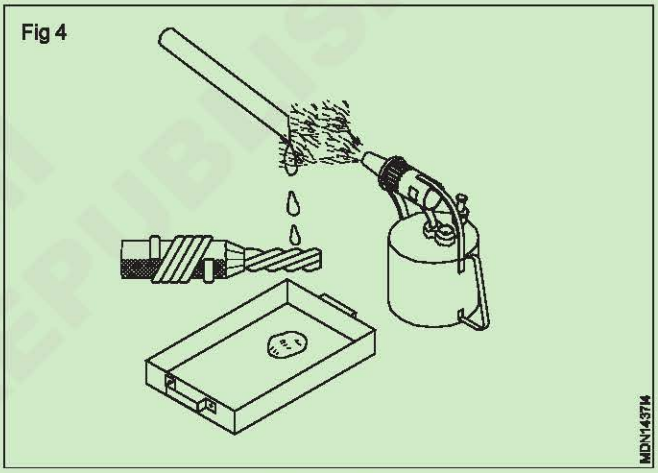


Fig 4



7 Apply a thin coat of flux to the cable end.

8 Tin the cable end by monitoring the blowlamp on the solder stick and by allowing the molten solder to fall on the bar stranded cable end. Place a clean tray below the cable end to collect the excess solder.

9 Apply a small quantity of flux inside the lug socket. Tin the lug by melting the solder stick to fill the socket and collect the excess molten solder in the tray. (Fig 5)

10 Apply some flux to the cable end and socket interior. (Fig 6)

11 Fill up the socket of the lug with the molten solder.

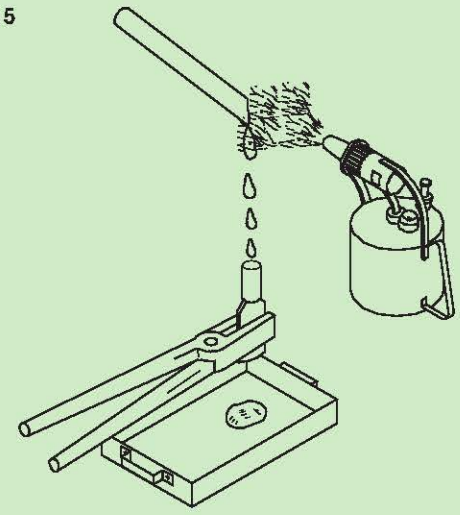
12 Monitor the blowlamp flame on the socket; insert the cable in the socket and hold the cable vertically.

13 Remove the blowlamp and hold the cable and socket without shaking. (Fig 7)

14 Remove the extra solder from the lug and the cable by wiping with a piece of cotton cloth while the solder is still hot.

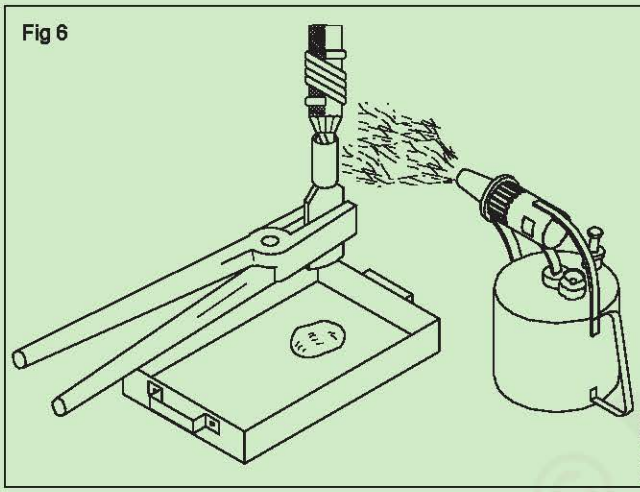
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Fig 5



MDN143715

Fig 6

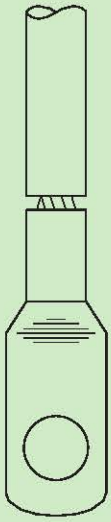


MDN143716

15 Keep holding the cable and lug until the solder solidifies.

Do not use water to cool the lug.

Fig 7



MDN143717

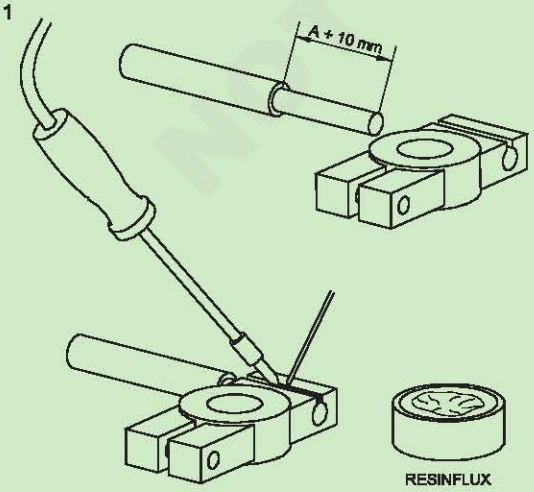
TASK 3 : **Solder the cable using soldering iron**

1 Clean the strands and get a copper face free from sulphate.

2 Insert the wire end as shown in the Fig 1.

3 Hold the clamp in a vice in between two wooden blocks to prevent heat flow to vice.

Fig 1



MDN1437J1

4 Connect a 1000w/220v soldering iron to an AC source. Keep the iron on a brick.

Do not over heat the iron. Overheating would impair wetting of iron. Wetting means coating soldering iron with solder.

5 Solder the end with clamp face with molten solder.

6 Hold the clamp horizontally and solder the split and close the split with solder.

7 Hold the clamp as shown in the Fig 2 and solder around the cable without melting the insulating sleeve.

Wound the insulation material with a wet cloth near the soldering end to prevent melting.

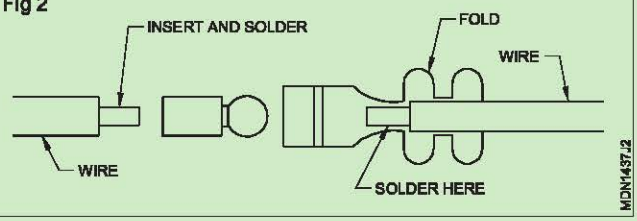
Soldering the circuit wire terminals

1 Remove the insulation as shown in the Fig 2 without cutting conductor strands.

2 Connect a soldering iron of 300w/220v to an AC supply and keep the iron on a brick.

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Fig 2



3 Clean the copper strands with emery paper.

4 Twist the end neatly.

5 Keep the end on a wooden plank.

6 Wet the iron with soft solder.

Do not over heat the iron

7 Coat the end with solder.

8 Insert the end into the small loop on the eyelet terminal.

9 Fold the terminal tabs one by one and crimp with a tool.

10 Now keep the clamp on wooden plank.

11 Keep the iron so that a wide area of contact is achieved for better heat transfer to obtain a molten flow of soft solder.

12 Wait for solidification of solder and inspect the result. Repeat the same operation for other terminal soldering.

Insulating the wires and cables

For small wires and cables various sizes of insulation sleeves are available. These sleeves can be inserted before soldering the terminals.

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Practice on measuring electrical parameters in circuits

Objectives : At the end of this exercise you shall be able to
- **form DC series circuits and verify its characteristics**
- **form DC parallel circuits and verify its characteristics.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Ohmmeter/Multimeter - 1 No.

Equipments

- Battery 12V, 6V - 1 No..

Materials

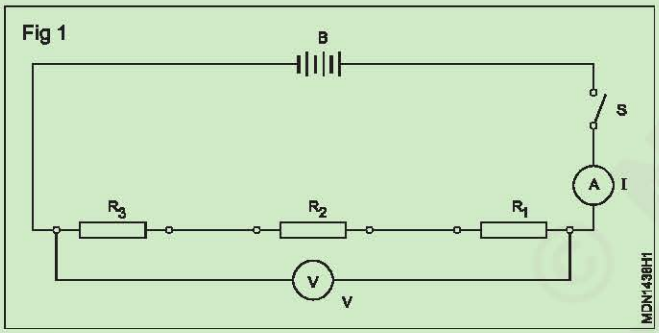
- Wires 4mm - as reqd.
- Insulation tape - as reqd.

PROCEDURE

TASK 1: **Connect DC series circuit (Fig 1) and verify its characteristics**

1 Form a circuit as shown in the Fig 1.

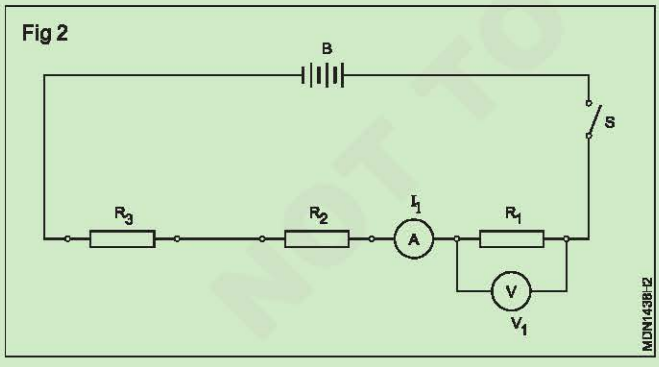
Fig 1



2 Close the switch 'S', measure the current 'I' and voltage 'V'.

3 Enter the measured values in Table No.1.

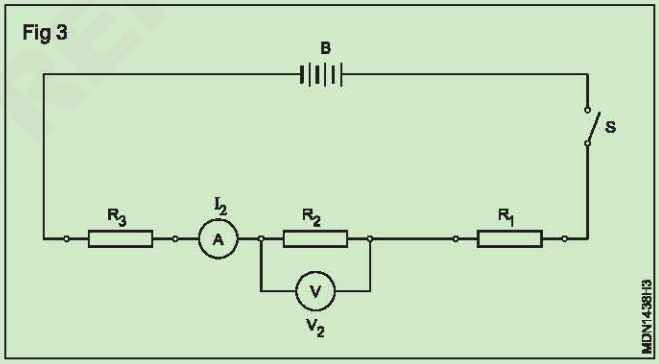
Fig 2



4 Switch off the supply, connect the ammeter and voltmeter as shown in the Fig 2. Switch on the supply and measure voltage V_1 and current I_1, through R_1.

5 Switch off the supply, connect the ammeter and voltmeter as shown in the Fig 3. Switch on the supply and measure the voltage V_2 and the current I_2 in R_2.

Fig 3



6 Draw a circuit diagram showing the position of 'A' and 'V' in the circuit to measure the current I_3 and voltage V_3 across R_3.

7 Connect and measure I_3 and V_3 across R_3.

8 Enter the measured values in Table 1.

9 Verify the characteristics of current, voltage and total resistance.

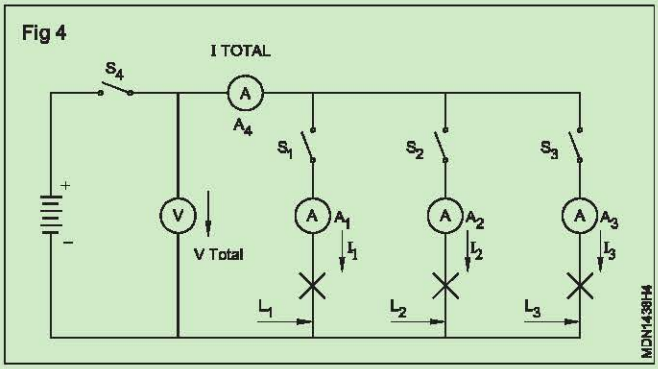
Table 1

Values	Total circuit	R_1=10	R_2= 20	R_3= 10
Current	I =	I_1 =	I_2=	I_3=
Voltage	V =	V_1 =	V_2=	V_3=
Res. R=	R = _____ =	R_1=_____ =	R_2=_____ =	R_3=_____ =

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TASK 2 : **Connect DC parallel circuit (Fig 4) and verify its characteristics**

Fig 4



1 Form the branches 1, 2, 3 by connecting the torch lamps L1, L2, L3 (150 mA, 6v) with a holder, an ammeter A4 (500 mA) and switch 'S4' in series Fig 4.

2 Connect the lamp terminals of the three branches together.

3 Connect the leads of each branch together and also connect with the lead of the switch S4.

4 Form the circuit as shown in circuit diagrams with voltmeter (V), ammeter (A4), switch 'S4' and battery.

5 Close the switch 'S4' and switch 'S1' in branch 1.

6 Read the ammeters 'A4' and 'A1' and record the values in Table 2.

7 Close the switches 'S4' 'S1' and 'S2' in branch 2.

8 Read the ammeters 'A4' 'A1' and 'A2' and record the values in Table 2.

9 Close the switches 'S4' 'S1' and 'S2' in branch 3.

10 Read the ammeters 'A4' 'A1' 'A2' and 'A3' and record the values in Table 2.

11 Repeat the above steps after clamping the torch lamp in any one branch with 6v 300 mA lamp and record the results in Table 2.

12 Repeat the exercise by replacing all the three 'lamps with holder' by 'wire-wound resistors' (two numbers of 100 ohms and one of 150 ohms).

13 Verify the characteristics of current, voltage and resistance.

Table 2

Sl. No.	I_1	I_2	I_3	I_{Total}	Switches closed	Components in the branches
1					S_4, S_1	3 lamps of 150 mA.
2					S_4, S_1, S_2	,,
3					S_4, S_1, S_2, S_3	,,
4					S_4	,,
5					S_4, S_1	2 lamps of 150 m and one lamp 300 mA.
6					S_4, S_1, S_2	,,
7					S_4, S_1, S_2, S_3	,,
8						Resistors - two 100 ohms and one 50 ohms.
9					S_4, S_1, S_2	,,
10					S_4, S_1, S_2, S_3	,,

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Practice on continuity test

Objectives : At the end of this exercise you shall be able to
- **check the fuses of all the lighting units**
- **find out the open and short circuits in the lighting circuit**
- **check the fuse**
- **check the relay.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Multimeter - 1 No.
- Wire cutter - 1 No.

Equipments

- Battery 12V - 1 No.
- Vehicle - 1 No.

Materials

- Auto fuses - as reqd.
- Test lamp - 1 No.
- Cable/Wire - as reqd.
- Fusible links - as reqd.
- Circuit breaker - as reqd.

PROCEDURE

TASK 1 : **Check the fuses of all the lighting units**

1 Check the battery for its charge.

2 Connect the test lamp clip to a good ground.

3 Touch the probe of the test lamp on either end of the fuse. If the test lamp lights, the fuse is in good condition.

If the test lamp lights only while touching one side that means the fuse is defective. If the test lamp does not light even on touching both the sides that means the power source is not on or the ground connection is bad.

4 Remove the fuse from its spring clip. Check whether it is blown or not.

If it is blown we can see through the glass tube.

If the fuse is blown due to short circuit the colour of glass tube becomes black (1) and the fuse wire melts like small balls. (Fig 1)

If the fuse is blown (2) due to overload the fuse wire is simply cut off. (Fig 2)

Fig 1

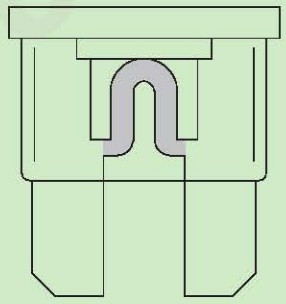
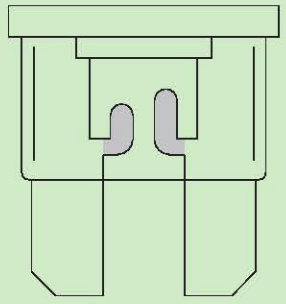


Fig 2



TASK 2 : **Fine out open and short circuit in the lighting circuit**

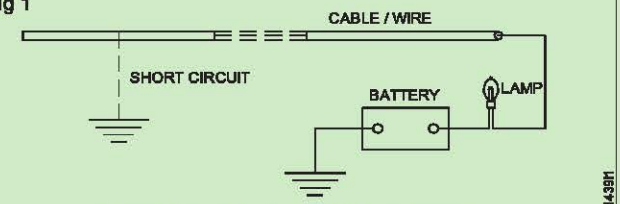
1 Check the wiring for open circuit by connecting an ohmmeter between the two terminals.

If there is an open circuit the ohmmeter reading will be more.

2 Trace the open circuit and rectify.

3 Check the wiring for short circuit with the test lamp. (Fig 1)

Fig 1



TESTING OF SHORT CIRCUITS IN A WIRING CIRCUIT

If there is a short circuit the test lamp will glow before the circuit is completed and also the fuse will be blown off.

TASK 3 : **Identify the fuse unit in the panel board (Fig 1)**

1 **Engine 7.5 A :** Alternator voltage regulator (IG terminal), fuel cut solenoid, intake shutter, indicator light.

2 **Heater 20 A :** Heater blower motor, air conditioner.

3 **Tail 15 A :** Instrument panel lights, license plate lights, parking lights, tail lights.

4 **Head (RH) 15 A :** High beam indicator light, right hand headlights.

5 **Charge 7.5 A :** Alternator voltage regulator, (L terminal), discharge warning light.

6 **AC 20 A :** Air conditioner.

7 **HAZ-HORN 15 A :** Emergency flashers, emergency flasher indicator lights, horn, turn signal indicator lights, turn signal lights.

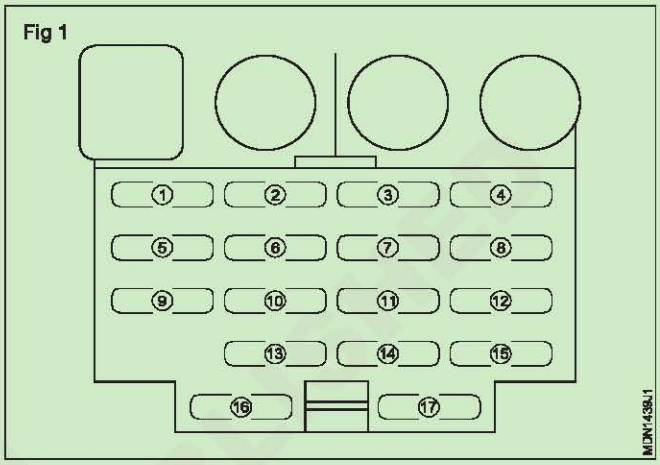
8 **Head (LH) 15 A** : High beam indicator light, left hand head lights.

9 **CIG 15 A :** Cigarette lighter, clock digital type.

10 **Wiper 15 A :** Windshield wipers and washer.

11 **Stop 15 A :** Stop light

Fig 1



12 **Radio 7.5 A :** Radio, stereo cassette tape player

13 **Gauge 7.5 A :** Back-up lights, engine temperature gauge, fuel gauge, warning lights, warning buzzers.

14 **Dome 7.5 A :** Clock (digital type), interior light.

15 16 **7.5 A and 15 A :** Spare fuses

16 Write the name of the parts in the Table 1.

Table 1

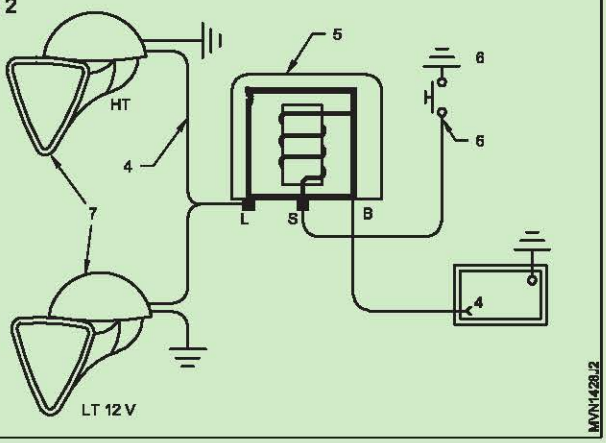
Sl. No.	Label No.	Name of the Parts and its rating
1	2	
2	5	
3	4	
4	1	
5	3	
6	11	
7	15	
8	12	
9	14	
10	6	
11	7	
12	9	
13	13	
14	16	
15	10	
16	8	

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TASK 4: **Checking the relay in horn circuit**

1 Disconnect the electrical connection from the horn relay (5) as shown in Fig 1.

Fig 2



2 Loosen the mounting nuts of the horn relay and remove it.

3 Check the condition of the horn relay using a rheostat and voltmeter.

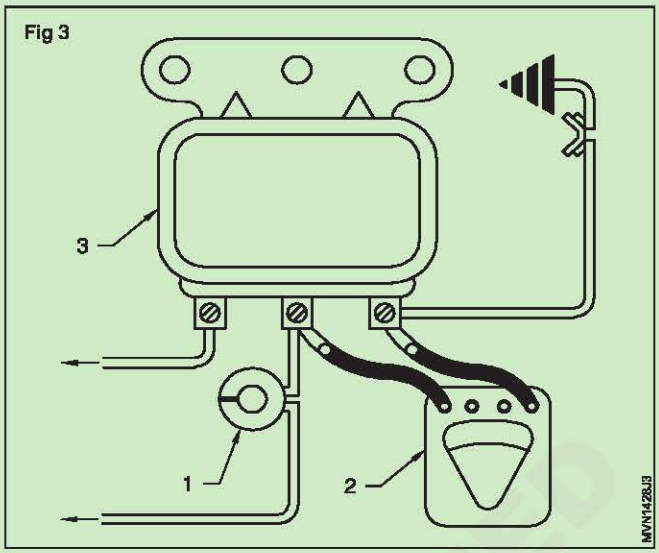
4 Connect the rheostat (1) in series to the battery and horn relay (3) (Fig 2)

5 Connect the volt meter (2) across the winding of the relay (3) to measure the closing voltage as shown in Fig 2.

6 Start the full resistance in the circuit. Slide the knob to increase or decrease the voltage on the relay winding.

If there is an error when the relay point closes, adjust by bending the armature spring post. (Increasing the spring tension increases the closing voltage.)

Fig 3



7 Replace the relay, if necessary.

8 Place the horn relay in its position and tighten the mounting nuts.

9 Refit the spring and the horn switch.

10 Fit the retainer and press it.

11 Connect the wires to the switch of the horn relay and sound the horn.

12 Operate the horn switch and test for the correct horn note.

Checking HL & Wiper motor relay.

Repeat the Task of checking the Relay.

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Diagonize electrical circuits

Objectives : At the end of this exercise you shall be able to
- **check the DC series circuit joints**
- **check the DC parallel circuit joints**
- **check the DC series parallel circuit.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Multimeter - 1 No.
- Ohm meter - 1 No.

Equipments

- Battery 12V - 1 No..

Materials

- Wires 4 mm - as reqd.
- Insulation tape - as reqd.

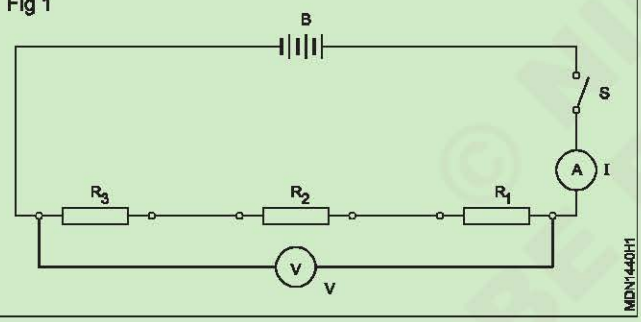
PROCEDURE

TASK 1 : **DC series circuit**

1 Prepare the D.C series circuit diagram

2 From a circuit as shown in the Fig 1.

Fig 1



3 Close the switch 'S', measure the current 'I' and voltage 'V'.

4 Enter the measured values in Table 1.

5 Switch off the supply, connect the ammeter and voltmeter as shown in the Fig 2. Switch on the supply and measure voltage V_1 and current I_1 through R_1.

6 Switch off the supply, connect the ammeter and voltmeter as shown in the Fig 3. Switch on the supply and measure the voltage V_2 and the current I_2 in R_2.

7 Draw circuit diagram showing the position of 'A' and 'V' in the circuit to measure the current I_3 and voltage V_3 across R_3.

8 Connect and measure I_3 and V_3 across R_3.

9 Enter the measured values in Table 1.

Fig 3

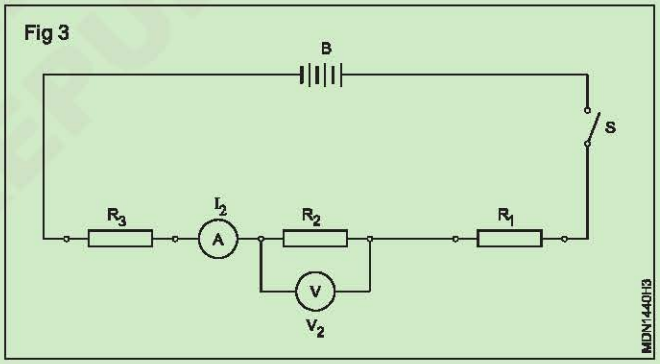


Fig 2

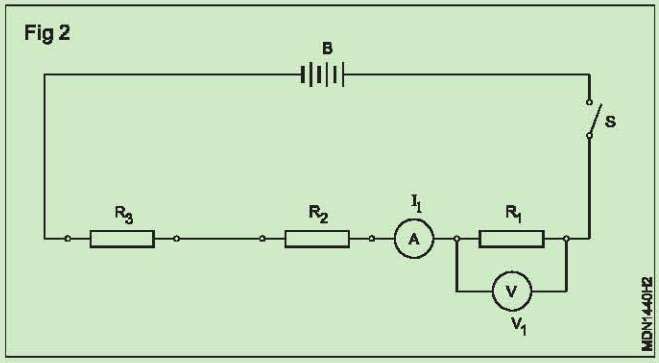


Table 1

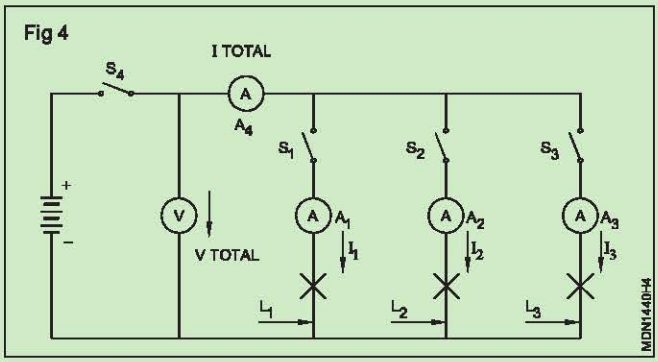
Values	Total circuit	$R_1 = 10$	$R_2 = 20$	$R_3 = 10$
Current	I =	I_1 =	I_2 =	I_3 =
Voltage	V =	V_1 =	V_2 =	V_3 =
Resistance	R =	R_1 =	R_2 =	R_3 =

TASK 2 : **DC parallel circuit**

1 Prepare the D.C parallel circuit diagram

2 Form the branches 1,2,3 by connecting double contact single filament 20W bulbs L_1, L_2, L_3 with a holder, an ammeter A4 of 0-30 Amp DC (1 Amp. DIV) and switch 'S_4' in series. (Fig 4)

Fig 4



3 Connect the lamp terminals of the three branches connect with the lead of the switch S_4.

4 Form the circuit as shown in circuit diagrams with voltmeter (V), ammeter (A_4), switch 'S_4' and battery.

5 Close the switch 'S_4' and switch 'S_1' in branch 1.

6 Read the ammeters 'A_4' and 'A_1' and record the values in Table 2.

7 Close the switches 'S4' , 'S1' and 'S2' in branch 2.

8 Read the ammeters 'A4' 'A1' and 'A2' and record the values in Table 2

9 Close the switches 'S4', 'S1', 'S2', and 'S3' in branch 3.

10 Close the switches 'S4', 'S1', 'S2' and 'S3' in branch 3.

11 Read the ammeters 'A4' 'A1' 'A2' and 'A3' and record the value in Table 2.

12 Repeat the above steps after clamping the torch lamp in any one branch with 6v 300 mA lamp and record the results in Table 2.

13 Repeat the exercise by replacing all the three 'lamps with holder' by wire-wound resistors' (two numbers of 100 ohms and one of 150 ohms).

Table 2

Sl. No.	I_1	I2	I3	I	Total	Switches closed	Components in the branches
1						S_4, S_1	3 lamps of 1.7 Amps each
2						S_4, S_1, S_2	"
3						S_4, S_1, S_2, S_3	"
4						S_4	"
5						S_4, S_1	2 lamps of 1.7 Amps lamp and one 300mA
6						S_4, S_1, S_2	"
7						S_4, S_1, S_2, S_3	"
8						S_4, S_1	Resistors two-one 100 ohms and another 150 ohms
9						S_4, S_1, S_2	"
10						S_4, S_1, S_2, S_3	"

— — — — — — —

TASK 3 : **DC Series parallel circuit**

Prepare the D.C series parallel circuit diagram

1 Calculate the voltage and currents for the series parallel circuit shown in Fig 5. Enter the values in Table 3.

2 Calculate the total resistance R_T and total current I_s for V_s = 50V and enter in Table 4.

3 Set the value of the rheostat resistances equal to the value given in Fig 6 (i.e. R_1 = 25 ohms, R_2 = 300 ohms, R_3 = 40 ohms and R_4 = 60 ohms by measuring the resistance value between one end and the variable point of the rheostat)

4 Form the circuit and measure the voltage and current. Record them in your note book.

5 Calculate the value of R_T from V_s and I_s and record them in your note book and Compare with the value obtained in step 3.

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Fig 5

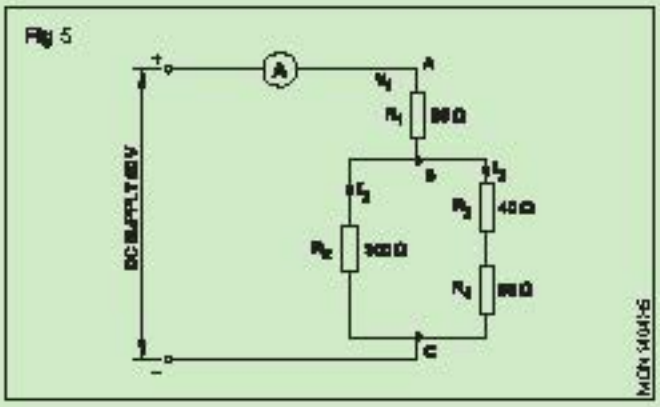


Table 4

Calculated Values	$R_T = R_1 + R_4\{R2 \mid\mid (R_3 + R_4)\} =$
Measured Values	$R_T = \frac{V_S}{I_S}$

Table 3

		V_{R1}	I_1	I_2	V_{R2}	I_3	V_{R2}	I_3	V_{R3}	R_3+R_4	$R_2 \mid\mid (R_3+R_4)$
V_s = 50V R_1 = 25W R_2 = 300W R_3 = 40W R_4 = 60W	Calculated Values										
	Measured Values										

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Exercise 1.4.29

Trouble shoot electrical circuit problem

Objective: At the end of this exercise you shall be able to
- **test the auto electrical components by using vehicle wiring circuits.**

Requirements

Tools/Instruments

• Trainee's tool kit	- 1 No.
• Test lamp	- 1 No.
• Multimeter	- 1 No.

Equipments

• Auto electrical wiring circuit	- 1 No.
• Battery	- 1 No.

Materials

• Fuse	- as reqd.
• Switch	- as reqd.
• Cable/Wire	- as reqd.

PROCEDURE

1 Identify the electrical (1-34) Components in the vehicle by using the automobile wiring circuits as shown in Fig 1.

2 Draw the starting circuit.

3 Draw the ignition circuit.

4 Draw the charging circuit.

5 Draw the flasher circuit.

6 Draw the lighting circuit.

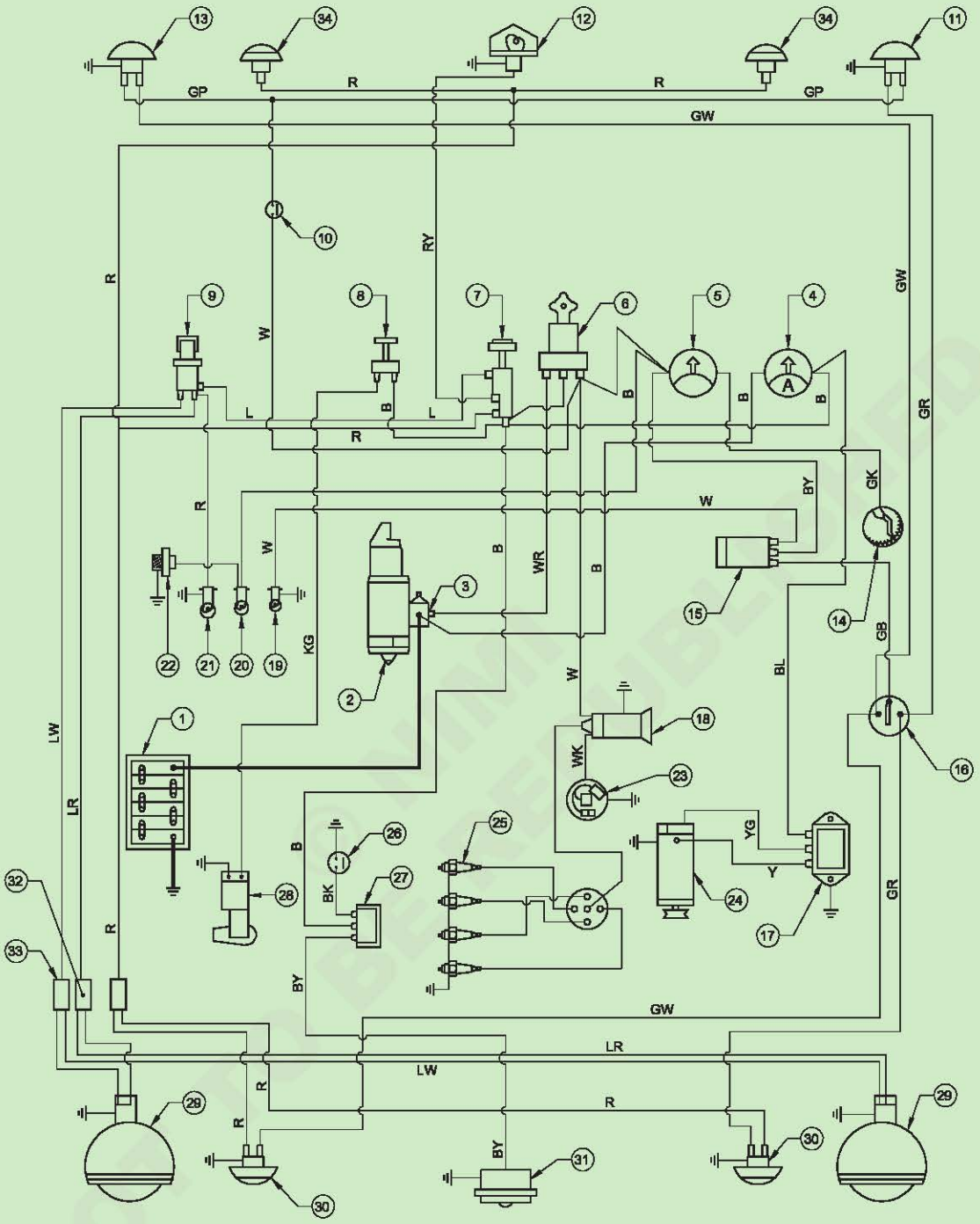
7 Place the auto wiring board on the work bench.

8 Connect with battery.

9 Check its function.

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Fig 1



Cleaning and top - up of lead acid battery

Objectives : At the end of this exercise you shall be able to
- **clean the battery terminals and the body of the battery**
- **check the level of the electrolyte and top-up**
- **check the specific gravity of the electrolyte with hydrometer**
- **measure the cell voltage and the battery voltage.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Hydrometer - 1 No.
- Multimeter - 1 No.
- Lead acid battery 6V or 12V 80AH - 1 No.

Equipments

- Battery Charger - 1 No.

Materials

- Distilled water - as reqd.
- Vaseline - as reqd.
- Cotton rag - as reqd.
- Sand paper - as reqd.
- Soda bicarbonate - as reqd.

PROCEDURE

Cleaning and Top-up of lead acid battery

1 Clean the battery terminals, if corroded, with sandpaper: if sulphated, clean with wet cotton waste or with soda bicarbonate.

Do not damage the battery terminal by scraping with any metal strip.

2 Unscrew all the vent plugs and check the level of the electrolyte.

Do not clean the battery top surface keeping the vent plugs open. The accumulated dirt may fall inside the cells and form sediments.

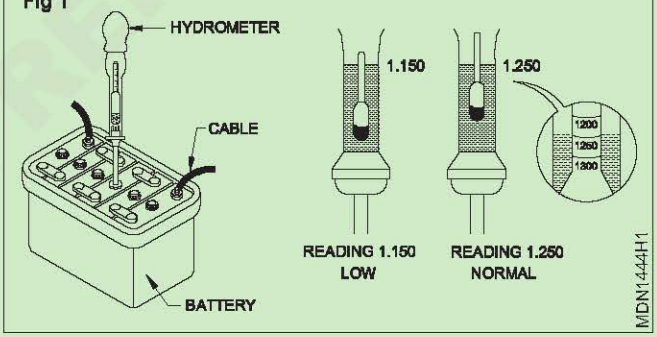
3 Top up the electrolyte to the marked level in all the cells with distilled water.

No electrolyte to be used to top up battery.

4 Open cell cap of battery and keep Hydrometer inside. Pump electrolyte upto reference mark.

5 Check the initial specific gravity of the electrolyte of each cell using a hydrometer (Fig 1)

Fig 1



Check the specific gravity of a battery

Objectives : At the end of this exercise you shall be able to
- **test the battery with a hydrometer**
- **test the battery with a volt meter.**

Requirements

Tools/Instruments

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

Equipments

- Vehicle - 1 No.

Materials

- Vaseline - as reqd.
- Battery acid - as reqd.
- Distilled water - as reqd.

PROCEDURE

TASK 1 : **Check the specific gravity and open circuit voltage test**

1 Disconnect the negative cables first from the battery terminal.

2 Disconnect the positive cables from the battery terminal.

3 Remove the mounting clamp nuts.

4 Lift the battery from the vehicle.

5 Clean the top of the battery with water and cotton rag.

6 Clean the battery terminals by a non-metallic wire brush or emery-paper.

7 Check and top up the electrolyte level with distilled water. (if necessary)

8 Keep the battery on a level wooden workbench.

9 Remove all the vent plugs.

10 Hold the hydrometer vertically. (Fig 1)

11 Place the nose of the hydrometer in the cell. Ensure that the nose is dipped in the electrolyte.

12 Press the rubber bulb of the hydrometer.

13 Release it to draw the electrolyte upwards. Ensure that the electrolyte does not come into the bulb.

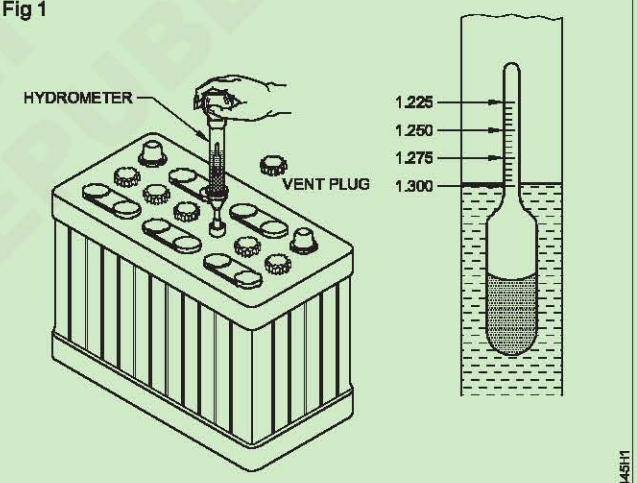
14 Note the float level which is floating in the electrolyte.

15 Record the reading in Table 1.

Table 1

1	2	3	4	5	6

Fig 1



TESTING SPECIFIC GRAVITY OF A BATTERY

16 Repeat the same procedure for all the cells and record the readings.

The above reading should not vary more than 25 points between cells.

Protect your hands and clothes from the battery acid.

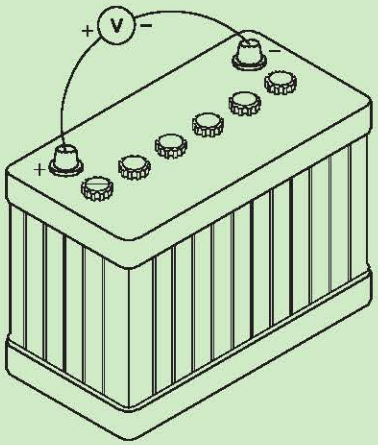
17 Connect the leads of the DC voltmeter (2) to the battery terminal (+ve to -ve). (Fig 2)

18 Take the reading from the voltmeter and record.

19 The voltmeter should read atleast 13.2 volts per battery. After carrying out the above tests compare the readings with the manufacturer's specifications. Recharge/ replace the battery if it is in poor condition.

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Fig 2



20 Clean the vent holes and tighten all the vent plugs.

21 Smear the battery terminals with Vaseline.

22 Place the battery in its position in the vehicle.

23 Tighten the battery mounting clamp nuts.

24 Clean the battery lugs with baking soda solution and water.

25 Connect the battery +ve cable first and tighten it.

26 Connect the battery -ve cable and tighten it.

27 Start the engine. Check whether the battery supplies sufficient current.

Disconnect the ground cable (-ve cable) first. This will minimize the possibility of arcing and a resultant battery explosion.

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Charge the battery

Objectives : At the end of this exercise you shall be able to
- **connect the battery to charger**
- **charge the battery in constant current method**
- **charge the battery in constant voltage method.**

Requirements

Tools/Instruments

• Trainee's tool kit	- 1 Set.
• Hydrometer	- 1 No.
• Volt meter	- 1 No.

Equipments

• Battery charger	- 1 No.
• Vehicle	- 1 No.

Materials

• Vaseline	- as reqd.
• Battery acid	- as reqd.
• Cable/Wire	- as reqd.
• Distilled water	- as reqd.
• Cotton rag	- as reqd.
• Water emery	- as reqd.

PROCEDURE

TASK 1 : **Battery charging**

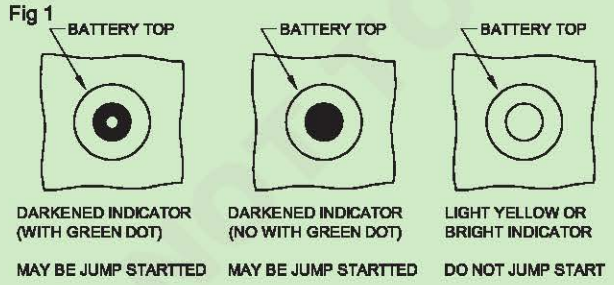
1 Place the battery on the charging table.

2 If the battery is not sealed, check the electrolyte level in all of the cells and adjust the level if necessary.

Do not attempt to charge a battery that appears to be frozen or if ice crystals are visible in the electrolyte. Allow the battery to become unfrozen fully before charging is attempted.

3 If the battery is sealed battery, check the built in hydrometer. Do not attempt to charge the battery if the indicator appears clear or light yellow. (Fig 1)

Fig 1



4 Clean the battery terminals and the battery top.

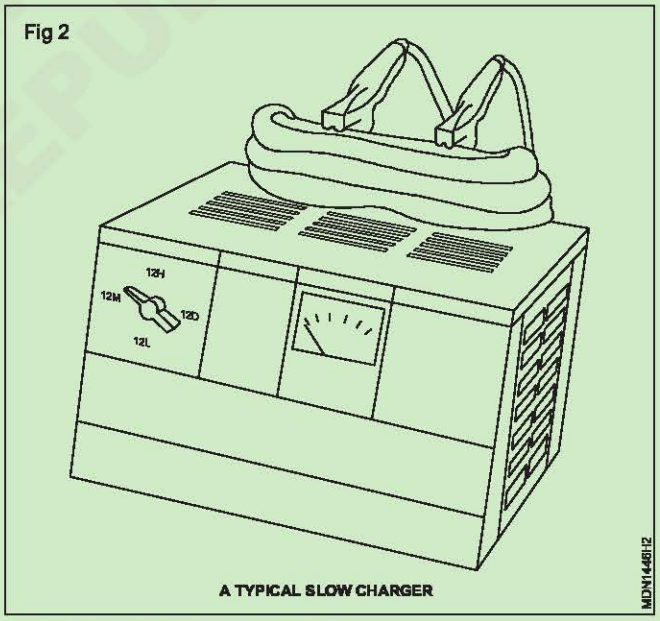
5 Consult an appropriate manual and determine the charging rate and time for the battery.

6 Turn off the charger switch. (Fig 2 & Fig 3)

Connect the charger leads to the battery. The positive (+) lead must be connected to the positive (+) terminal.

The negative (-) lead must be connected to negative (-) terminal.

Fig 2



7 Turn on the charger switch.

On some chargers, the timer must be set to turn on the charger.

8 Adjust the charging rate.

9 Adjust the timer.

10 Check the charging rate and the battery temperature after the battery has been charging for about 15 minutes. Adjust the charging rate if required.

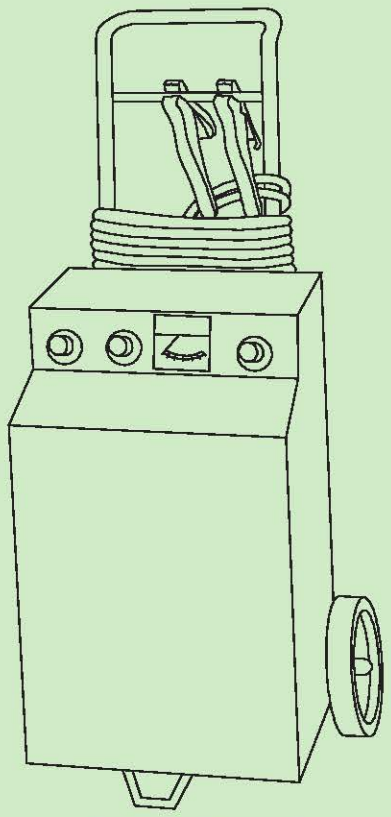
11 Continue charging until the allotted time or until the battery is fully charged.

12 Turn off the charger switch.

13 Disconnect the charger leads from the battery.

Watt rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes	50 Amperes
Below 2450	10 Hours	5 Hours	2 ½ Hours	2 Hours	-	-
2450-2950	12 Hours	6 Hours	3 Hours	2 Hours	1 ½ Hours	-
Above 2950	15 Hours	7 ½ Hours	3 ¼ Hours	2 Hours	1 ¾ Hours	1 ½ Hours

Fig 3



A TYPICAL FAST CHARGER

MDN1445H3

To avoid damage, charging rate must be reduced or temporarily halted if:

Electrolyte temperature exceeds 125°F.

Violent gassing or spewing of electrolyte occurs.

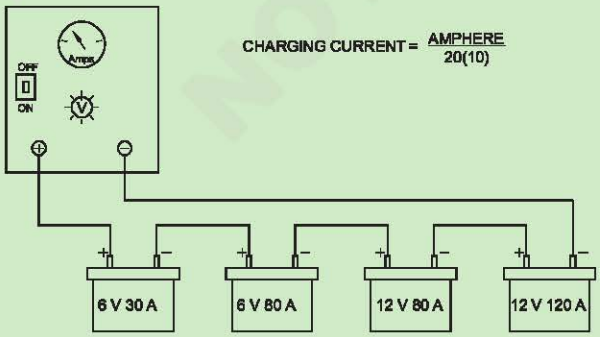
Battery is fully charged when over a two hour period at a low charging rate in amperes all cells are gassing freely and no change in specific gravity occurs. For the most satisfactory charging, the lower charging rates in amperes are recommended.

Full charge specific gravity is 1.260-1.280 corrected for temperature with electrolyte level at split ring.

TASK 2 : **Constant current charging method**

1 Connect all the batteries in series as shown in Fig 1.

Fig 1



CONSTANT CURRENT METHOD

MDN1445I1

2 Connect the charger to batteries.

3 Set the voltage rate in charger according to no. of batteries.

4 Charge the battery.

5 Switch off the battery charger

6 Test the specific for gravity of each battery.

7 Record the reading in Table. 1

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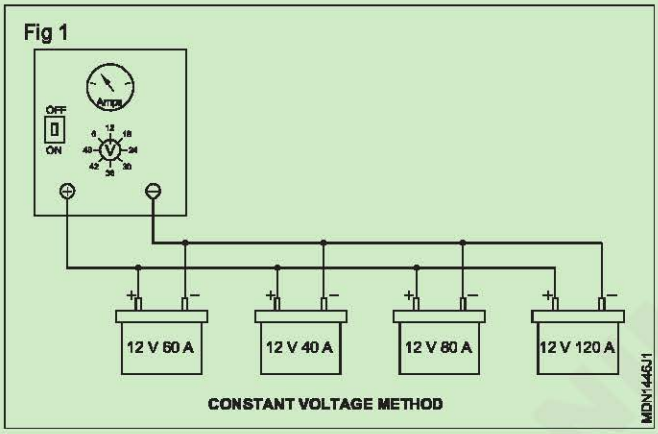
Table 1

Cell Battery	1	2	3	4	5	6
1						
2						
3						
4						

TASK 3 : **Constant voltage charging method (Fig 1)**

1 Connect all the batteries in parallel as shown in Fig 1

Fig 1



CONSTANT VOLTAGE METHOD

2 Connect the charger to batteries.

3 Set the current rate by varying the voltage to be charged.

4 Charge the battery till full charging

5 Switch off the battery charger

6 Record the readings in Table 2.

7 Parasitic draw (Switch off) of battery

8 Check the battery for self discharge by checking the battery charged condition periodically.

9 Check the battery, for discharge, externally as follows

10 Switch off the ignition switch

11 Check and clean the impurities and contaminated water layer on the top of the battery

12 Clean the top surface of the battery after topup the battery

13 Check any loose contact between battery post & terminals

14 Check any loose contact in the auto vehicle wiring circuit

15 Check and Replace the defective contact of all switches in the vehicle

16 Check and clean the sulphur formation of battery terminals

Table 2

Cell Battery	1	2	3	4	5	6
1						
2						
3						
4						

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Check the relays and solenoid

Objectives : At the end of this exercise you shall be able to
- **check the condition of the solenoid switch in the starting system**
- **check the condition of the relay in the wiring circuit.**

Requirements

Tools/Instruments

• Trainee's tool kit	- 1 No.
• Test lamp	- 1 No.
• Multimeter	- 1 No.

Equipments

• Vehicle	- 1 No.
• Battery	- 1 No.

Materials

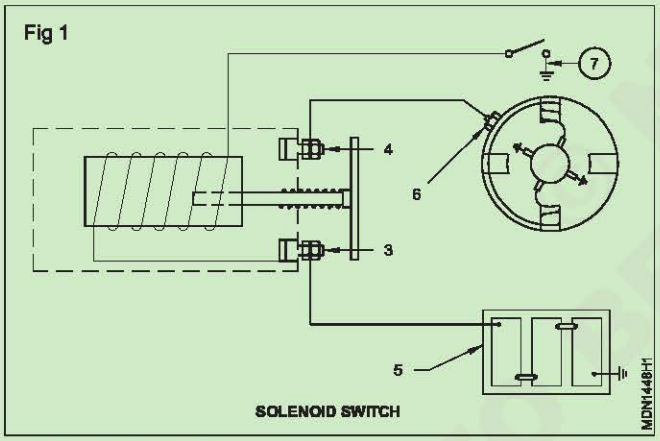
• Fuse	- as reqd.
• Switch	- as reqd.
• Cable/Wire	- as reqd.
• Insulation tape	- as reqd

PROCEDURE

TASK 1: **Checking solenoid switch**

1 Check the solenoid switch terminals (3&4) and clean them. (Fig 1)

Fig 1



2 Check the battery cable connections from the battery (5) to the solenoid switch terminals (3). Tighten if found loose.

3 Check the battery cables from the solenoid switch terminals (4) to the starter motor terminals (6). Tighten it if found loose.

4 Check the wire connection from the solenoid switch terminals to the starting switch (7).

5 Connect the test lamp to the brake light switch terminal (1&2). If the switch is not closed, the lamp will glow.

6 Disconnect the cable wires from the solenoid switch.

7 Connect one end of the test lamp with the solenoid switch terminal (3) and ground the other end of the test lamp.

8 It will burn, but this test will not indicate short circuit.

9 Connect one end of the test lamp with starter switch terminal and the other end to the earth with switch open. If the lamp burns bright, the solenoid is shorted. Replace the switch.

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TASK 2 : **Checking the relay in horn circuit**

Refer the exercise 1.4.27 for Task 4.

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Practice on testing diodes

Objectives : At the end of this exercise you shall be able to
- **identify the type of diode package**
- **determine the forward to reverse resistance ratio of diodes**
- **identifying transistor**
- **testing transistor**

Requirements

Tools/Instruments/Equipments

- Trainee's tool kit - 1 No.
- Multimeter - 1 No.
- Transistor - as reqd.
- Data book - 1 No.

Materials/Components

- Assorted types of diodes/Transistor (Blue, yellow, black red colour) - 20 No./each.
- Red colour sleeve wire - 10 cms. each
- Patch cords - as reqd.

PROCEDURE

TASK 1 : **Identify diode package and terminals**

1 Pick any one diode from the given assorted lot. Record the code number printed on the diode in O&T sheet.

2 For the chosen diode, refer chart 1 and identify and record the type of package (such as glass/plastic/ ceramic/metal etc.).

3 For the chosen diode referring to Chart 1, identify and put a small red colour sleeve over the anode terminal of the diode.

4 Repeat step 1 to 3 for atleast 5 diodes of different types and get your work checked by your instructor.

TASK 2 : **Checking diodes using ohmmeter/multimeter**

1 Set the ohmmeter/multimeter to x100 ohms range. Carryout resistance-zero-setting of meter.

Choose other ohms range if necessary.

2 Pickup one of the identified diodes in Task 1. Connect the ohmmeter probes across the diode terminals as shown in Fig 1a. Record the resistance reading shown by the meter in Table 1 of O&T sheet.

3 Reverse the meter probes connected to the diode as shown in Fig 1b and record the reading shown by the meter in the Table 1.

4 From the readings noted in steps 2 and 3, calculate and record the ratio between forward and reverse resistance.

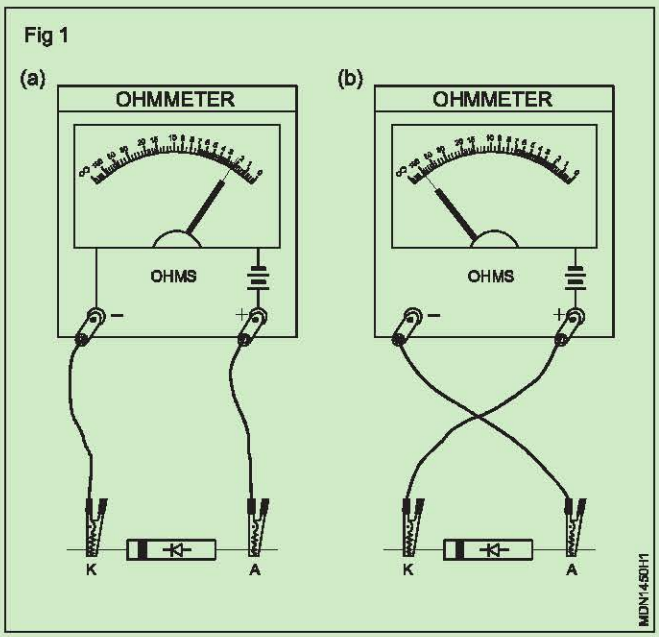
5 From the recorded information give your conclusion about the condition of the diode. Use the tips given below for making conclusion;

- In good diodes, resistance will be less than 100 ohms in one direction and very high or almost infinity/open in the other direction. In the worst cases the ratio between low to high resistance could be at least 1:1000.
- Shorted diodes show zero or very low resistance in both directions.
- Open diodes shows infinity/open in both directions.

6 Repeat step 2 to 4 for atleast ten more given diodes of different types.

7 Get the work checked by your instructor.

Fig 1



Observation and Tabulation Sheet

Table 1

Label Number	Code Number printed on the DIODE	Type of package	Resistance value in		Ratio between forward and reverse resistance	Condition of diode FIT/UNFIT
			one direction	opposite direction		

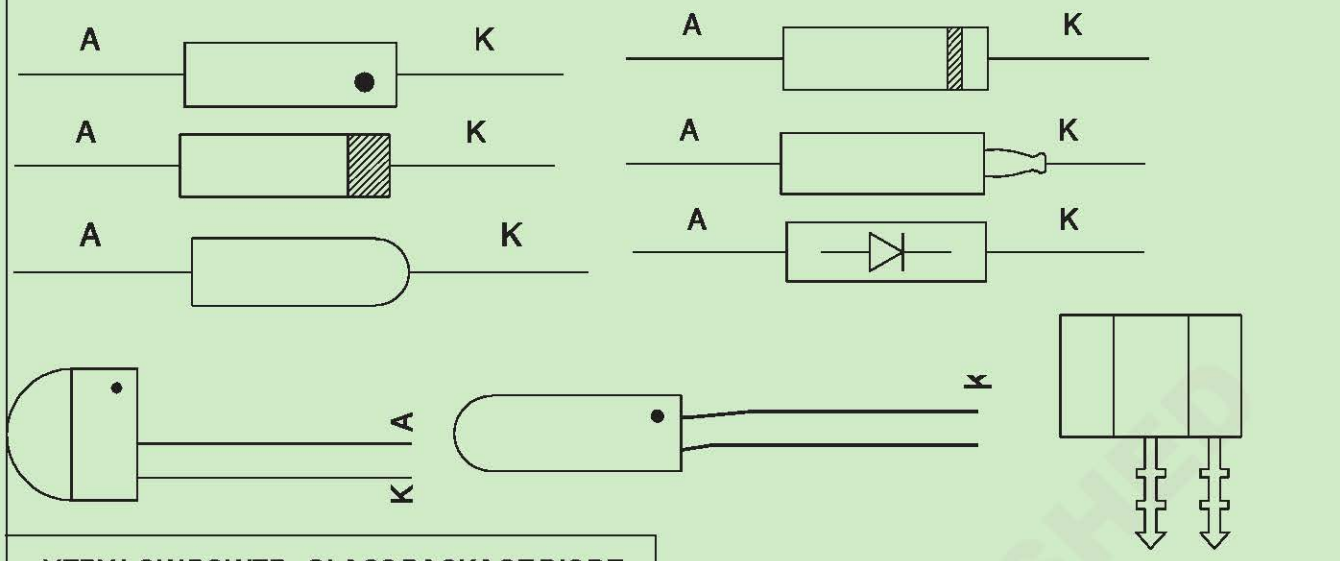
(Trainee) (Instructor)

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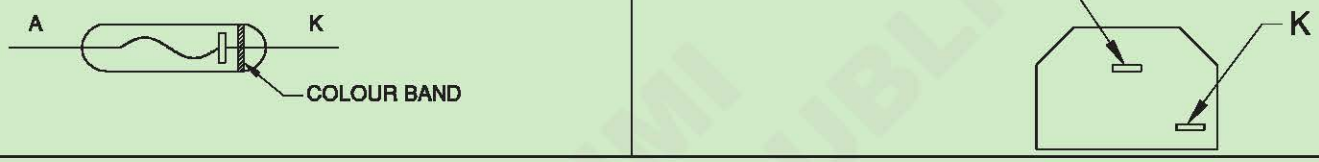
CHART 1

TYPES OF DIODES AND PACKAGING

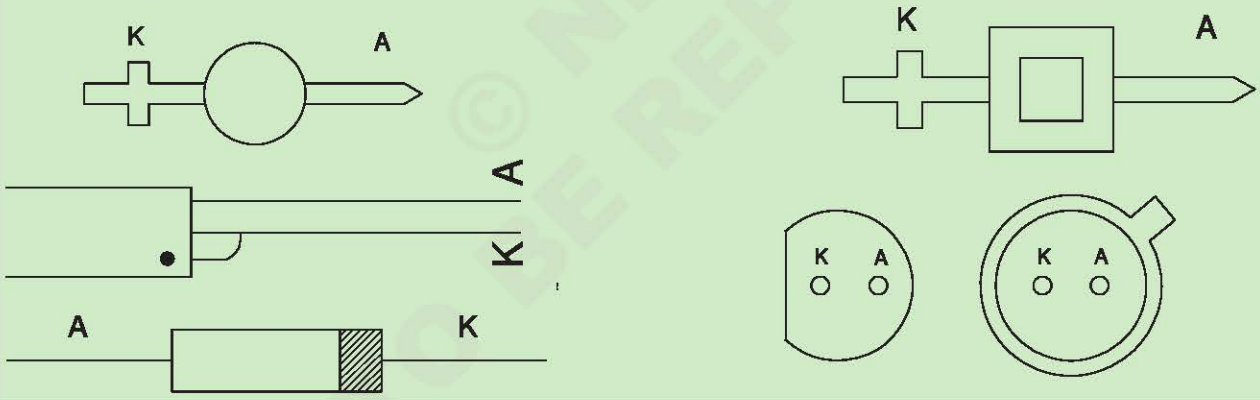
LOW POWER - PLASTIC PACKAGE DIODES



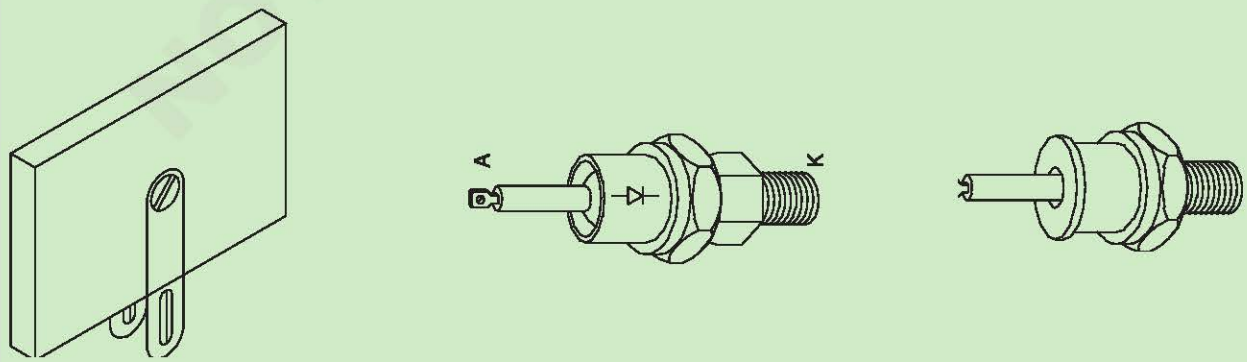
VERY LOW POWER - GLASS PACKAGE DIODE



LOW POWER - METAL PACKAGE DIODE

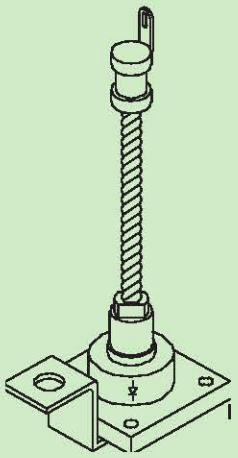


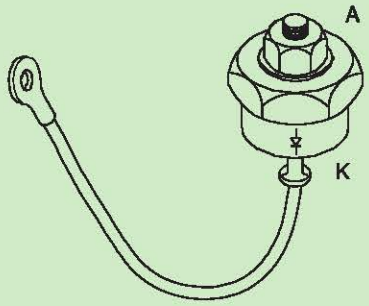
HIGH POWER - METAL PACKAGE DIODE



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VERY LOW POWER - METAL PACKAGE DIODES





TASK 3 : **Identifying transistor type and leads, referring to data manual**

1 Take any one transistor from the given assorted lot, enter its label number and transistor type number in Table 1.

2 Refer to transistor data manual and find and record the following details of the transistor in Table 1 of O&T sheet.

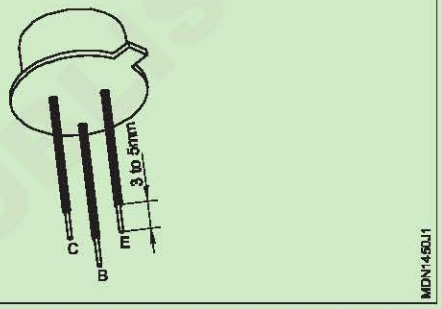
- Whether silicon or germanium
- Whether NPN or PNP
- Type of packaging or case outline (Example: TO5, TO7 etc.)

3 From the type of package recorded, the transistor data manual and draw the pin diagram indicating base, emitter and collector for the transistor, in Table 1.

4 Put sleeves of suitable length, as shown in Fig 1, to the identified pins of the transistor using the colour scheme given below.

Base	-	Blue colour sleeve
Emitter	-	Red colour sleeve
Collector	-	Yellow colour sleeve
Shield	-	Black colour sleeve

Fig 1



Note: In some power transistors, the metal body itself will be the collector. In such cases mark 'C' on the metal body using a pencil. All transistors will not have shield pin.

5 Repeat steps 1 to 4 for atleast five transistors of different types in the given lot and get your work checked by your instructor.

TASK 4 : **Testing transistor**

1 Identify which terminal of the ohmmeter being used is connected to the +ve terminal of the internal battery of the meter. Set the meter range to Rx100W.

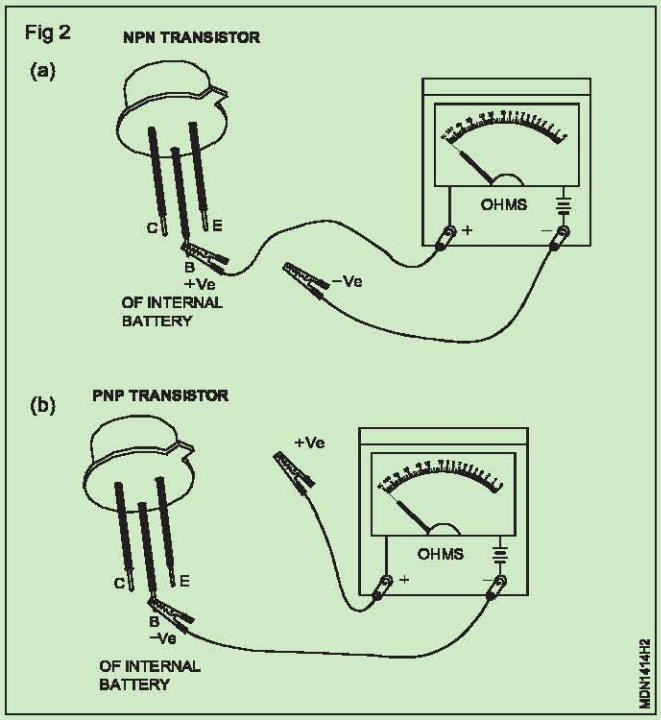
Ohmmeters in very low or very high ohms range can produce excessive current/voltage and may damage low power transistors while testing.

2 Take a transistor whose pins are identified and sleeved at Task 3. Depending on whether the chosen transistor is NPN or PNP, clip/hold the +ve or -ve of the meter prod to the base of the transistor as shown in Fig 2a and 2b.

3 Clip the other meter prod to the emitter. Check if the base-emitter junction diode of transistor shows low resistance (few tens of ohms) or very high resistance (few tens of kilo ohms). Record your observation in Table 1.

4 Reverse the polarity of the prod connected across the base-emitter and check if the base-emitter junction diode of transistor shows low resistance or very high resistance. Record your observation in Table 1.

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5 From the recorded observations in steps 3 and 4, and referring to the table given below, conclude and record, the condition of the base-emitter junction diode of the transistor as GOOD, **open** or **shorted** in Table 1 of O&T sheet.

Note: If the resistance of the junction measured in both directions is high, in addition to the condition of the junction given in table, one other possibility is, your identified base pin may be wrong. You may be measuring resistance across emitter-collector. In case of doubt, recheck the identified pins of the transistor and repeat steps 2, 3 and 4.

6 Repeat the steps 2,3,4 and 5 and check the condition of the base-collector junction diode of the transistor.

7 Measure the resistance across the emitter-collector and record the observation as V-HIGH (> 1MW) or LOW (< 500W).

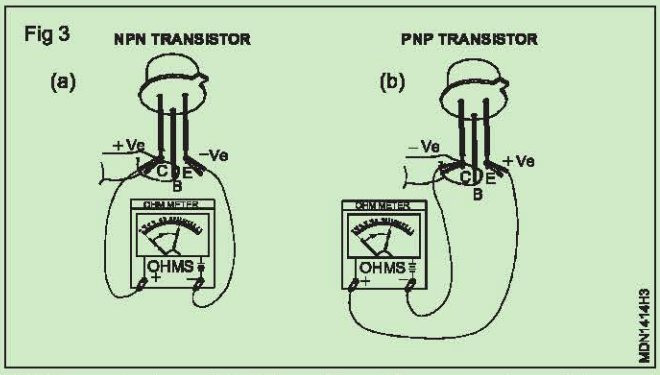
Table 1

Resistance of P-N junction with meter prods in one direction	Resistance of P-N junction with meter in reversed direction	Condition of P-N junction
Low	Very High	Good
Low	Low	Shorted
Very High	Very High	Open (See note above)

Note: In a good transistor the resistance between the emitter and collector will be very high. A low resistance indicates that the transistor is leaky.

8 Clip the meter across the emitter-collector with correct polarity as shown in Fig 3. Touch the base-collector with moist fingers as shown in Fig 3 and check if the resistance shown by the meter decreases indicating that the transistor is turning ON. Record your observation as YES or NO in Table 1 of O&T sheet.

9 From the observations recorded at steps 5,6,7 and 8, give your conclusion on the overall condition of the transistor under test.



10 Repeat steps 1 to 9 for atleast five more transistors of different types.

11 Get your work checked by your instructor.

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Identification of hydraulic and pneumatic components

Objectives : At the end of this exercise you shall be able to
- **identify the hydraulic clutch components in a vehicle**
- **identify the components of pneumatic brake system in a vehicle.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments

- Vehicle with hydraulic clutch - 1 No.
- Vehicle with pneumatic brake - 1 No.

Materials

- Hydraulic oil - as reqd.
- Cotton waste - as reqd.

PROCEDURE

TASK 1 : **Locating of hydraulic clutch components on a vehicle**

1 Place the vehicle on the level ground.

2 Support the vehicle tyre with stoppers (wooden block)

3 Apply hand brakes.

4 Open the bonnet.

5 Remove the negative battery cable.

6 Trace the hydraulic clutch system and locate the components i.e. Master cylinder reservoir, Master cylinder, Slave cylinder, Hydraulic lines and Throw-cut lever.

7 Identify the parts in the system as shown in Fig 1.

8 Write the name of the parts in the Table 1.

Fig 1

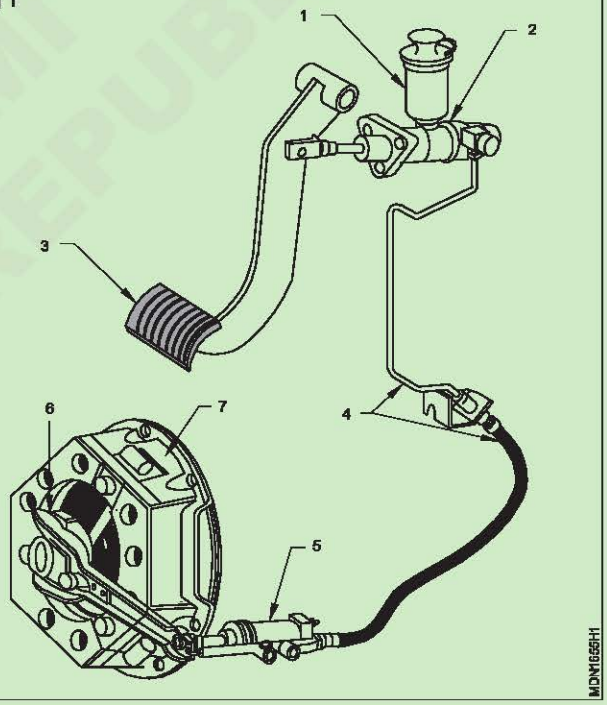


Table 1

Sl. No.	Lable No.	Name of the Parts
1	2	
2	5	
3	4	
4	1	
5	3	

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TASK 2 : **Tracing pneumatic components in a vehicle**

1 Identify the air compressor in the Fig 1, which provide compressed air.

2 Locate air tank , which receives the compressed air from air compressor.

3 Locate unloader valve which unloads excess air, once the set air pressure is reached in air tank.

4 Identify brake valve which permits air to flow, apply brake, when brake pedal is pressed.

5 Locate 2 front breaker chambers and 2 rear brake chambers which pushes slack adjuster for application of front & real bracker

6 Locate black adjusters , for front & rear breaker.

7 Layout diagram of air breaker system.

8 Identify air pressure gauge, which indicated the pressure of air, in the air tank.

9 Write the parts in the table 2.

Fig 1

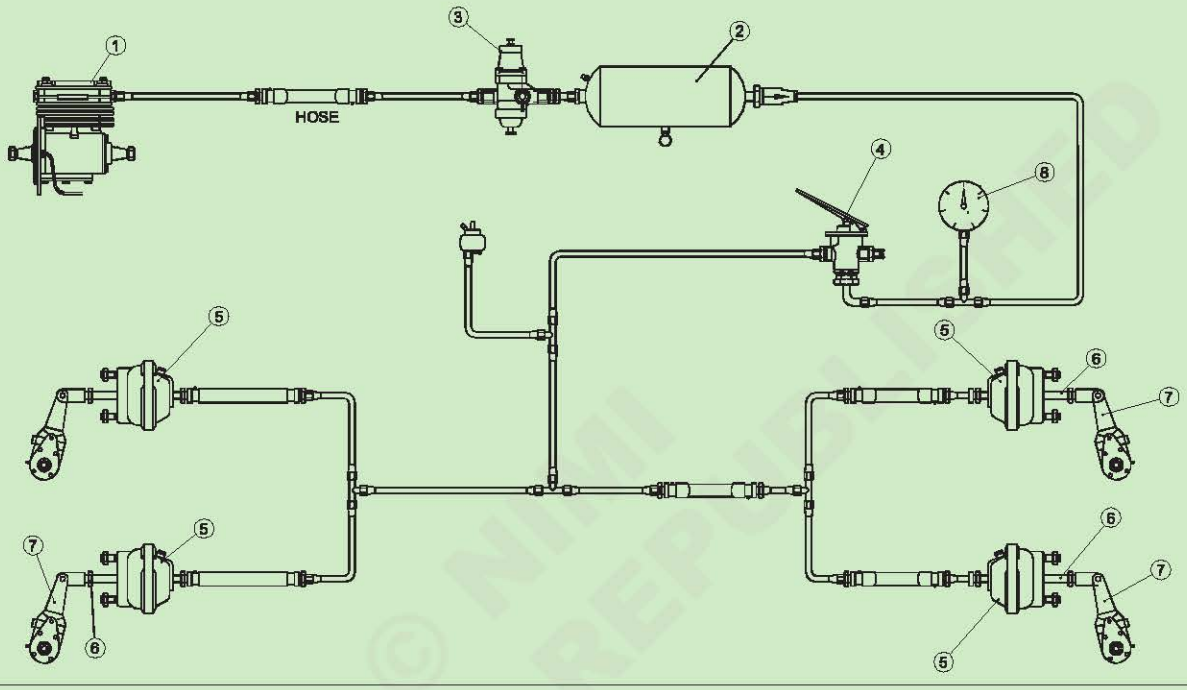


Table 2

Sl. No.	Name of the Parts	Location
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

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Tracing and studying of hydraulic circuits

Objectives : At the end of this exercise you shall be able to
- **identify the parts of hydraulic jack**
- **identify the parts of hydraulic brake.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 Set.
- Bleeding kit - 1 No.

Equipments

- Hydraulic jack trolley type - 1 No.
- Hydraulic power steering in vehicle - 1 No.
- Hydraulic brake in vehicle - 1 No.

Materials

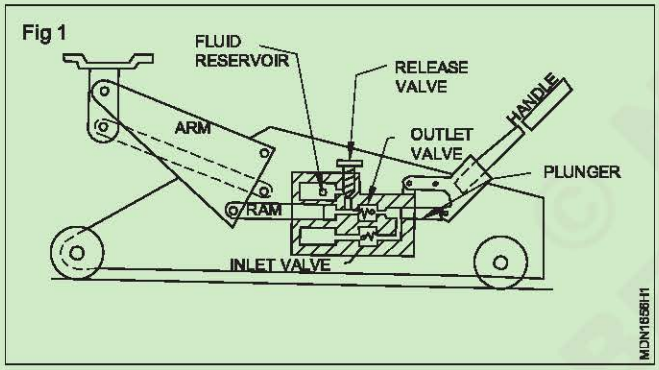
- Cotton waste - as reqd.
- Hydraulic fluid - as reqd.

PROCEDURE

TASK 1 : **Hydraulic jack**

1 Place the cut section model of the hydraulic jack on the work bench. (Fig 1)

Fig 1



2 Trace the hydraulic jack system and locate the components i.e, reservoir, plunger, Non return valve Ram, Relief valve and shut off valve,

3 Identify the parts in the system as shown in Fig 1

4 Write the name of the parts in the table 1

5 The following parts should be matched as given below column (a), arm (b), fluid reservoir (c), Release valve (d), out let valve (e) handle (f) plunger (g) & Inlet valve (h).

Table 1

Sl. No.	Label word	Name of the parts
1	f	
2	d	
3	b	
4	g	
5	e	
6	a	
7	c	

TASK 2 : **Identify the components of the hydraulic brake system**

1 Place the cut-section model of the hydraulic brake system on the work bench.

2 Draw the line diagram of hydraulic brake system.

3 Locate the parts of the hydraulic brake system (Fig 1) and drum braking system. (Fig 2 & 3) i.e.Brake pipe line unions, Brake push-rod, Brake flexible hoses, Brake pedal return spring, Master cylinder, Hold down spring, Brake lining, Brake steel pipe lines, Brake adjuster, Shoe return spring, Stop light switch, Hand brake lever, Pivot, Brake plate carrier, Wheel cylinder, Parking brake cable, Brake shoe, Brake pedal, Lock nut and Clevis.

4 Write the name of the parts in the Table 1.

Fig 1

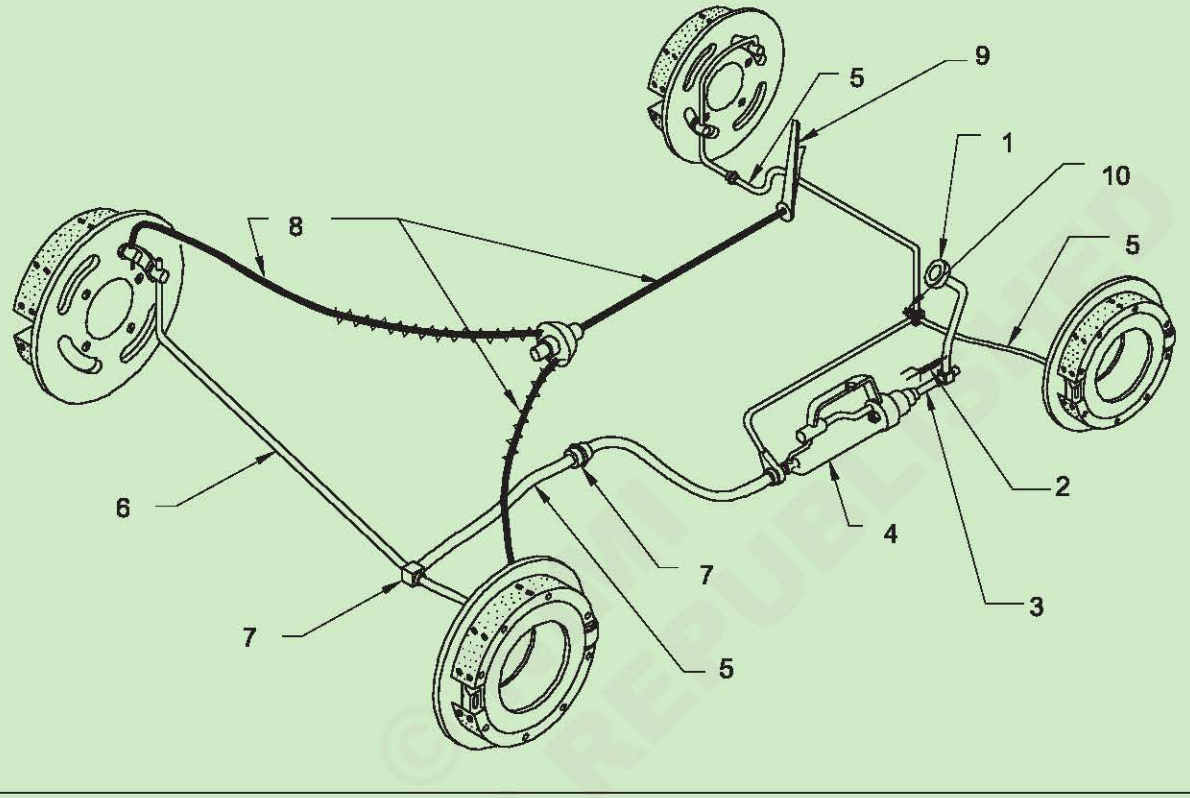


Fig 2

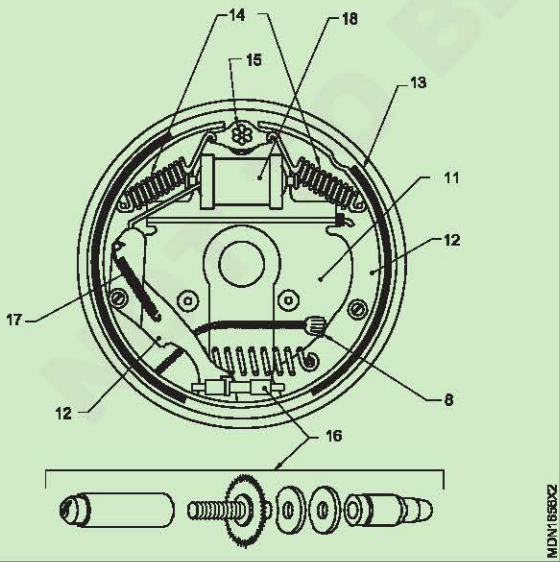
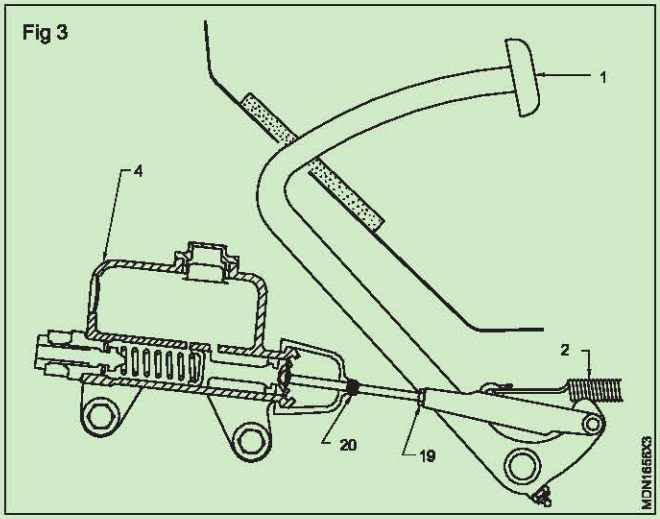


Fig 3



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Table 1

Sl. No.	Label No.	Name of the Parts
1	2	
2	5	
3	4	
4	1	
5	3	
6	11	
7	15	
8	17	
9	12	
10	18	
11	14	
12	19	
13	6	
14	20	
15	7	
16	9	
17	13	
18	8	
19	10	
20	15	

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Tracing and studying of air brake system

Objective : At the end of this exercise you shall be able to
- **identify the components of pneumatic brake system in a vehicle.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 Set.

Equipments

- Vehicle with air brake system - 1 No.

Materials

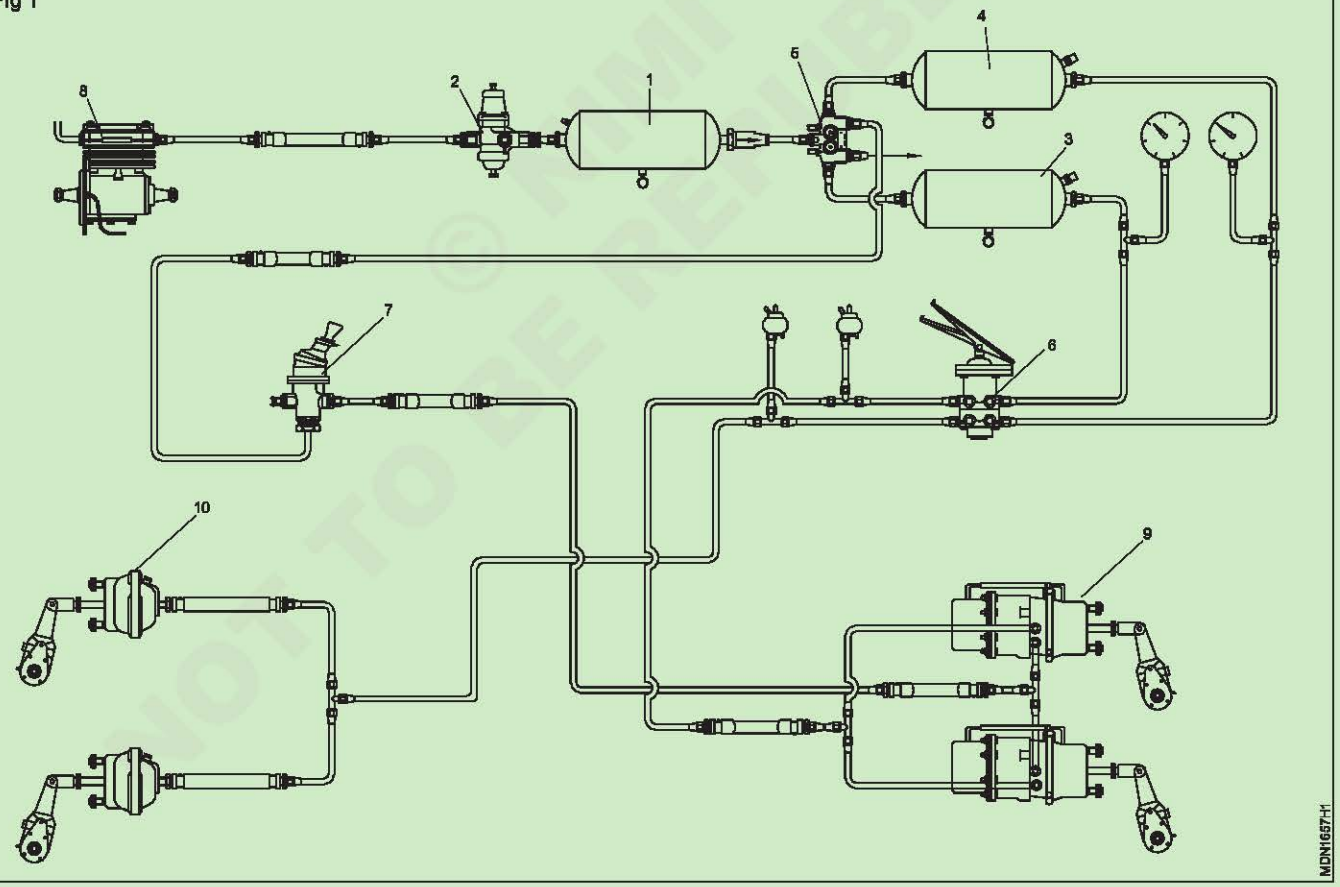
- Cotton waste - as reqd.

PROCEDURE

1 Locate the parts of the pneumatic brake system. Air tank, air compressor, unloader valve service reservoirs, protective valve or brake valve, hand control valve brake chamber, air union.

2 Write the name of the parts in the Table 1.

Fig 1



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Table 1

Sl. No.	Label No.	Name of the Parts
1	2	
2	5	
3	4	
4	1	
5	3	
6	6	
7	7	
8	9	
9	10	
10	8	

———————

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Identify the different types of vehicles

Objective: At the end of this exercise you shall be able to
- **identify the different types of vehicles.**

PROCEDURE

1 Locate the type of vehicle name (Fig 1)

a) Car b) Truck Punjab body or straight truck c) Truck half body d) Truck Flat form type e) Tractor f) Tractor with articulated trailer g) Tanker h) delivery van i) Dumper truck j) Station wagon k) Pick up l) jeep

2 Write the name of the parts in Table 1.

Fig 1

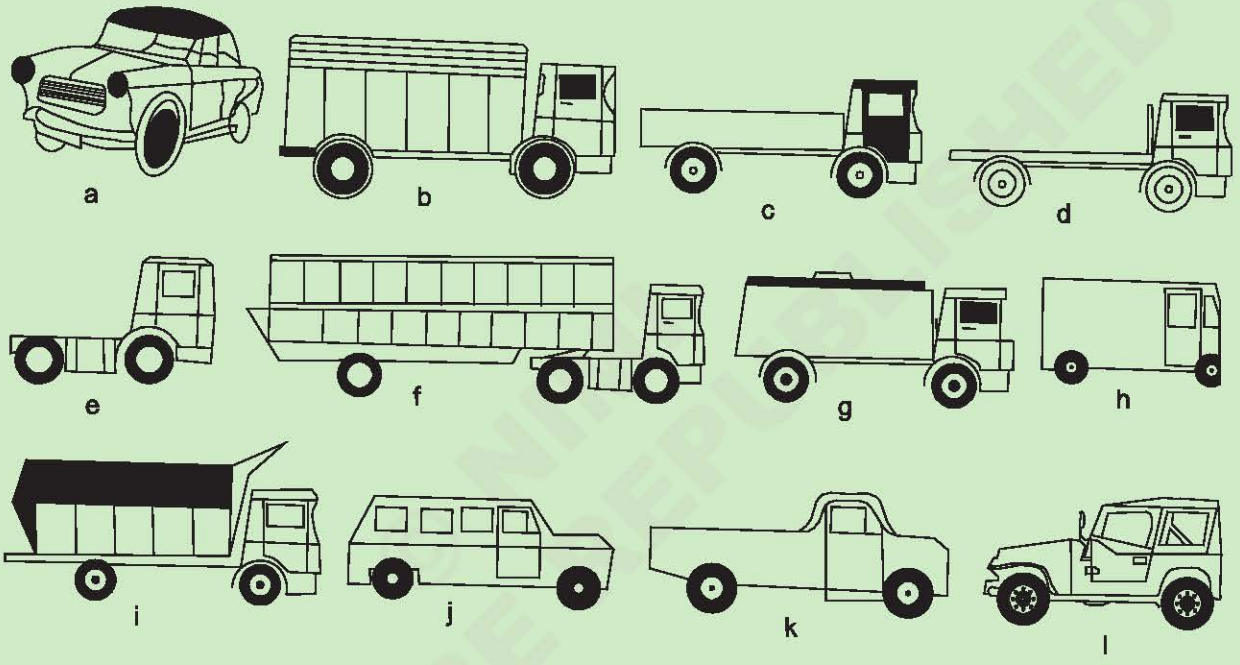


Table 1

Sl.No.	Match word	Vehicle name	Sl.No.	Match word	Vehicle name
1	b		11	i	
2	a		12	f	
3	e				
4	d				
5	c				
6	g				
7	h				
8	l				
9	k				
10	j				

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Studying vehicle specification data

Objectives : At the end of this exercise you shall be able to
- **identify the parts of the vehicle**
- **check the specification of the parts as per vehicle specification data.**

Requirements

Tools/Instruments

• Trainee's tool kit	- 1 No.
• Compression gauge	- 1 No.
• Measuring tape	- 1 No.
• Vacuum gauge	- 1 No.
• Bore dial gauge	- 1 No.
• Hydro meter	- 1 No.
• Voltage tester	- 1 No.

Equipment

• Vehicle	- 1 No.

Materials

• Cotton waste	- as reqd.
• Engine oil	- as reqd.
• Hydraulic fluid	- as reqd.

Note : Instructor demonstrate of vehicle specification

Mahindra Bolero GLX

Engine	XD-3PFI Diesel
Type	4-stroke oversquare, 4-cylinder, in line
Bore	94.0 mm
Stroke	90.0 mm
Cubic Capacity	2498 cc
Compression Ratio	23 : 1
Max. Gross Power	72.5 hp at 4000 R.P.M. (DIN 70020)
Max. Gross Torque	15.3 kg-m at 2000 R.P.M
Fuel Injection System	Distributor pump
Weight of Engine (dry)	200 kg with flywheel and starter
Cooling System	By Belt driven pump on cylinder head, thermostat controlled
Transmission	5-speed, All synchromesh
Ratios	1st Gear : 4.03 :1 2nd Gear : 2.39 :1 3rd Gear : 1.52 :1 4th Gear : 1.00 :1 5th Gear : 0.84 :1 Reverse : 3.76 :1
Transfer Case Ratios	For 4WD only High - 1 : 1, Low - 2.48 :1
Suspension	
Front	2WD : Independent, Coil Spring, Double acting telescopic shock absorber and anti roll bar
	4WD : Semi-elliptical leaf type, stabilizer bar at front
Rear	Semi-elliptical leaf type
Frame	Rectangular tubular section 5 intermediate cross members (6 for IFS). Rear bumper
Steering	Power steering - worm & roller type with universal joints
Turning Radius	5.4 mts.
Clutch	Hydraulic, single dry plate 235mm (9.25" dia)
Brakes	
Type	Hydraulic with tandem master cylinder with vacuum assisted servo
Front	13 mm disc and calliper type
Rear	Drum : 27.4 x 50.8 mm (11" x 2")
Parking	Internal expanding type on rear wheels. Hand lever and cable type.
Axle	
Front	IFS-2WD: Stub Axle 4WD : Full flating hypoid type
Capacity/Ratio	1000 kg / 4.88 : 1
Rear	Full floating hypoid type

Capacity/Ratio	1700 kg / 4.88 : 1
Electricals	
Battery	12 volts, negative earth
Capacity	70 amp. hr
Alternator	65 amp. with built-in regulator and vacuum pump
Drive	Belt drive
Wheels and Tyres	
Wheels	Rim size 6J x 15
Tyre	P215 / 75 R 15 radial
Fuel System	
Capacity	60 litres fitted with electrical float unit
Weights	
Kerb weight	1615 kg (2 WD) 1695 kg (4 WD)
G.V.W.	2200 kg (2 WD) 2280 kg (4 WD)

Identify the vehicle parts and check the specification of parts under guidance of instructor

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Identification of Vehicle Identification Number (VIN)

Objective : At the end of this exercise you shall be able to
- **identify the vehicle of identification number specification**

Requirements

Tools/Instruments
- Measuring Tape - 1 No.

Equipments
- Car - 1 No.

Materials
- Cotton waste - as reqd.
- Paper - as reqd.
- Pencil - 1 No.
- Eraser - 1 No.

General information for VIN

Vehicle Identification Number (VIN) is composed of 17 digits and classified into three large groups such as WMI, VDS and VIS. Example:- MALBB5 IBC AMI 73752

	Digit	Passenger Car	MPV	BUS
WMI	1	Geographic Zone		
	2	Manufacturer		
VDS	3	Vehicle Type		
	4	Series		
	5	Body Style and Version		
	6	Body Type		
	7	Restraint System	GVWR	Brake System
	8	Engine Type		
	9	Check Digit / Drive Side		
VIS	10	Model Year		
	11	Plant of product		
	12-17	Serial number		

- WMI: World Manufacturer Identifier
- VDS: Vehicle Descriptor Section
- VIS : Vehicle Indicator Section
- MPV: Multipurpose Passenger Vehicle (Ex : MPV,SUV,RV)
- GVWR : Gross Vehicle Weight Rating

Note: Vehicle code may vary depend upon manufacturer

Check the VIN number in your institute vehicle under guide line of instructor.

- Place a car in a plain ground.
- Apply hand brake and chock the wheels.
- Identify the location of VIN number in your vehicle.
- Note the VIN of your vehicle on plain paper.
- Decode the VIN details as per the manufacturer's general informations.

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Studying of garage service equipments

Objectives : At the end of this exercise you shall be able to
- **operate the air compressor**
- **operate the hydraulic car hoist**
- **operate a car washer**
- **operate the mechanical/hydraulic jack and jack stand**
- **operate a grease gun**
- **operate an oil spray gun**
- **operate the mechanical press**
- **operate the hydraulic press**
- **operate the two post car hoist**
- **operate the four post car lift**
- **operate the engine hoist.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No's
- Measuring Tape - 1 No's.

Equipments

- Car - 1 No.
- Air compressor - 1 No.

Materials

- Cotton waste - as reqd.
- Soap oil - as reqd.

PROCEDURE

Air compressor (Fig 1)

1 Check the oil level.

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

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

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

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

6 Switch 'on' the compressor

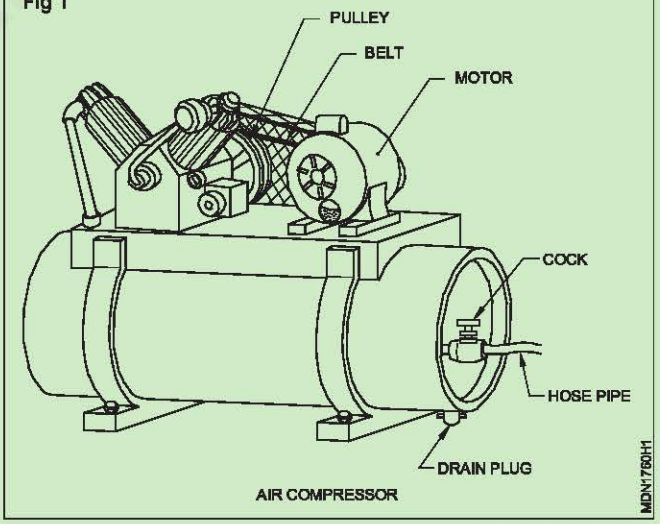
7 Observe the sound of the compressor. If any abnormal sound is found, stop the compressor immediately. (Consult your instructor)

8 Switch 'off' the compressor.

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

10 Close the cock after using the compressed air.

Fig 1



AIR COMPRESSOR

Skill Sequence

Hydraulic car hoist

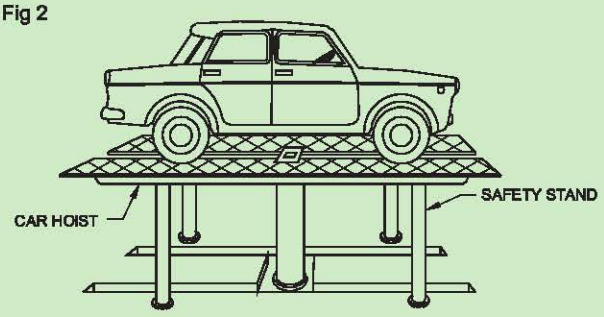
Objectives: This shall help you to
- **operate service station equipments**

Hydraulic car hoist (Fig 2)

Park the vehicle in the centre of the car hoist.

Clamp the front and rear axle or check wheels.

Fig 2



HYDRAULIC CAR HOIST

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

Close the cock when it reaches the required height.

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

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

Remove the safety stands.

Ensure that nobody is present underneath the vehicle.

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

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

Car washer

Check the oil level.

Check the belt tension.

Check the belt guard for its position.

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

Open the water tank.

Check the water level.

Hold the gun before starting the car washer.

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

Open the water gun.

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

After completing the cleaning, stop the car washer.

Close the water intake cock (water supply).

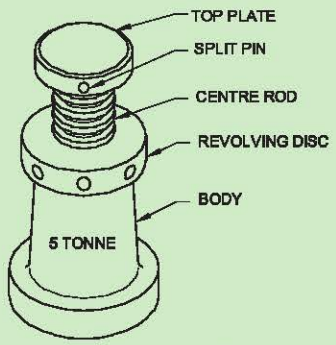
Mechanical jack (Fig 3)/Hydraulic jack (Fig 4)

Park the vehicle on level ground.

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

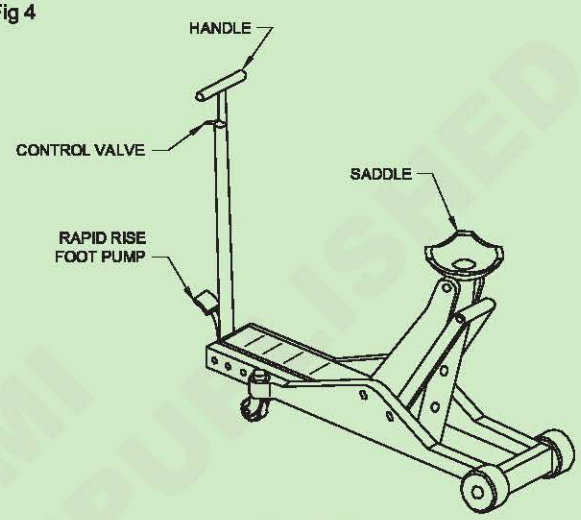
Check the free movements of threads in a mechanical jack by hand and in the hydraulic jack. Check the oil level and its operations.

Fig 3



MECHANICAL JACK

Fig 4



HYDRAULIC JACK

Place the jack under the vehicle in specified place.

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

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

Lower down the jack and remove it.

After completing the specific job jack up again.

Remove the support/horses.

Lower down the jack and remove it.

Safety points

1. **Never work under a vehicle supported only by a floor jack.**
2. **Lift saddles must be properly located and in secured contact.**
3. **Always check for equipments, parts or personnel beneath the car before lowering.**

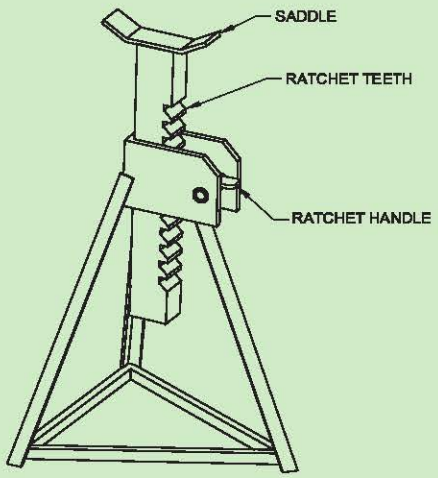
Jack stand (Fig 5)

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

Stands must be properly and securely placed.

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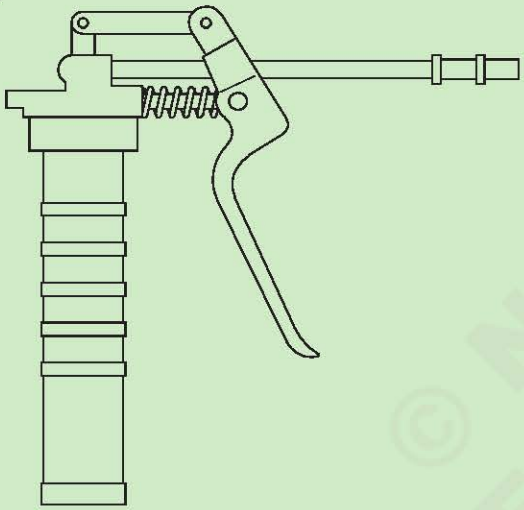
Fig 5



TYPICAL ADJUSTABLE JACK STAND

Grease gun (Fig 6)

Fig 6



GREASE GUN

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

Check visually, the grease nipple holder for any damage.

Fill up the gun with the specified grease.

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

Use the gun for the required purpose.

Oil spray gun

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

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

Connect the oil spray gun to the quick release coupler.

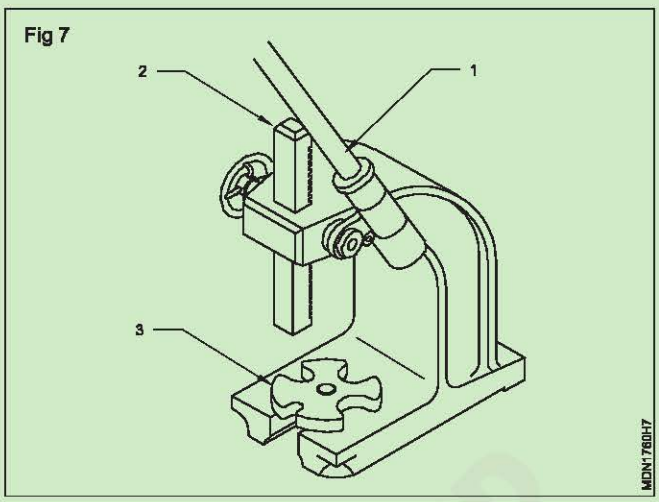
Operate the oil spray gun.

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

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

Mechanical (Arbor) press (Fig 7)

Fig 7



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

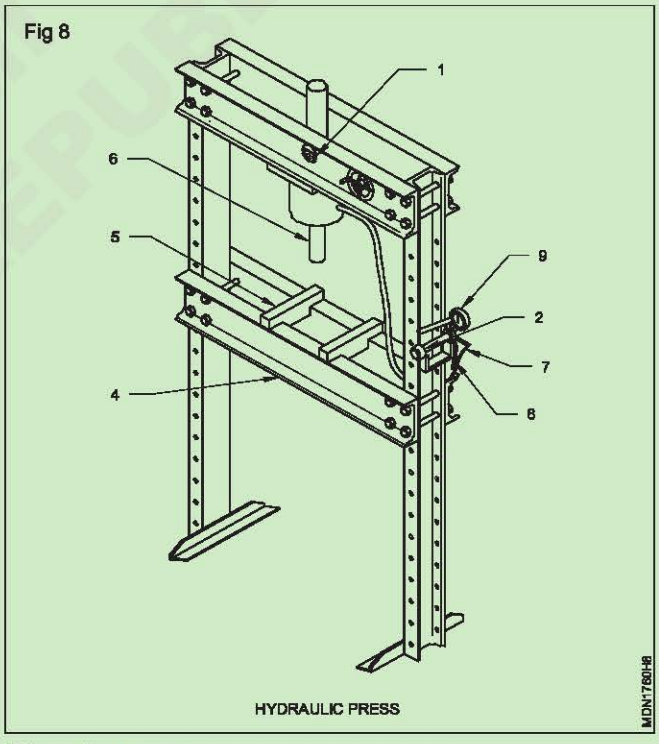
Select the plate(3)according to the work.

Place the component on the plate.

Press the work slowly and listen for abnormal noise.

Hydraulic press (Fig 8)

Fig 8



HYDRAULIC PRESS

Clean the press.

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

Check the hydraulic press for its free function and leakage

Lock the cylinder plunger releasing knob(2).

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

Align the anvil (5) according to the job.

Place the job on the anvil (5).

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

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

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

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

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

Safety

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

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

3 Remove the job and clean.

Two post car hoist

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

Adjust and fix the telescopic two post lift lifting arm.

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

Set safety mechanism to prevent uneven lifting.

Use the extra safety nut.

Check the chain drive and operate the lifting switch.

Use the anchoring bolts for safety (Fig 9).

Four post lift

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

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

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

Drive the hydraulic cylinder in stable & lowering.

Offering pull range mechanical protection by using safety block

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

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

Engine hoist

Keep the vehicle on level ground.

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

Pull up hand brake lever of vehicle.

Fig 2

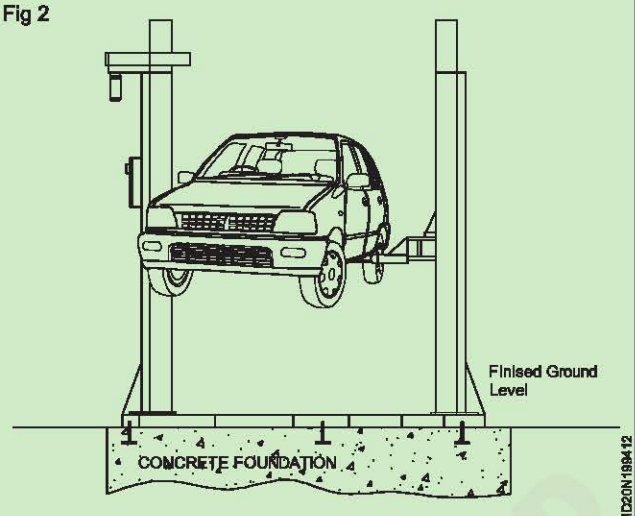


Fig 10

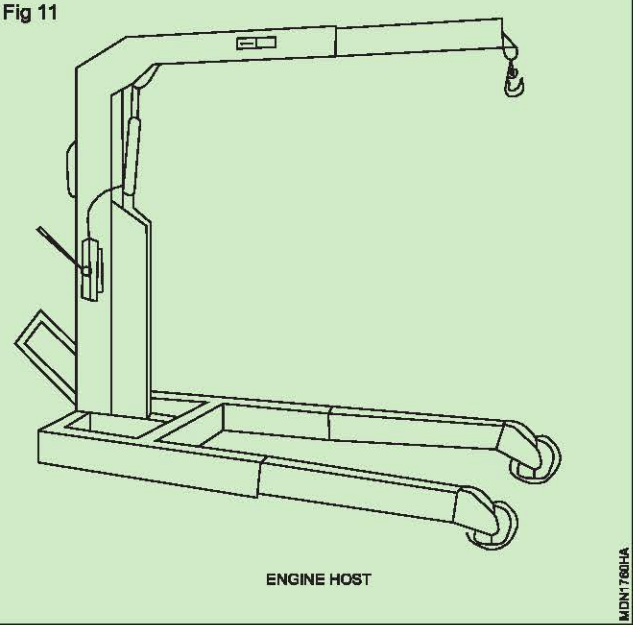


Place the hoist on firm ground & fix a rope to such part of engine.

Lift the hoist slowly till free from the vehicle.

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

Fig 11



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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/Machineries

- Cut sectional model of multi cylinder 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).

23 Locate the camshaft (29). (Fig 4)

24 Locate the oil sump (23) (Fig 3)

25 Locate the oil pump (24) (Fig 4)

26 Locate the oil filter (25) (Fig 1)

27 Locate the connecting rod caps (26). (Fig 4)

28 Locate the piston and connecting rod in the engine (27) (Fig 4)

Fig 1

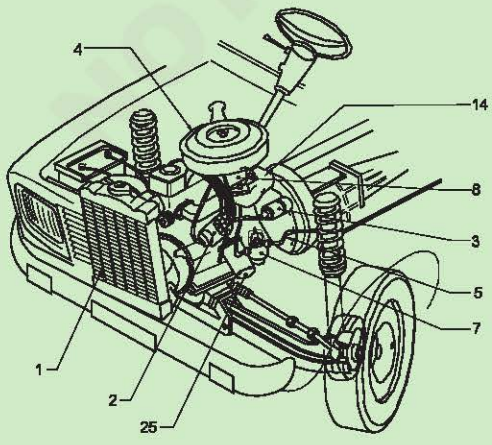
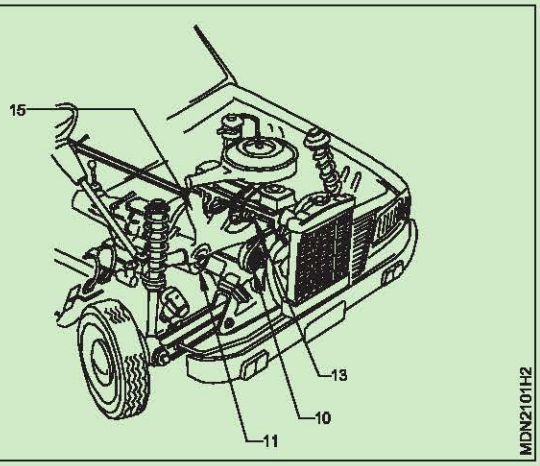


Fig 2



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Fig 3

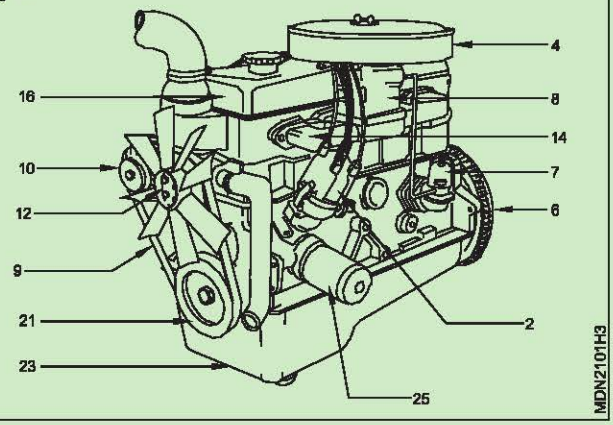
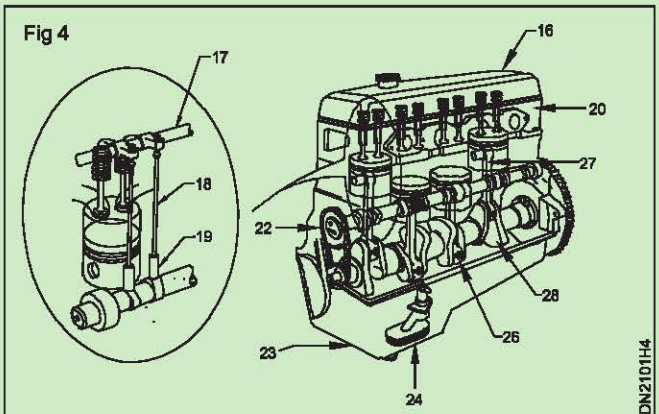


Fig 4



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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 compressor, Piston ring expander, valve lifter - 1 No each.

Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.

Equipments

- Multi cylinder diesel engine (cut sectional model)

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 filter, 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 to 3.

4 Write the name of the parts in the Table 1.

Fig 1

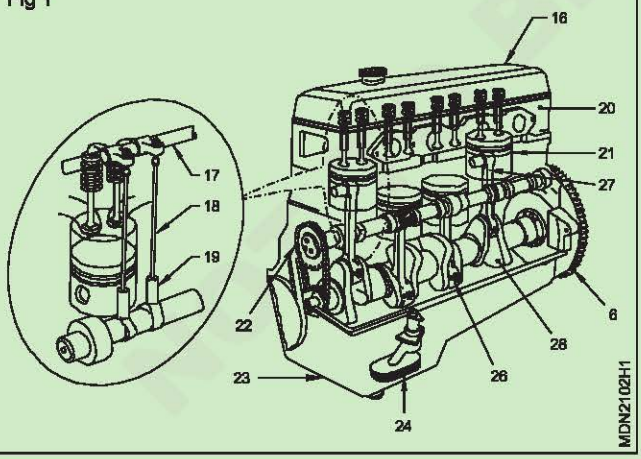


Fig 2

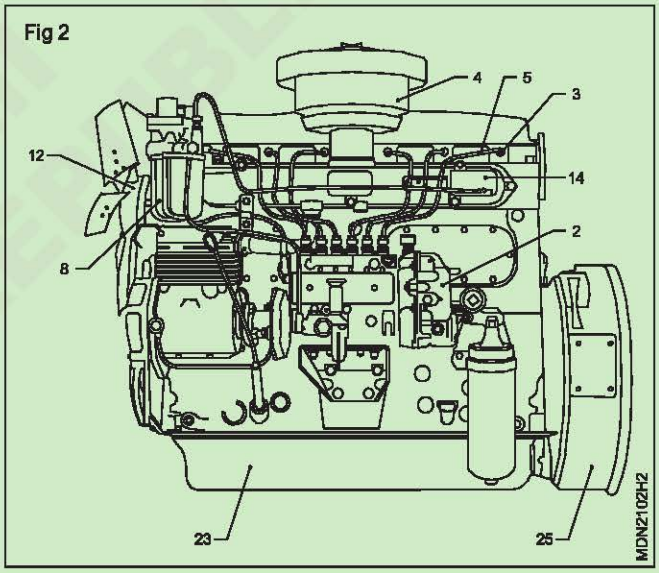
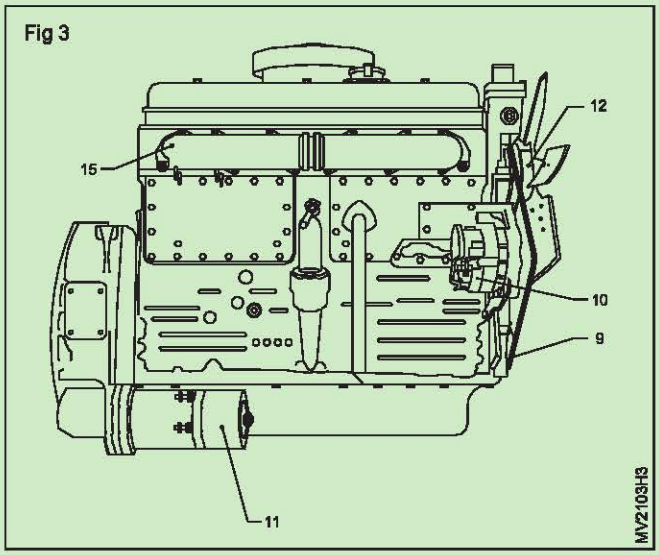


Fig 3



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Table - 1

Sl.No.	Label no	Name 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	

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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

- Trainee's tool kit - 1 No.
- Lead acid battery 12V with cables - 1 No.

Equipments/Machineries

- Multicylinder four stroke diesel engine - 1 No.
- Running condition of diesel LMV vehicle - 1 No.

Materials

- Tray - as reqd.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Engine oil - as reqd.
- Coolant - as reqd.

PROCEDURE

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)

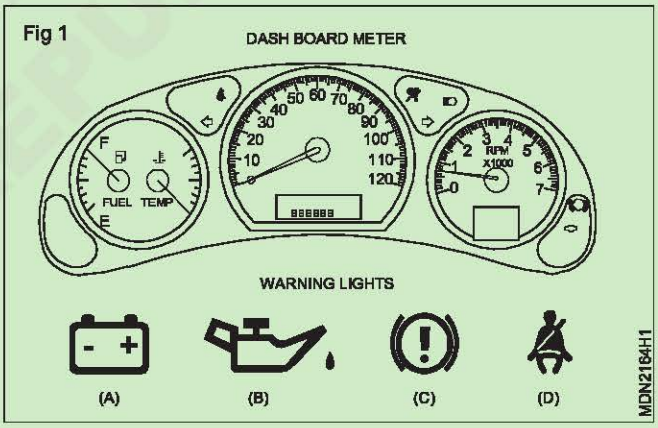
b Engine oil light glows in red (i.e. oil is low (or) nil) (Fig 1B)

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)

Fig 1



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.

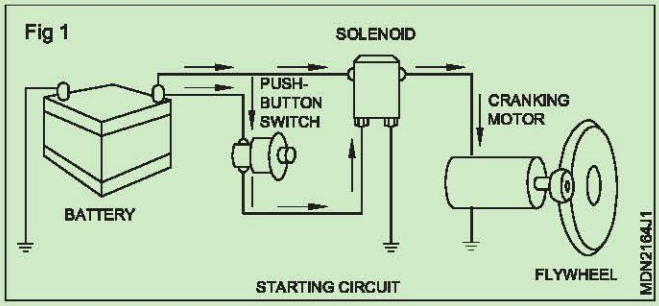
If the engine does not start immediately do not keep starter button (pressed (or) key turned) beyond 10 seconds.

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This leads to the battery get discharged and overheated.

3 Check the idling speed R.P.M in tachometer.

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. If it is not glowing, it means battery is charging.

2 Observe the engine oil warning light. If it is not glowing, it means 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.

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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)

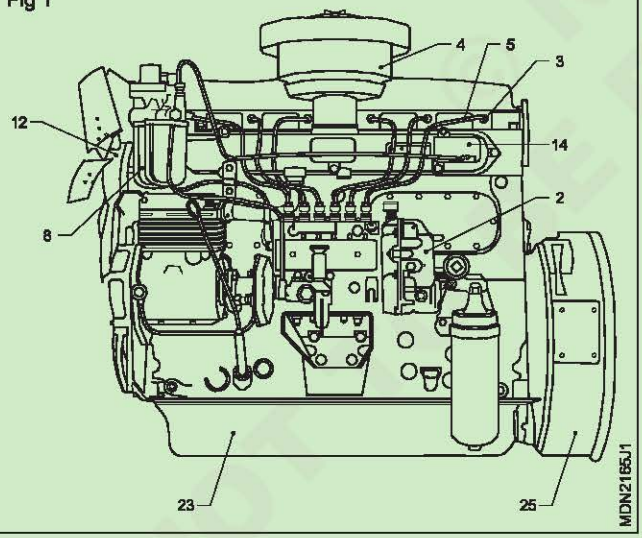
2 Drain the water (if provided)

3 Remove the radiator (if provided)

4 Disconnect electrical connections

5 Disconnect the fuel pressure pipes (5) (Fig 1)

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)

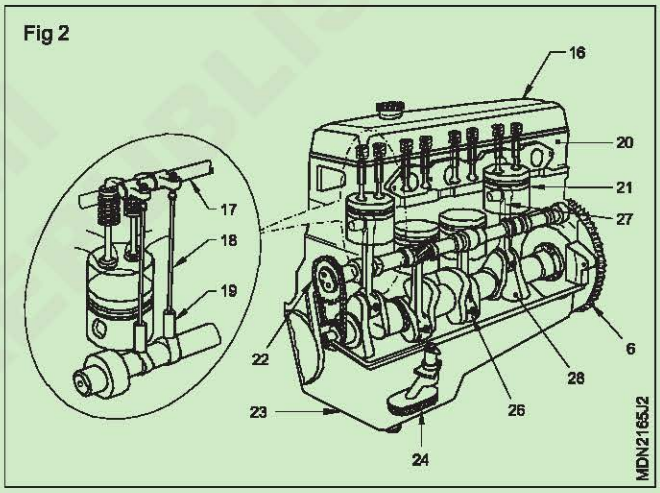
10 Remove the flywheel (6)

11 Remove the fan belt (9)

12 Remove the dynamo/alternator (10)

13 Remove the self-starter (11). (Fig 3)

Fig 2



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.

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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/ numbers on the caps.)

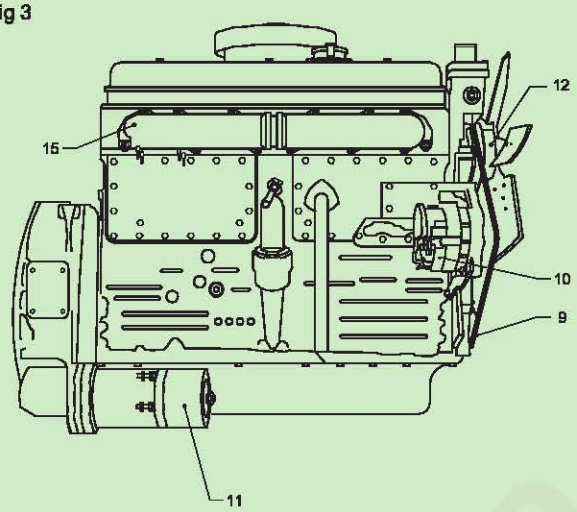
32 Remove the piston (21) and connecting rod (27) from the engine. (Note down the marks/numbers on the pistons.)

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).

Fig 3



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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.

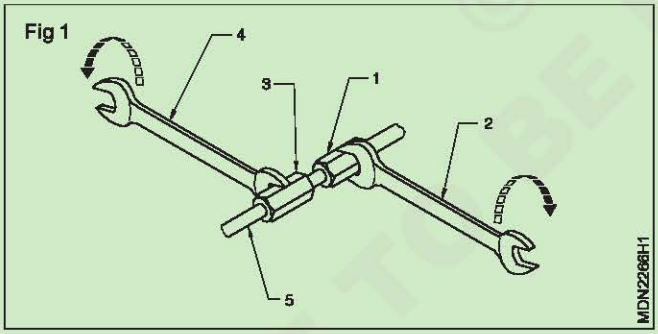
PROCEDURE

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)

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.

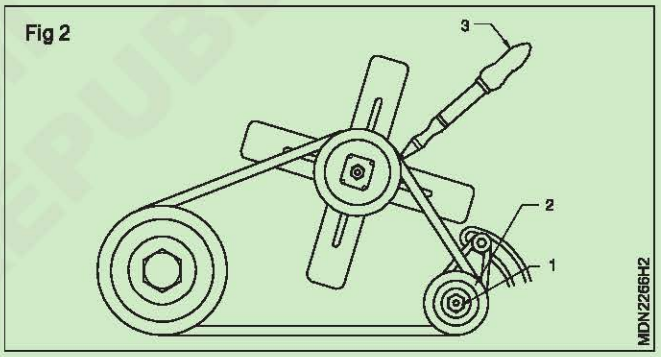
6 Remove the F.I.P. and keep it in a vertical position on a plain surface.

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.

Fig 2

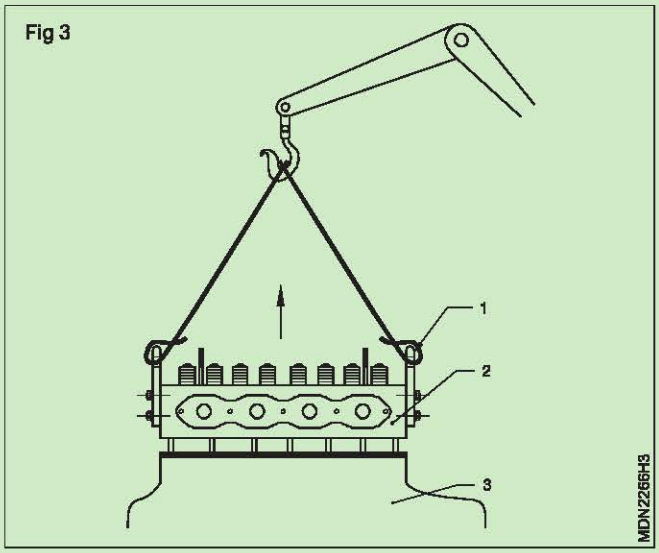


10 Remove the tappet side cover and remove the tappets.

11 Remove all the cylinder head nuts/bolts.

12 Fix the lifting hooks (1) at both ends of the cylinder head (2). (Fig 3)

Fig 3



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

14 Ensure that the cylinder head is 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)

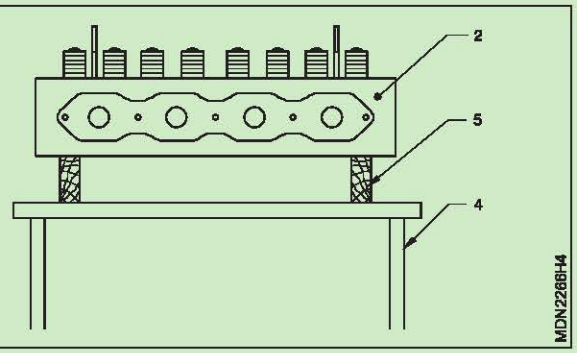
16 Remove the cylinder head gasket and keep it in a safe place.

17 Remove the carbon deposit on the cylinder head with a wire brush /scraper.

18 Clean the cylinder head with cleaning solvent used.

19 Visually check the cylinder head for its damages and cracks

Fig 4



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

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

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Practice on removing rocker arm assembly and manifolds

Objectives: At the end of this exercise you shall be able to
- **remove the rocker arm assembly from the cylinder head**
- **remove the manifolds from the cylinder head.**

Requirements

Tool/Instruments

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

Equipments/Machinaries

- Multi cylinder diesel engine - 1 No.

Materials/Components

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

PROCEDURE

TASK 1 : **Removing rocker arm assembly**

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.

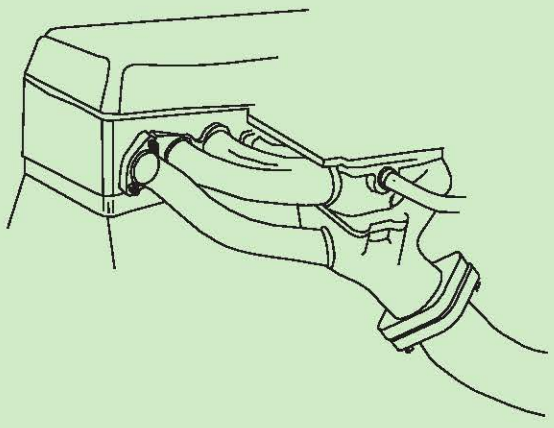
8 Remove the inlet manifold mounting bolts and take out from the cylinder head and place it on the work bench.

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.

Fig 1



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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 clean 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 reqd.
- Kerosene - as reqd.
- Lube oil - as reqd.

PROCEDURE

TASK 1: **Remove valves**

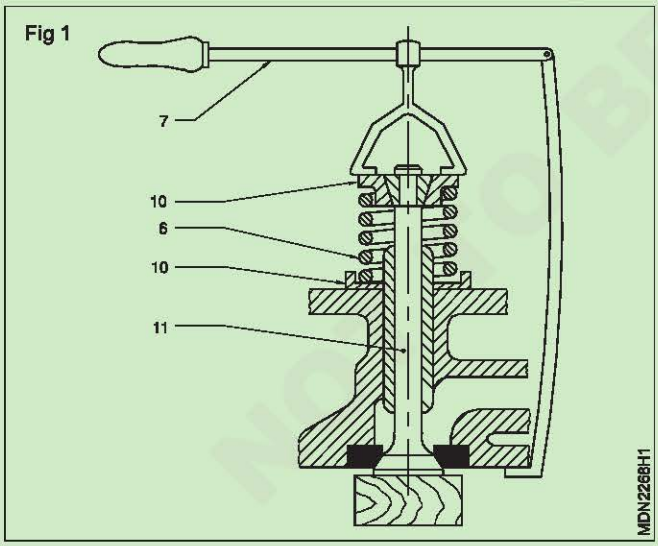
1 Place the cylinder head on a work bench over the two wooden block stands.

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).

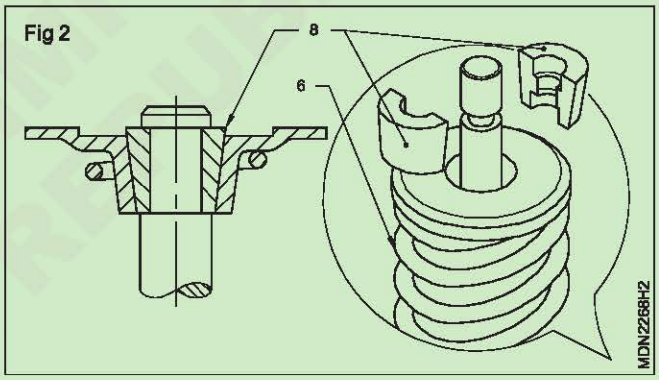
Fig 1



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)

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.

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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

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

Equipments/Machinaries

- Diesel engine - 1 No.

Materials/Components

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

PROCEDURE

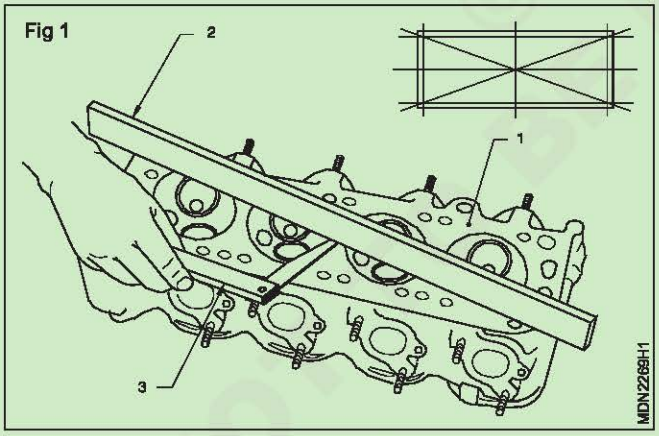
TASK 1: **Checking flatness of cylinder head surface by straight edge and feeler gauge**

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.

Fig 1



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.

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

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.

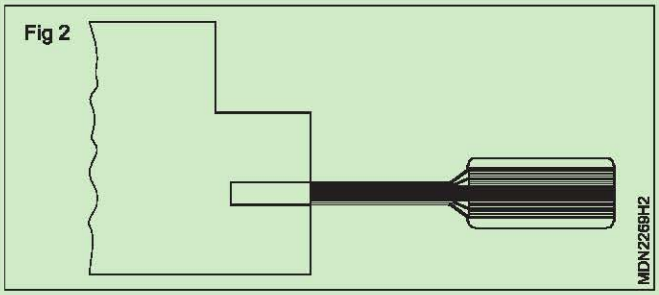
7 Clean the feeler gauge thoroughly by using a cloth.

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)

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

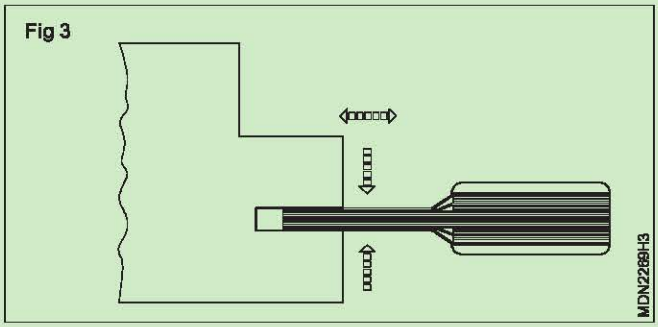
Fig 2



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 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 & exhaust)

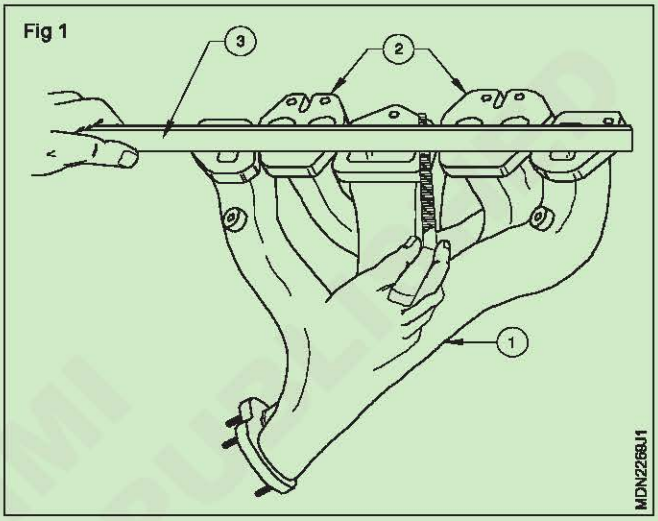
2 Place the manifold surface parts upward to be checked

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 resurfacing/replacement of the manifold if wear is more than the limit specified by manufacturer or damaged.



Checking valve seat and valve guide

Objectives: At the end of this exercise you shall be able to
- **check valve seat inserts**
- **check valve guide.**

TASK 1 : **Check valve seat inserts and valve guides**

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.

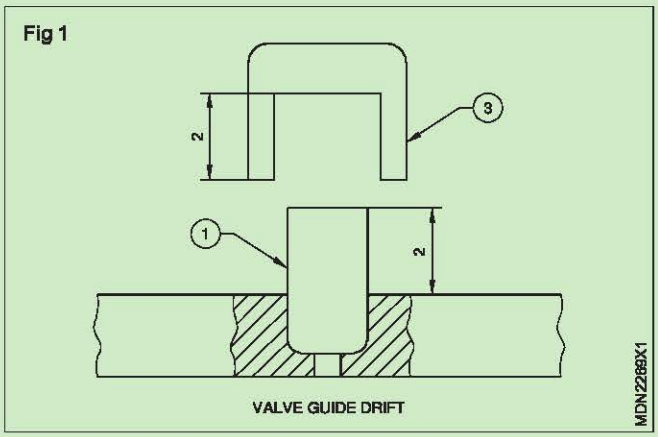
12 If the clearance between the valve guide and valve stem is found more than the manufacturer's specified limit, change the valve guide as per the following procedure.

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 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 and overhauling rocker arm assembly

Objectives: At the end of this exercise you shall be able to
- **check the valve seat leakage with special tool**
- **check the rocker shaft and levers for wear and cracks**
- **reassemble the rocker shaft and levers in proper method.**

Requirements

Tool/Instruments

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

Equipments/Machinaries

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

Materials/Components

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

PROCEDURE

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

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)

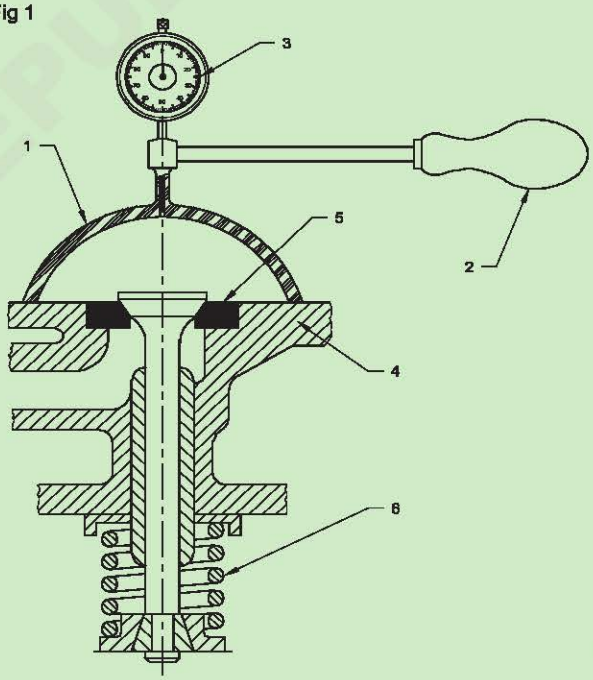
3 Covering the cylinder head valve seat (5) and create a vacuum with the help of the suction bulb (1) (rubber bulb)

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 mentioned procedure.

Fig 1



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.

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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)

Fig 1

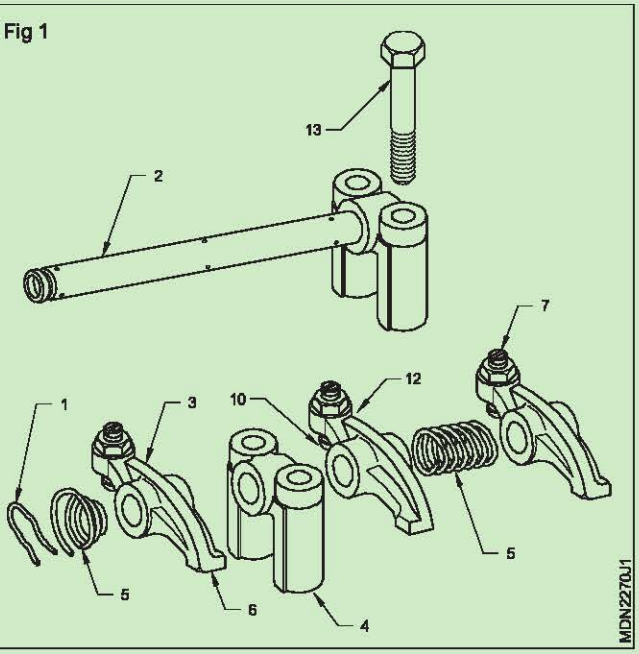
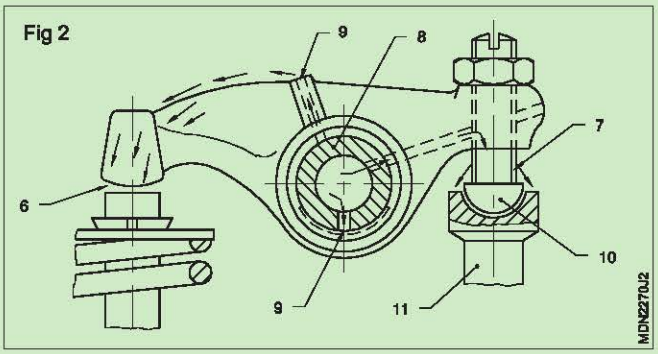


Fig 2



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.

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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

Tool/Instruments

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

Equipments/Machinaries

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

Materials/Components

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

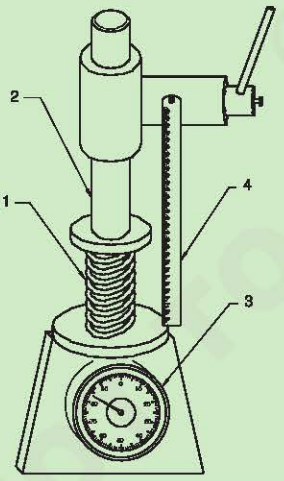
PROCEDURE

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).

Fig 1



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

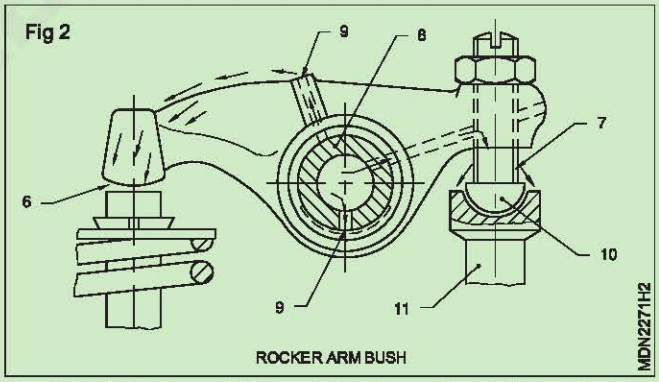
5 Press the spring (1) by moving the column (2) downward. The gauge (3) will show the load on the spring. Press column (2) till the testing load (specified by the manufacturer) is obtained.

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)

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 Check 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 Insert the valve in the valve guide.

16 Support the valve head, so that it is held firmly on its seat.

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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)

23 Fit the circlip/lock screw at both ends of the rods shaft

24 Loosen the ball pins / nuts to ensure that the push-rods do not bend while tightening the rocker shaft support brackets nuts/bolts on the cylinder head.

25 Fit the rocker arm shaft assembly in the correct position on the cylinder head.

26 Tighten the rocker arm shaft support bracket nuts or bolt to the specified torque (Use torque wrench)

Skill Sequence

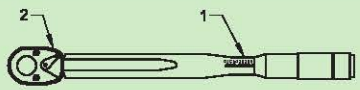
Refit the cylinder head, manifolds and adjusting valve tappet clearance

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.**

Fit the inlet and exhaust manifold with cylinder head place the cylinder head on the engine block with head gasket. Tighten all the cylinder head bolts/nuts in correct sequence to the specified torque (use a torque wrench - refer to service manual). Fig 1

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

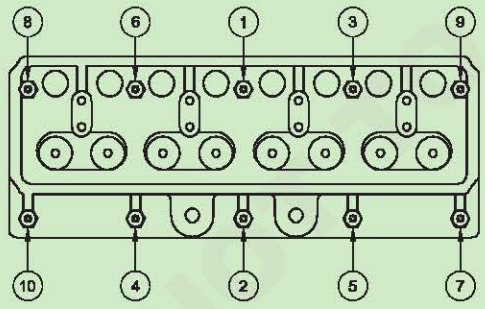
Fig 1



TORQUE WRENCH

MDN2271J1

Fig 2



TIGHTENING CYLINDER HEAD

MDN2271J2

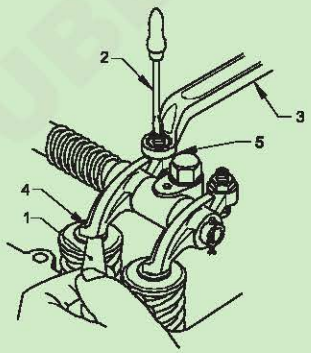
Assemble and fit the rocker arm assembly. Turn the crank shaft in the clockwise direction and coincide the flywheels TDC 1/6 or 1/4 mark with the flywheel housings pointer. Ensure that the 1st cylinder is in compression stroke.

Hold firmly the tappet adjusting screw with a good screwdriver. (Fig 3)

Loosen the lock-nut with a ring spanner.

Insert a feeler gauge (1) of the specified thickness between the valve stem and the rocker tip (4).

Fig 3



OVERHEAD VALVE

MDN2271J3

Tighten the adjusting screw (5) by a screwdriver (2) and at the same time move the feeler gauge to and fro.

Stop tightening of the adjusting screw when the feeler gauge can be slid with a slight effort, but it should not be jammed.

Rotate the push-rod. It should also rotate with a slight load but it should not be jammed.

Hold the adjusting screw in position with the screwdriver firmly and tighten the lock-nut by a ring spanner.

Ensure that the adjusting screw does not turn while tightening the locking nut.

Check again the adjustment by sliding the feeler gauge leaf in the gap and turning the push rod.

Repeat the above steps to adjust the tappet clearance for other valves bringing the respective pistons on TDC of compression stroke according to firing order.

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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.

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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

• Trainee's tool kit	- 1 No.
• Socket spanner set	- 1 Set
• Torque wrench	- 1 Set
• Piston Ring expander	- 1 Set
• Drift	- 1 Set
• Mallet	- 1 Set
• Ball pein hammer	- 1 No.
• Ring groove cleaner	- 1 No.
• Internal circlip plier	- 1 No.
• Feeler gauge	- 1 No.
• Bench vice	- 1 No.

Equipments/Machineries

• Air compressor	- 1 No.
• Engine	- 1 No.
• Arbor press	- 1 No.

Materials

• Soap oil	- as reqd.
• Kerosene	- as reqd.
• Banian cloth	- as reqd.
• Lube oil	- as reqd.
• Emery sheet	- as reqd.
• Piston ring	- as reqd.

PROCEDURE

1 Drain the engine coolant.

2 Drain the engine oil and remove the oil pan.

3 Remove the cylinder head.

4 Using 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.

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. (Care in handling and cleanliness of piston, bearings and piston pin)

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 till 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.

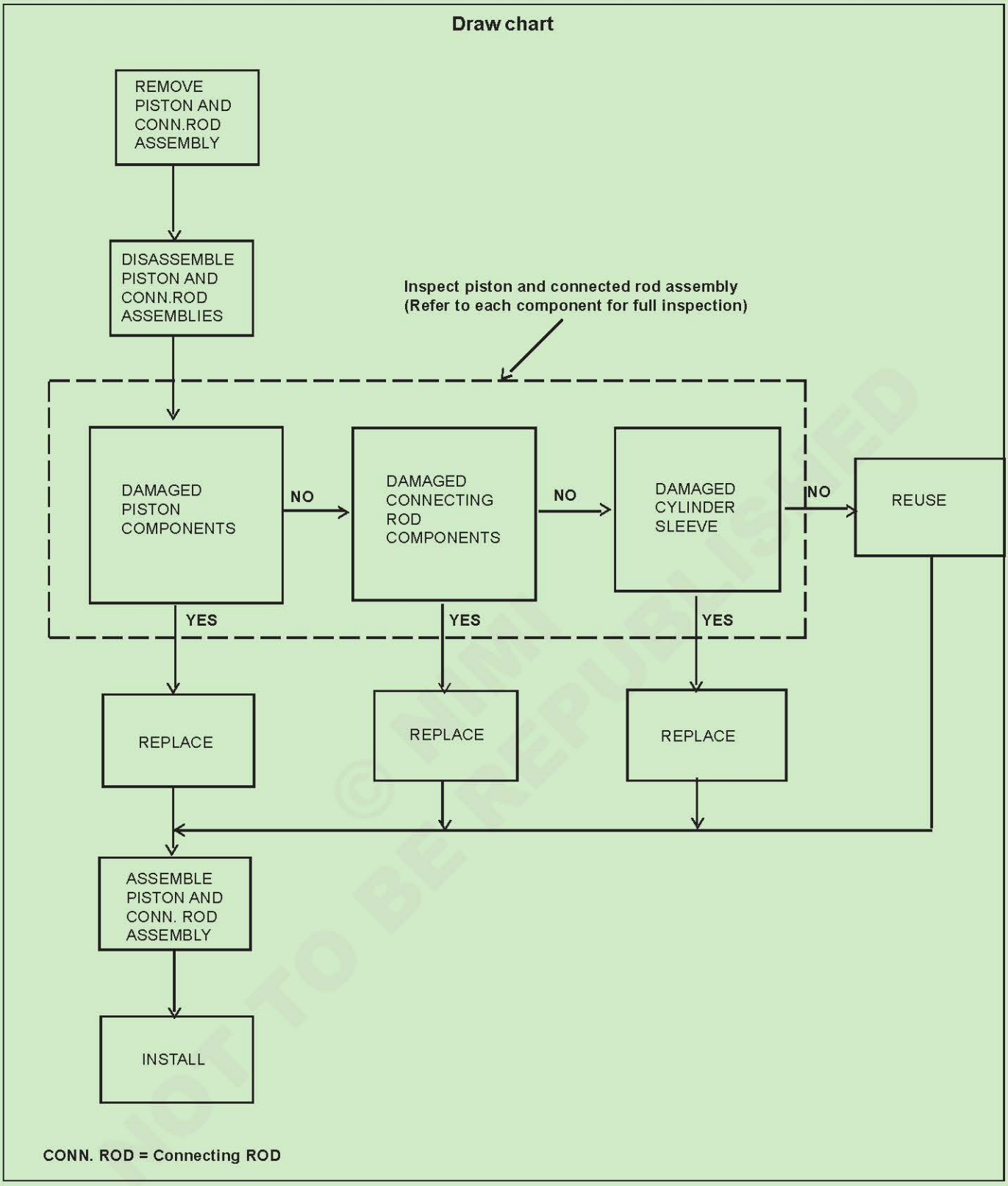
28 Install oil pan.

29 Refill the recommended oil to the proper level.

30 Close the drain cocks and fill the recommended coolant.

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Draw chart



CONN. ROD = Connecting ROD

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Practice on removing oil sump and oil pump

Objectives: At the end of this exercise you shall be able to
- **remove the oil sump from the engine**
- **remove the oil pump from the engine.**

Requirements

Tools/Instruments

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

Equipments/Machineries

• Multi cylinder diesel engine	- 1 No

Materials/Components

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

PROCEDURE

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

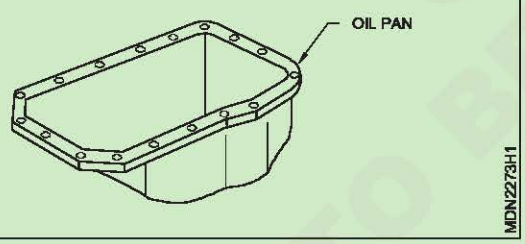
1 Loosen the engine oil sump drain plug

2 Place the tray under the sump

3 Remove the drain plug and ensure the oil is completely drained from the oil sump

4 Crank the engine to drain remaining oil from the engine

Fig 1



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)**

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.

6 Dismantle the oil pump parts and clean it (Fig 2)

7 Inspect the dismantled parts, if any damages found, replace the defective parts.

8 Assemble the all parts in sequence

9 Check the pressure of the oil pump with your instructor's guidance.

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Fig 1

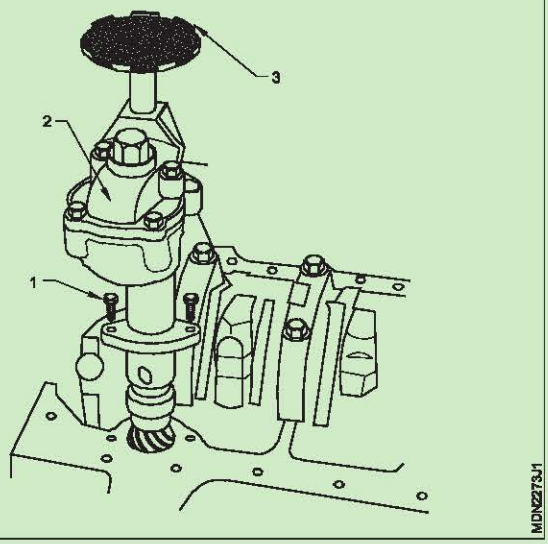
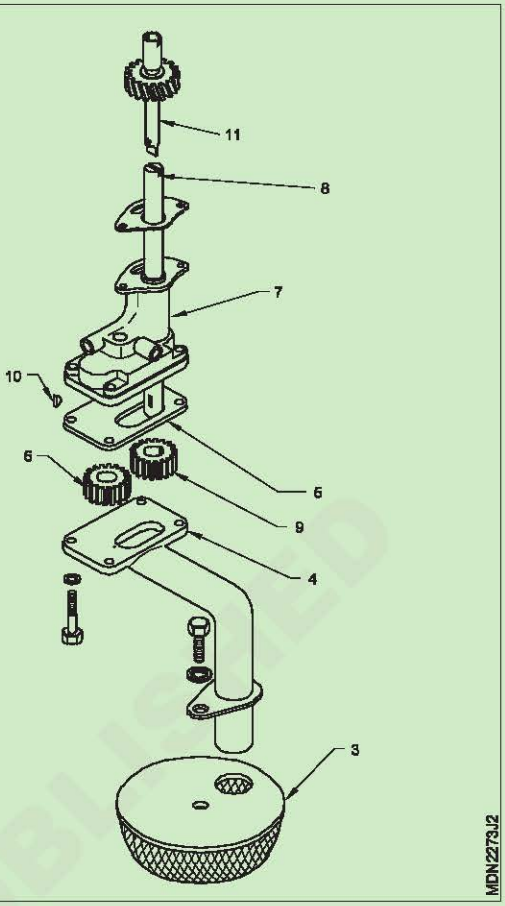


Fig 2



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Practice on removing piston with connecting rod assembly

Objectives: At the end of this exercise you shall be able to
- **remove the big end bearing from the connecting rod**
- **remove the piston with connecting rod.**

Requirements

Tools/Instruments

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

Equipments/Machineries

• Multi cylinder diesel engine	- 1 No.

Materials/Components

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

PROCEDURE

TASK 1 : **Remove the piston connecting rod assembly**

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 crank shaft (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 crank shaft (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

Fig 1

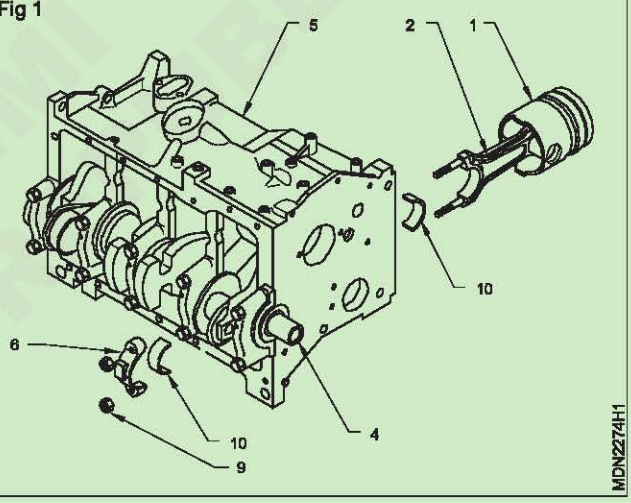
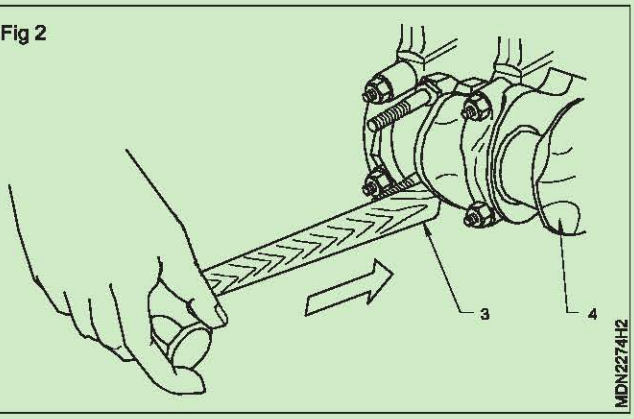


Fig 2



Practice on removing and measuring the piston

Objectives: At the end of this exercise you shall be able to
- **remove the piston rings and piston pin from the piston**
- **remove the piston from the connecting rod**
- **check the piston ring clearance**
- **check the wear of piston skirt and crown.**

Requirements

Tools/Instruments

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

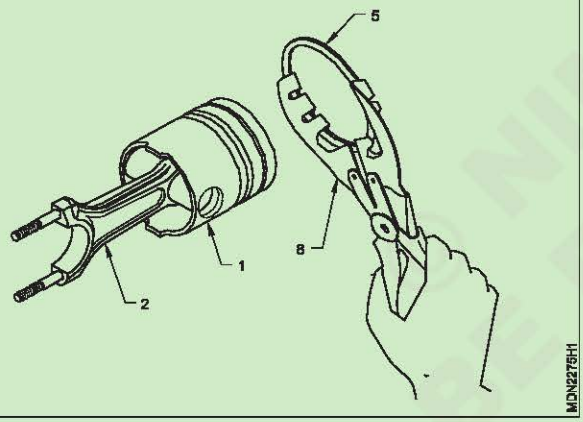
Materials/Components

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

PROCEDURE

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

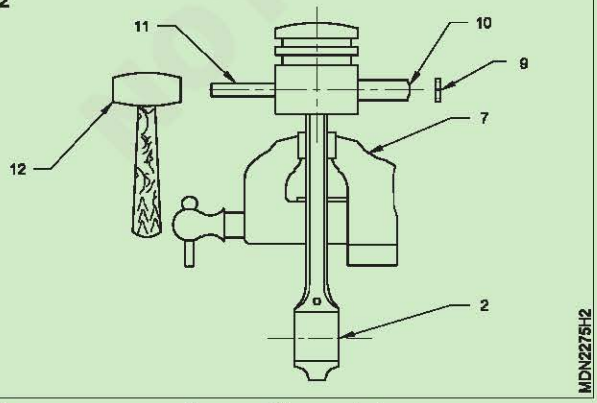
Fig 1



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)

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 points.

12 Check the wear of piston ring grooves and land.

13 Measure the piston diameter at different points. (Fig 4)

Fig 3

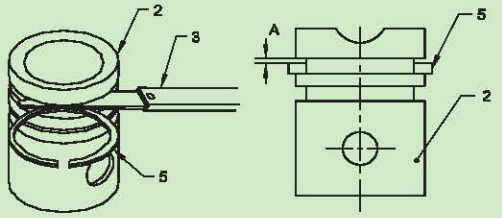
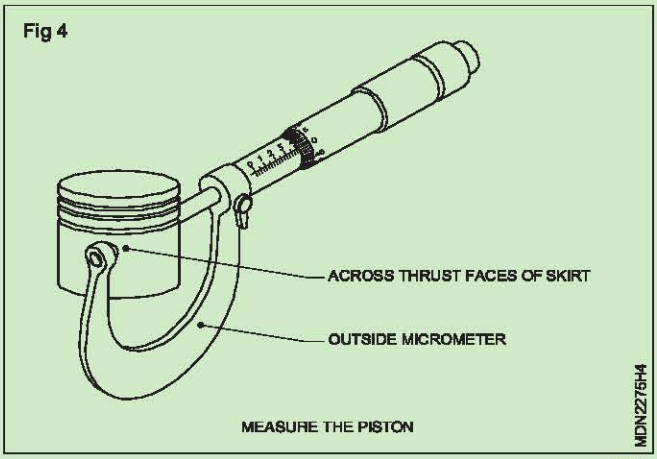


Fig 4



Measure the clearance of piston, ring and big end bearings

Objectives: At the end of this exercise you shall be able to
- **check the piston ring close gap**
- **check the clearance between the piston and cylinder wall**
- **check the clearance between crank pin and big end bearing.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

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

1 Clean the cylinder bore with baniyan cloth

2 Clean the selected piston ring for measurement.

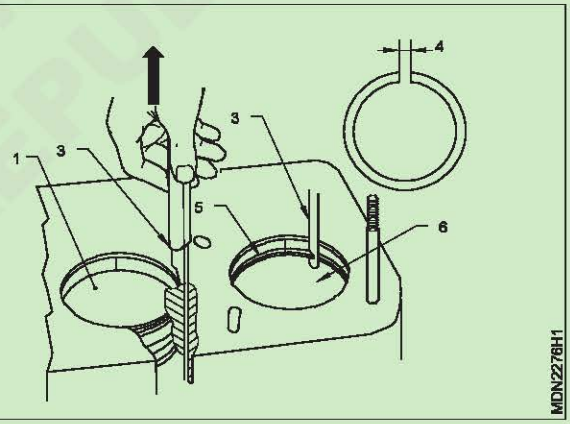
3 Insert the piston ring inside of the cylinder bore

4 Ensure the piston ring placed in specified 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.

Fig 1



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 baniyan cloth.

3 Clean the cylinder bore with baniyan 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.

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TASK : 3 **Measure the clearance between the crank pin 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 tightening 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 to be followed to other crank pin and connecting rod bearings.

Note : Never place plastic gauge above oil holes

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Check connecting rod for bend and twist

Objectives: At the end of this exercise you shall be able to
- **check the connecting rod bend and twist**
- **assemble the piston and connecting rod.**

Requirements

Tools/Instruments

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

Equipments/Machineries

- Multi cylinder diesel engine - 1 No.

Materials/Components

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

PROCEDURE

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.

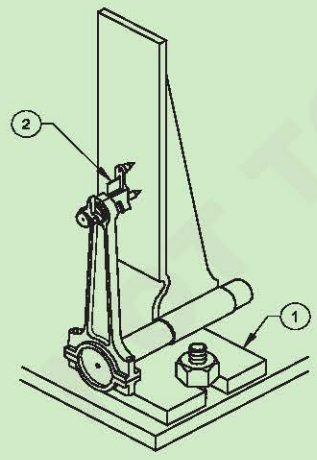
3 Check the connecting rod's small end bush bearing for wear and scoring.

4 Check the connecting rod's alignment for bend and twist.

5 Check the gudgeon pin surface for any damage.

6 Place the connecting rod on the alignment fixture (1). (Fig 1)

Fig 1



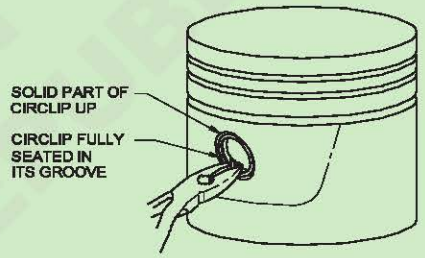
CONNECTING ROD ALIGNMENT FIXTURE

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)

Fig 2



INSTALL CIRCLIP

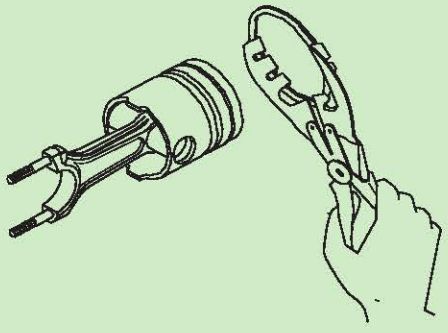
10 Align the connecting rod's small end bore and the gudgeon pin bore of the piston.

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.

Fig 3



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Overhauling of crankshaft

Objectives: At the end of this exercise you shall be able to
- **use of service manual**
- **check the clearance of crankshaft.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

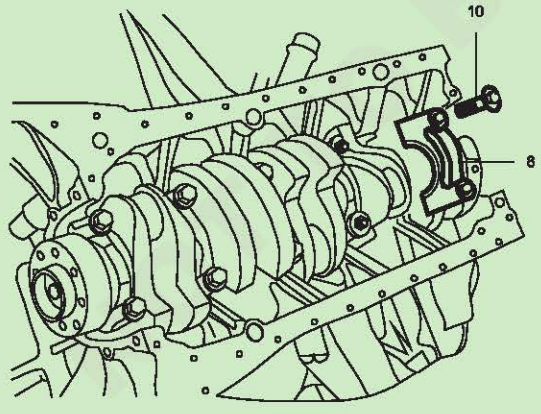
1 Remove the bearing cap bolt (10). (Fig 1)

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).

Fig 1



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.

Fig 2

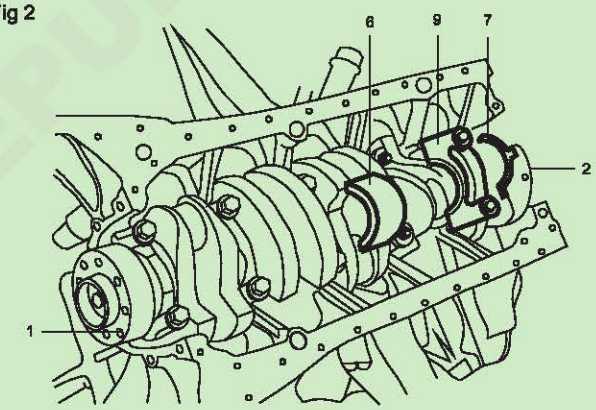
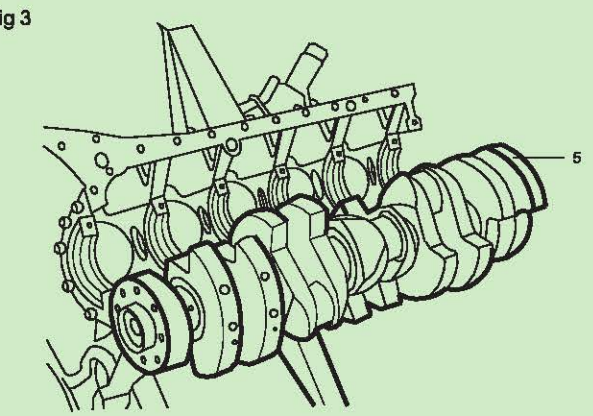


Fig 3

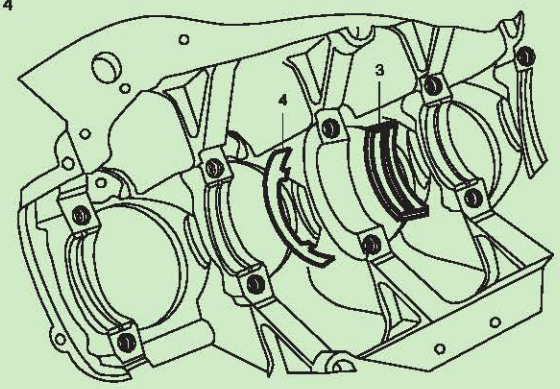


8 Thoroughly clean the oil gallery.

9 Select proper new bearing shells with references to table.

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Fig 4

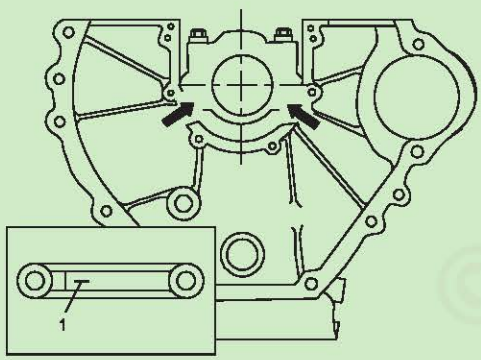


10 Coat the new bearing shells with oil and insert into the crankcase and into the crankshaft bearing caps.

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

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

Fig 5



Installation Notice

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

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

12 Measure crank shaft 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

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

(Example) Measured value 'E' = 57.700 mm

Measured value 'F' = 57.659 mm

Clearance 'G' = 0.041 mm

Fig 6

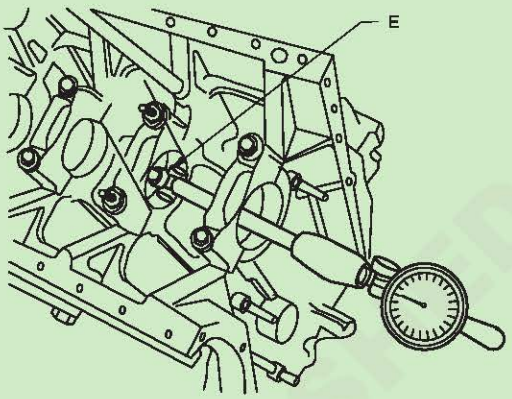


Fig 7

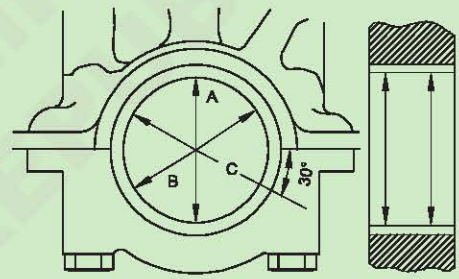
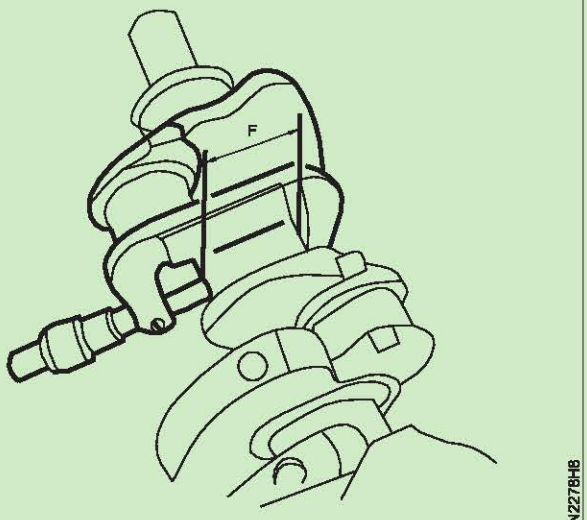


Fig 8



16 Remove the crankshaft bearing cap.

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

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Fig 9

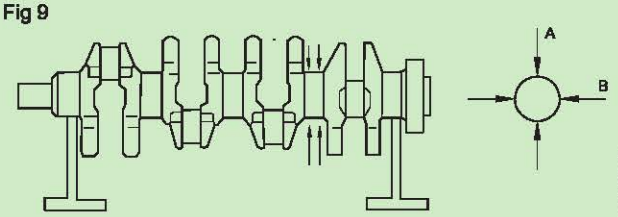
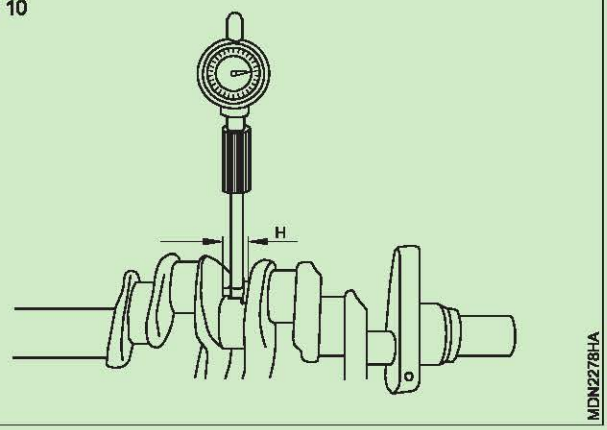


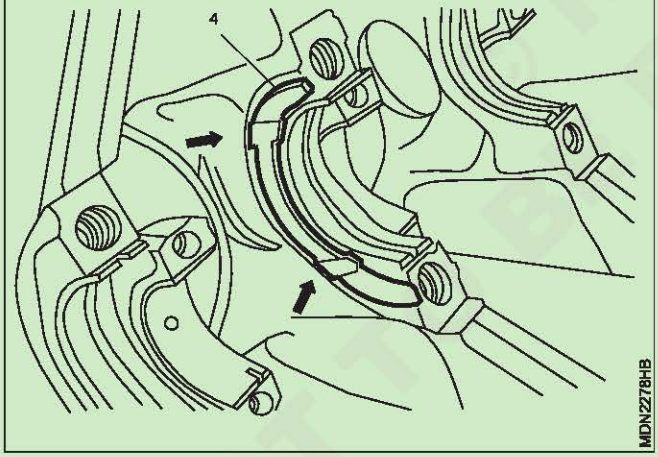
Fig 10



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

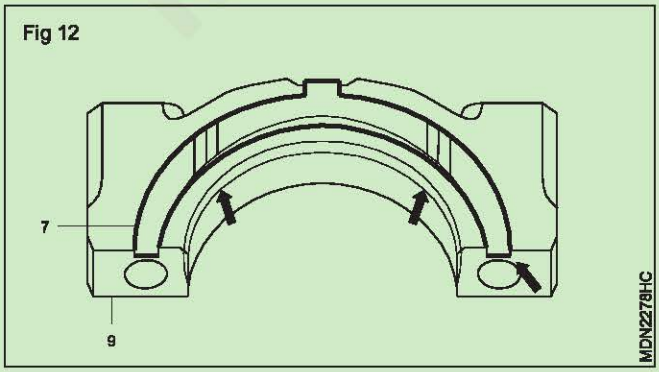
18 Coat the upper thrust bearing (4) with oil and insert into the crankcase so that the oil grooves are facing the crank webs (arrow).(Fig 11)

Fig 11



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)

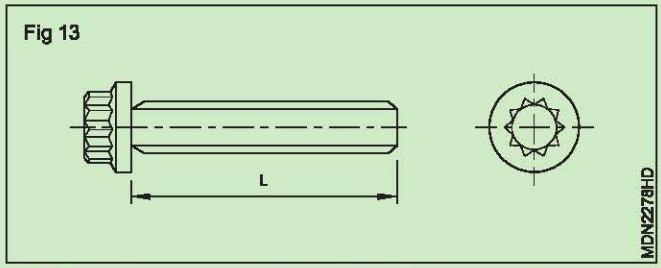
Fig 12



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)

Fig 13



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

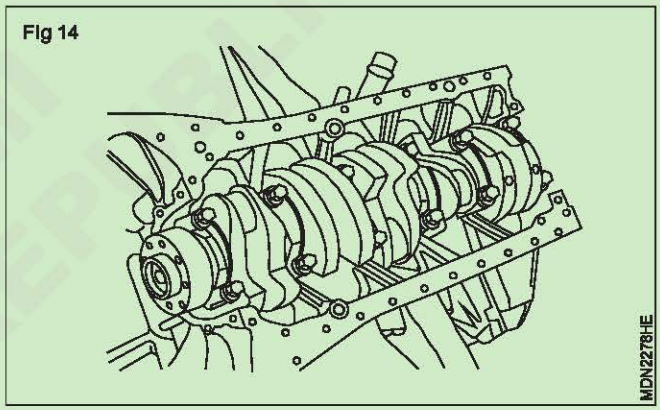
21 Install the crank shaft bearing caps according to marking and tighten the bolts.

Installation Notice

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

Install from No. 1 cap.

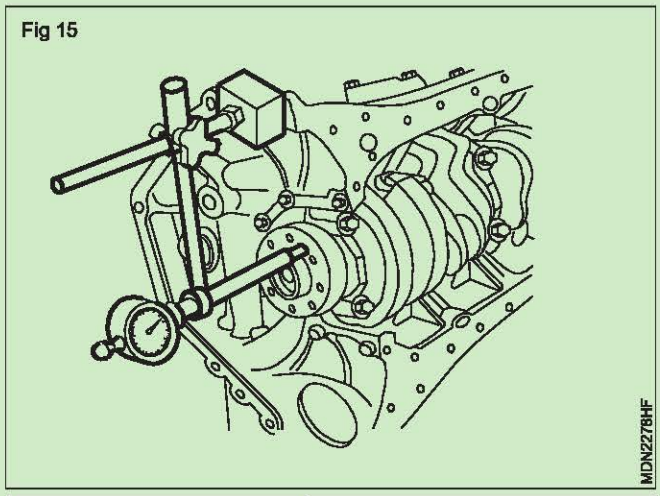
Fig 14



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

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

Fig 15



Clearance	0.100 - 0.245 mm

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 crank shaft bearing by replacing the thrust washers.

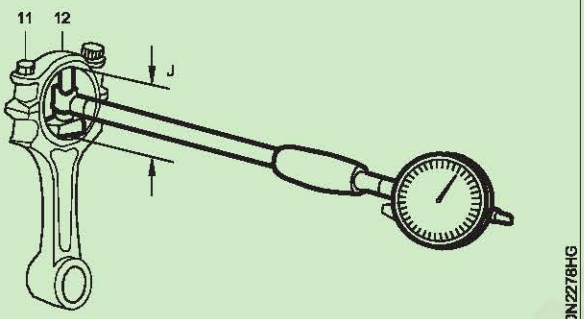
24 Insert the new connecting rod bearing shells into the connecting rod and connecting rod bearing shells into the connecting rod and tighten the 12-sided stretch bolts (11).

Installation Notice

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

25 Measure inner diameter of connecting rod bearing. (Fig 16)

Fig 16



26 Measure connecting rod bearing journal diameter (k).

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

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

(Example) Measured value 'J' = 47.700 mm

Measured value 'K' = 47.653 mm

Clearance 'G' = 0.047 mm

Radial Clearance 'L'	0.026 - 0.068 mm

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

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.

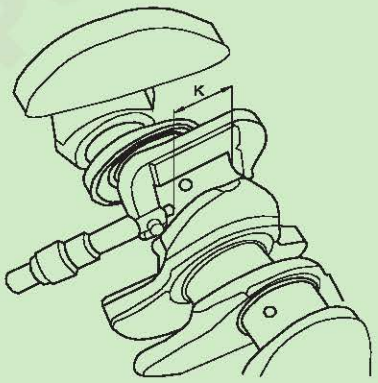
29 Install the piston.

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

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

Plastic gauge is a measuring tool used for measuring clearances

Fig 17



NOT TO BE REPUBLISHED

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 crank shaft assembly from the engine.**

Requirements

Tools/Instruments

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

Equipments/Machineries

- Multi cylinder diesel engine - 1 No.

Materials/Components

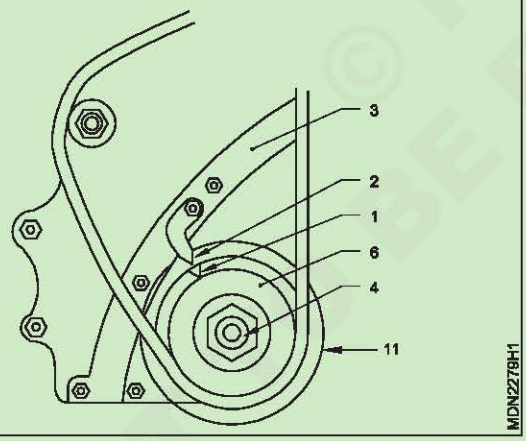
- Tray - 1 No.
- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Lube oil - as reqd.

PROCEDURE

TASK 1 : **Removal of damper pulley**

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

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.

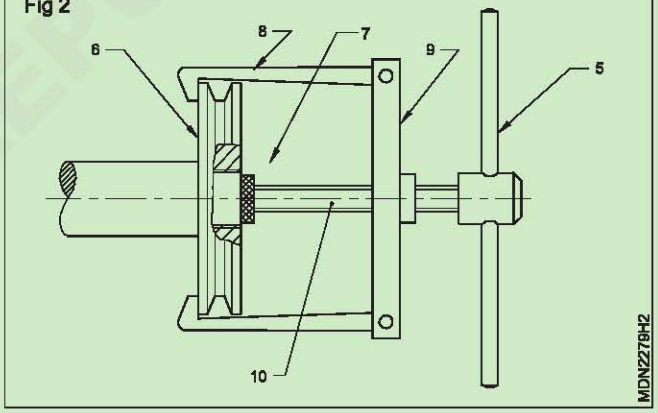
4 Remove the crank shaft pulley nut(4).

5 Place the puller (5) on the crank shaft pulley (6). Ensure the distance piece (7) does not sit inside the crank shaft 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 crank shaft.

Fig 2



8 Remove the damper pully (11) with the help of puller, and remove the timing cover by 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.

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Fig 3

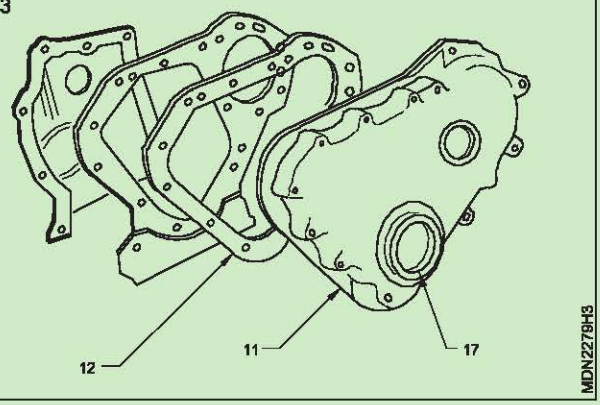


Fig 4

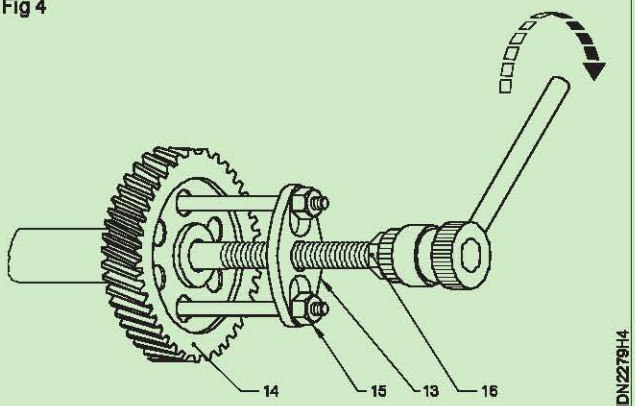
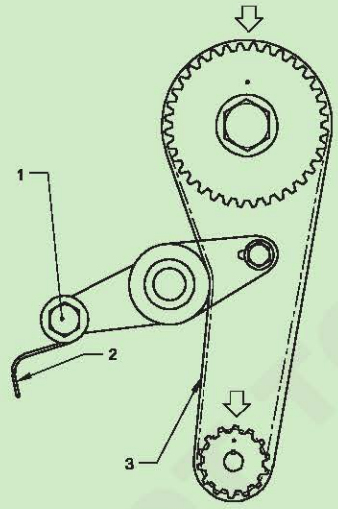


Fig 5



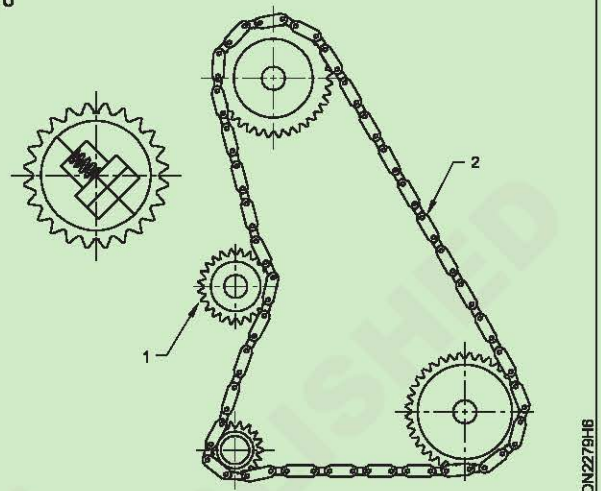
17 Loosen the water pump bolt (1) till the spring's (2) tension is reduced.

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)

Fig 6



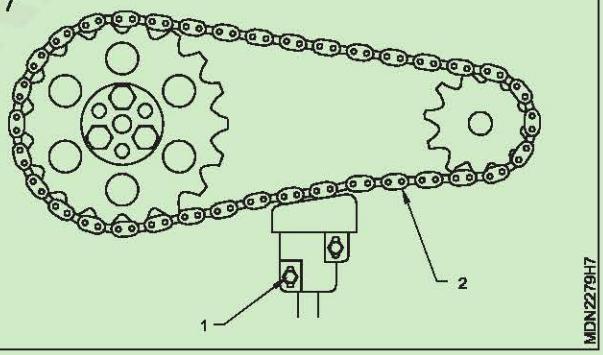
21 Remove the bolt.

22 Remove the spring.

23 Remove the tensioner pad.

24 Take out the chain (2) from the chain sprocket.

Fig 7



TASK 2 : **Removal of flywheel**

1 Lock the flywheel by placing a wooden piece (1) between the flywheel and crank shaft 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.

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Fig 1

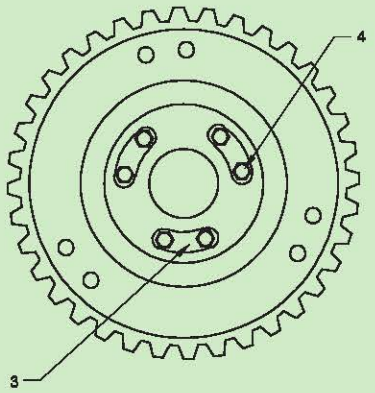
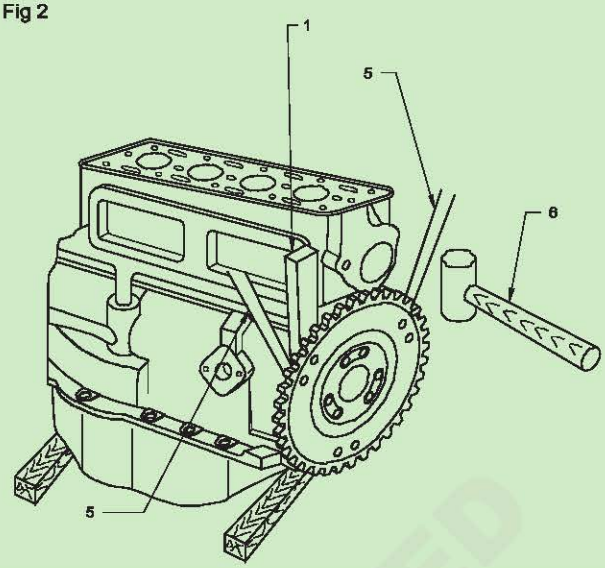


Fig 2



TASK 3 : **Removal of crank shaft**

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/ crank shaft seizure. (Fig 1)

6 Lift the crank shaft (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 1

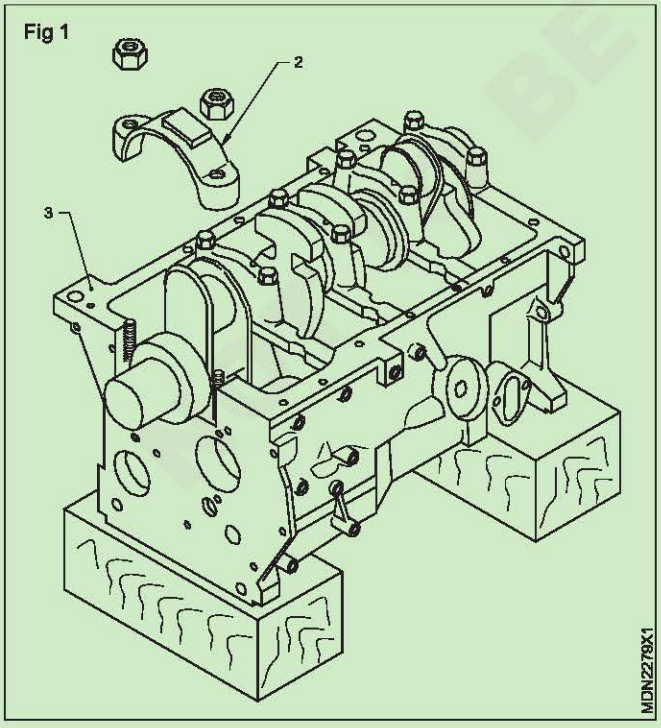
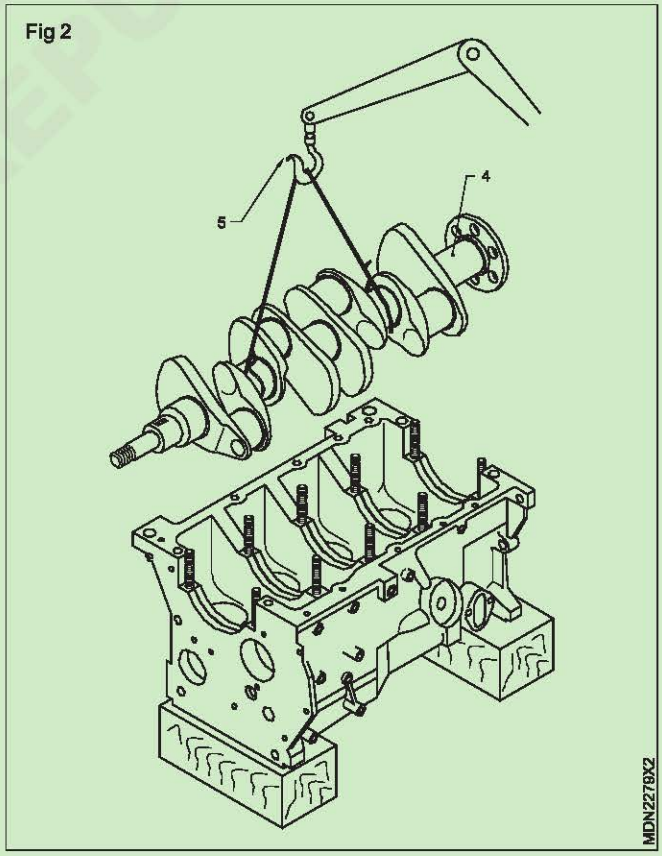


Fig 2



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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

- Trainee's tool kit - 1 No.
- Dial indicator - 1 No.
- 'V' block - 1 No.

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

1 Remove the crank pulley

2 Disconnect and remove the all connecting rods caps

3 Loosen the mounting of crank shaft

4 Remove the crankshaft from the engine

5 Place the crankshaft in tray on the work bench

6 Clean the crankshaft

7 Clean the thrust half washers and oil retainers (Fig 1)

8 Check the thrust washers for wear and damages

9 Check the crank shaft oil retainers (1) for damages

10 Place the crankshaft on the 'V' blocks and ensure crankshaft freely rotates.

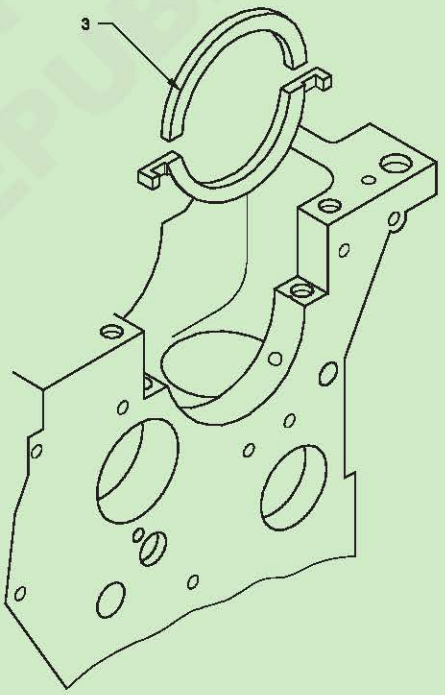
11 Set the dial indicator for checking the thrust surfaces and rotate the crankshaft and measure the wearness.

12 Refer the wearness reading with service manual reading

13 If thrust surface wear is more than the specified limit, recommend for regrinding

14 If any damage found in thrust half washers and oil retainers, replace it.

Fig 1



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Measuring the crankshaft taper and ovality

Objectives: At the end of this exercise you shall be able to
- **check the crank shaft journal wear**
- **measure the crank shaft journal for taper and ovality.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Outside micrometer - 1 No.
- 'V' block - 2 No.

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

1 Remove the crank shaft from the engine block.

2 Clean the crank shaft assembly with cleaning solvent.

3 Clean the crank shaft with compressed air and baniyan cloth.

4 Check the crank shaft visually for cracks and damages.

5 With the help of an outside micrometer, measure the journal diameter at positions `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 & 2)

6 If the taper and ovality is more than the given specified limit, then the crankshaft should be reground to undersize.

7 Measure the oil clearance between the crankshaft main journal and the bearing shell.

Fig 1

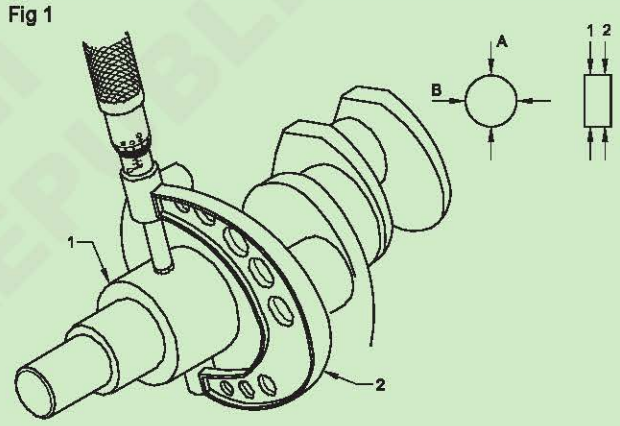
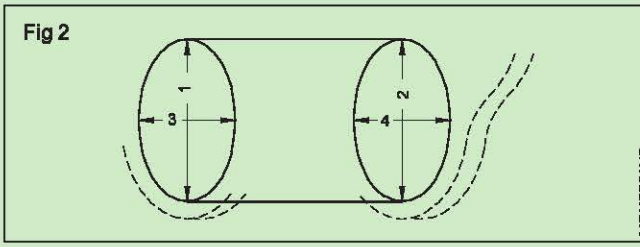


Fig 2



NOT TO BE PUBLISHED

Inspect the crankshaft

Objectives: At the end of this exercise you shall be able to
- **check bend & twist of the crank shaft**
- **check fillet radii of the crank shaft.**

Requirements

Tools/Instruments

• Trainee's tool kit	- 1 No.
• 'V' block	- 2 No.
• Dial gauge with magnetic base	- 2 No.

Equipments/Machineries

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

Materials/Components

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

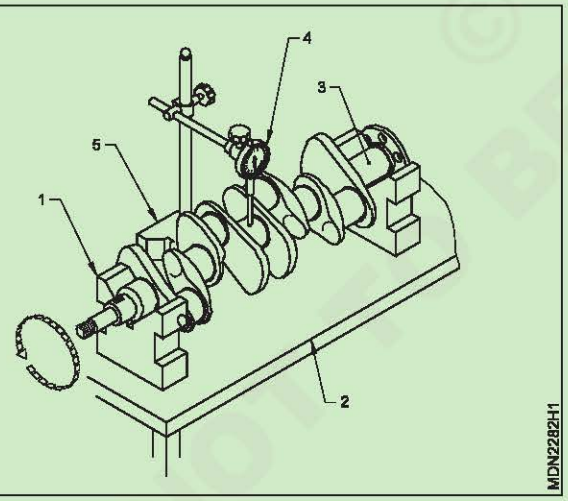
PROCEDURE

1 Place two 'V' blocks (1) on the surface table (2).

2 Place the crankshaft (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)

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.

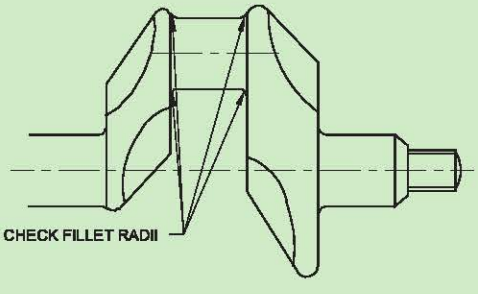
8 Repeat the above steps at three places, so as to cover the complete length of the shaft (3).

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.

Fig 2



Inspect the flywheel and spigot bearing

Objectives: At the end of this exercise you shall be able to
- **inspect the flywheel and mounting flange**
- **inspect the spigot bearing.**

Requirements

Tools/Instruments

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

Equipments/Machineries

• Multi cylinder diesel engine	- 1 No.

Materials/Components

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

PROCEDURE

Inspecting flywheel and mounting flange

1 Clean the surface of flywheel.

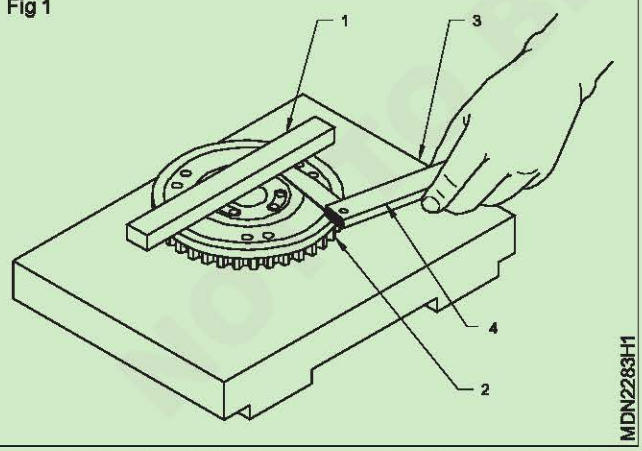
2 Visually check the flywheel (Fig 1) friction surface by using a straight edge (1) and feeler gauge (4).

3 If flywheel warpage is more than the specified limit by the manufacturer, then recommend for machining.

4 Ensure that flywheel thickness after machining has not become less than the specified thickness.

5 Clean the crank shaft flange and flywheel mating surface.

Fig 1



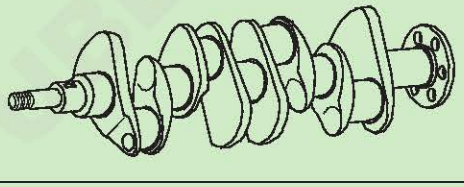
6 Visually check the flywheel mounting flange (Fig 2) for damage and cracks

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 bearing noise [If wornout, replace with new bearing].

Fig 2

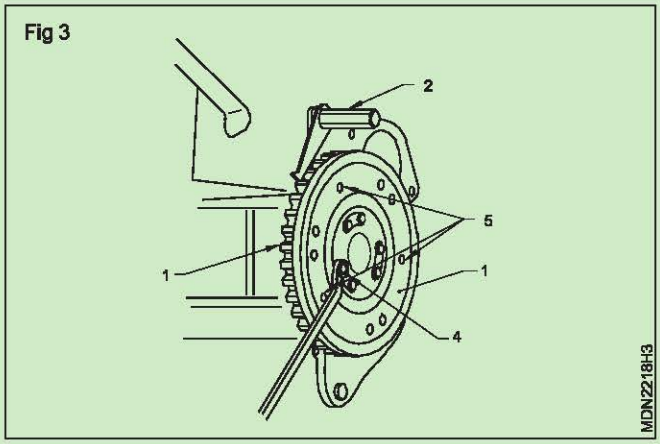


10 Fit the spigot bearing in the socket of crank shaft rear end/Flywheel.

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)

Fig 3



14 Install the flywheel (1) on the crank shaft 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

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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.

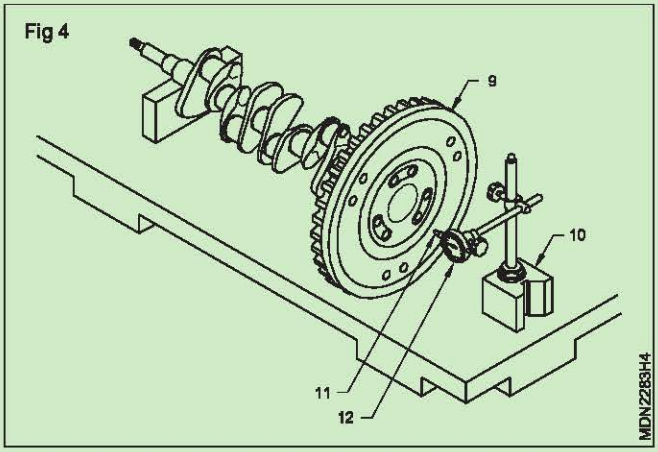


Fig 4

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Check the vibration damper

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

Requirements

Tools/Instruments

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

Materials/Components

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

PROCEDURE

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 pulley (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 dismantled parts of the vibration damper

10 Inspect the dismantled parts for wear and damages

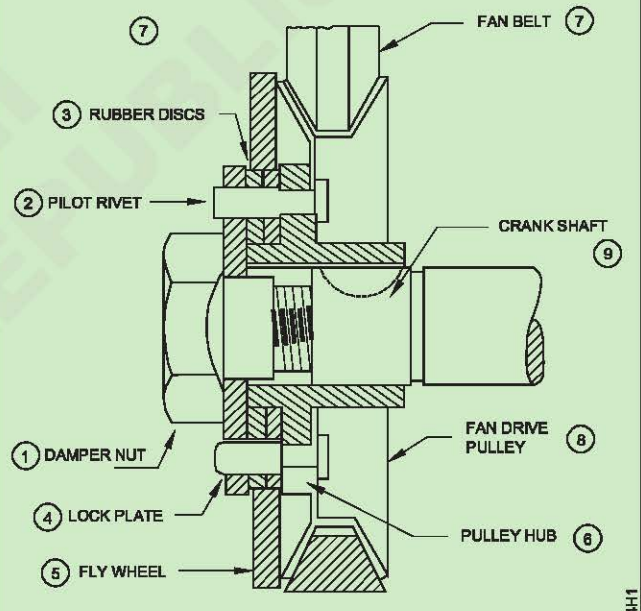
11 Select the damaged/ wearing parts and replace it with new parts.

12 Assemble the all dismantled parts of vibration damper.

13 Fit the vibration damper on the crank shaft.

14 Ensure the vibration damper is properly installed with the fan drive pulley.

Fig 1



VIBRATION DAMPER

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Removing and checking the camshaft

Objectives: At the end of this exercise you shall be able to
- **remove and inspect camshaft from the engine**
- **check cam shaft bend and twist**
- **inspect cam lobe and journal**
- **measure cam lobe height .**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

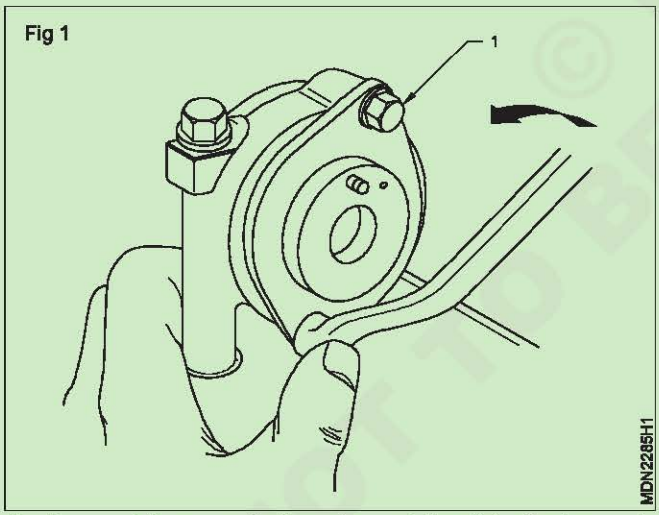
Materials/Components

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

PROCEDURE

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

Fig 1



2 Support the camshaft and carefully slide the journals through each bearing. Avoid contact of the surface with cam lobe and pull out the camshaft. (Fig 2)

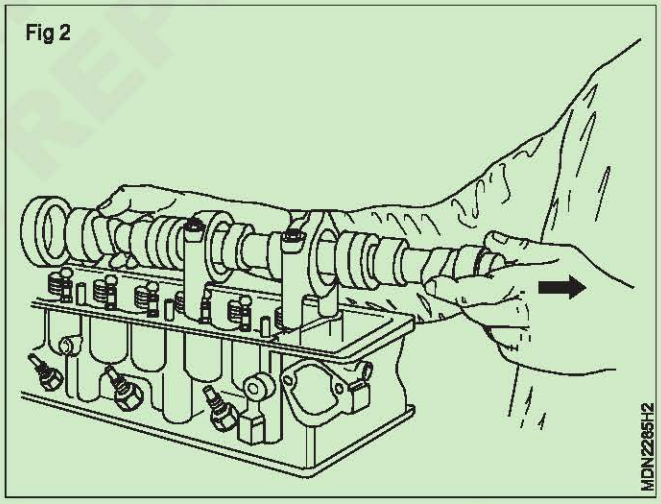
3 Clean the camshaft thoroughly.

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

Fig 2



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.

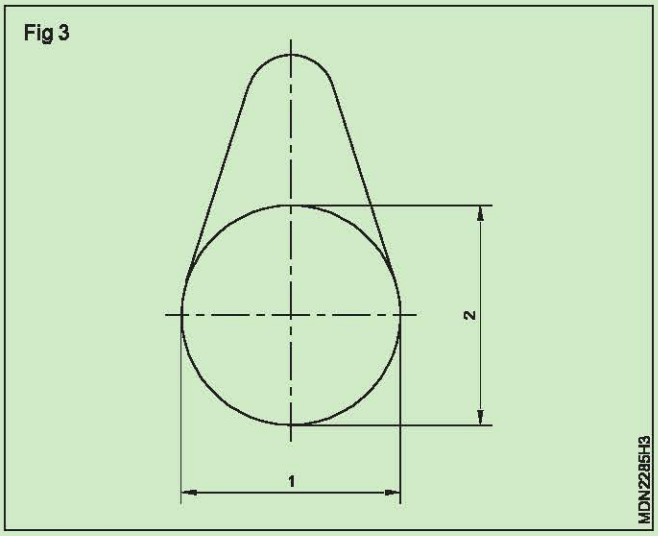
10 Check oil pump drive gear for pitting, wear and damage.

11 Check eccentricity for driving fuel pump.

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

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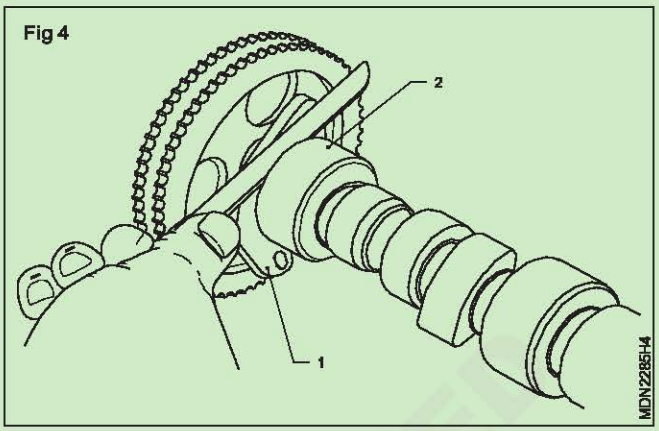
Fig 3



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.

Fig 4



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Assembling the crank shaft, piston and connecting rod assembly

Objectives: At the end of this exercise you shall be able to
- **fix the bearings in the cylinder block**
- **fix the crank shaft in the cylinder block**
- **fix the connecting rod bearing cap**
- **check crank shaft end play.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

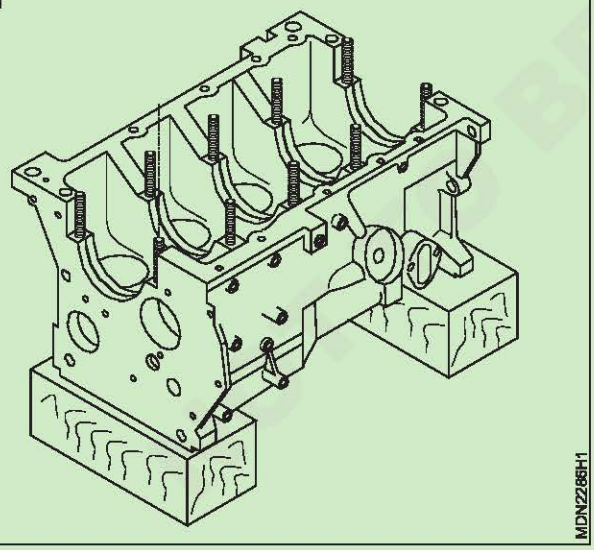
Materials/Components

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

PROCEDURE

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

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 holes of the bearing shell and that of the parent bore are perfectly aligned.

5 Install the crank shaft rear bearing seal (oil seal). Insert the rubber packing (rubber rod) in the holes between the bearing cap and the cylinder block.

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 crank shaft in its position in the cylinder block.

Place the shell bearings into their respective bearing caps.

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

8 Lubricate and install the main bearing caps. Ensure that the bearing caps are fitted into their original positions.

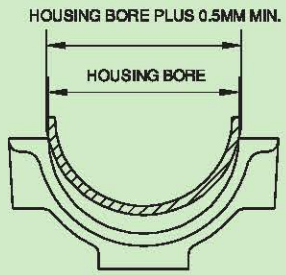
9 Hand-tighten the main bearing cap bolts.

10 Tighten the middle bearing cap to the specified torque and check the crank shaft for free rotation.

11 Loosen the main bearing caps and bolts on one side.

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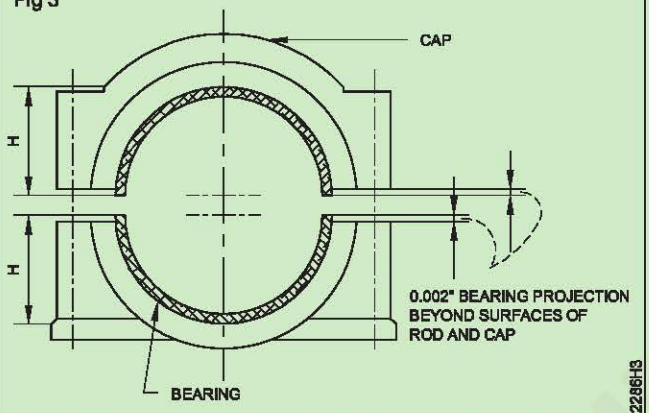
Fig 2



CHECK BEARING SPREAD

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)

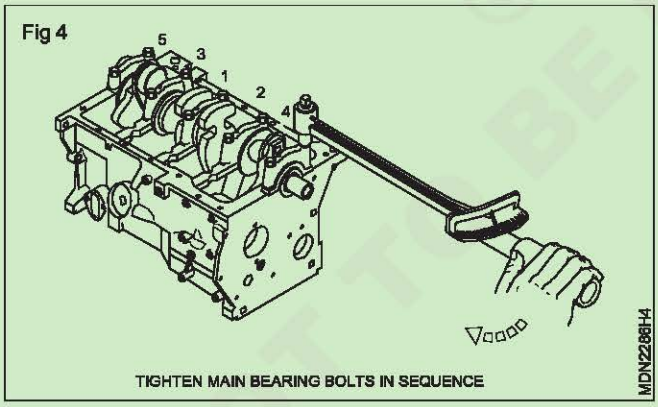
Fig 3



FIT OF BEARING IN HOUSING ALLOWS A SLIGHT PROJECTION OR CRUSH

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)

Fig 4



TIGHTEN MAIN BEARING BOLTS IN SEQUENCE

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

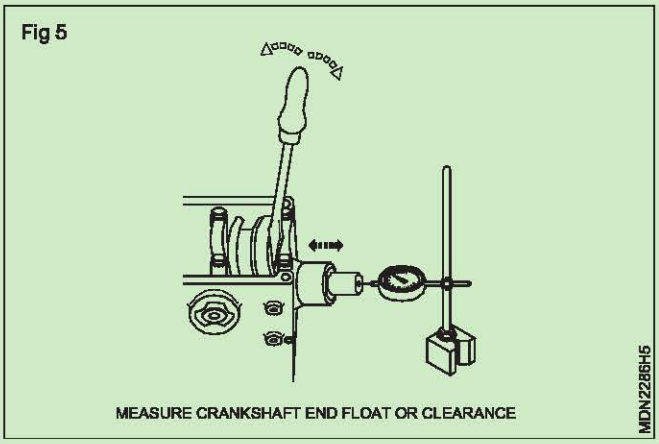
15 Check the crank shaft end play. (Fig 5)

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

17 Clean the cylinder block surface.

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

Fig 5



MEASURE CRANKSHAFT END FLOAT OR CLEARANCE

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 crank shaft while rotating the crank shaft. (Fig 6)

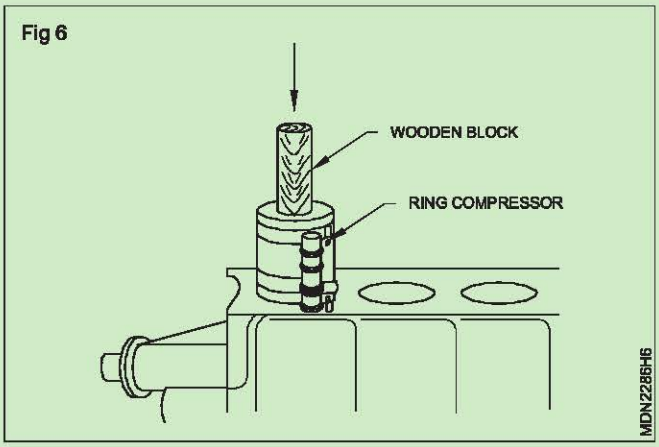
25 Fit the connecting rod bearing cap, along with the lower bearing shell.

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

27 Rotate the crank shaft and check for free rotation.

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

Fig 6



Practice on cleaning and checking the cylinder blocks

Objectives: At the end of this exercise you shall be able to
- **clean the cylinder block**
- **check the cylinder block.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

TASK 1: **Cleaning the cylinder block**

1 Put the cylinder block on wooden blocks (Fig 1)

2 Clean cylinder block with suitable solvent or steam

3 Clean the oil passages of cylinder block with help of wire brush

4 Remove all sludge of dirt and carbon deposits in crankcase, cylinder walls and valve chambers

5 Remove carbon deposits in cylinder block

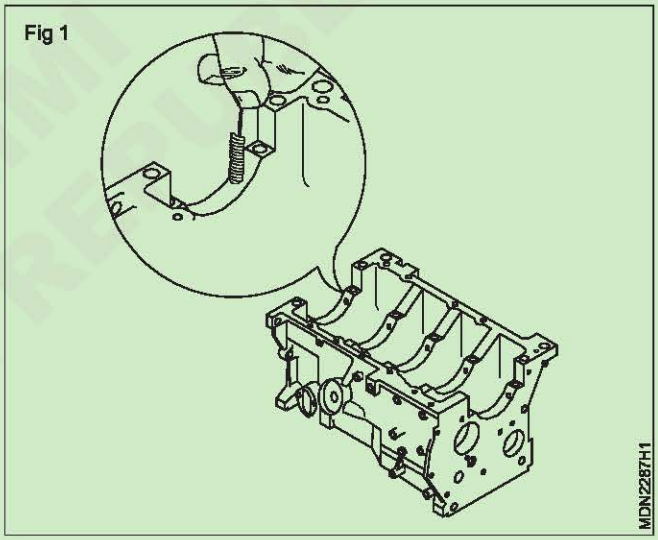
6 Use scrapper to remove hard carbon deposits and take care not to damage the highly finished surfaces

7 Clean the cylinder block by using compressed air blast

8 Visually check the cylinder block for cracks and damages

9 Replace the cylinder block if any damage is found.

Fig 1



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Measure the cylinder bore taper, ovality and flatness

Objectives: At the end of this exercise you shall be able to
- **check cracks and flatness of cylinder block**
- **check taper and ovality of cylinder bore and clean oil passages.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

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

1 Place the cylinder block on two wooden blocks.

2 Clean the top plain surface of the cylinder block.

3 Wipe the plain surface with clean banian cloth.

4 Keep the straight edge on the surface of the cylinder block and press the straight edge at the centre with your left hand.

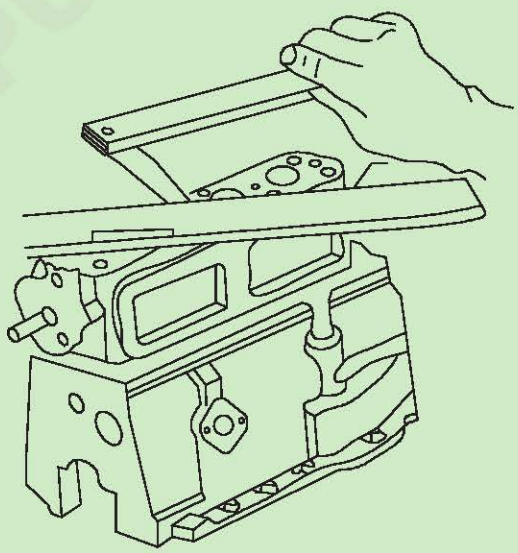
5 Insert the feeler gauge leaves between the straight edge and the surface of the cylinder block (Fig 1).

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 if maximum face out is more than the specified limit by the manufacturers.

Fig 1



TASK 2: **Check taper, ovality of cylinder bore 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.

3 Select the correct size of extension rod (1) which is more than measuring range.

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).

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7 Set the needle at '0' (zero) 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).

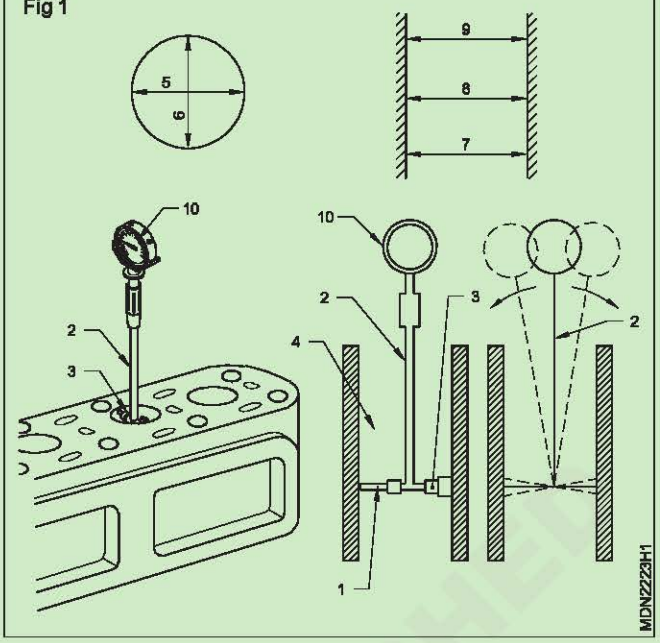
11 The difference in measurement between (5) and (6) at all places is ovality. The difference in measurement between (7) and (8), (8) and (9), and (9) and (7) is taper.

12 Note down maximum ovality and taper. If any one of them is more than the specified limit, recommend for reboring/ 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

Fig 1



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Reassembling the diesel engine parts

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

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

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Torque wrench, Ring expander - 1 No.
- Box spanner set - 1 No.
- Feeler gauge - 1 No.

Equipments/Machineries

- Multi cylinder diesel engine
- Zib crane/engine hoist

Materials/Components

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

PROCEDURE

TASK 1 : **Assembling crank shaft and camshaft**

1 Clean the 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.

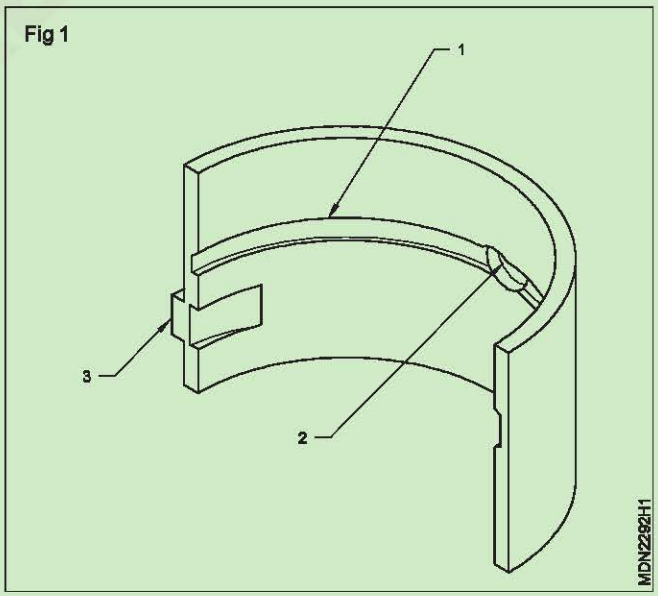
8 Fit the bearing caps ensure that the marks are matched, and tighten the caps at the recommended torque in given sequence.

9 Check free rotation of crank shaft after tightening each cap.

10 Check the end play of crank shaft, 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.

Fig 1



12 Fit the camshaft bushes. Ensure that the oil hole in block and bush is aligned.

13 Insert camshaft in its position.

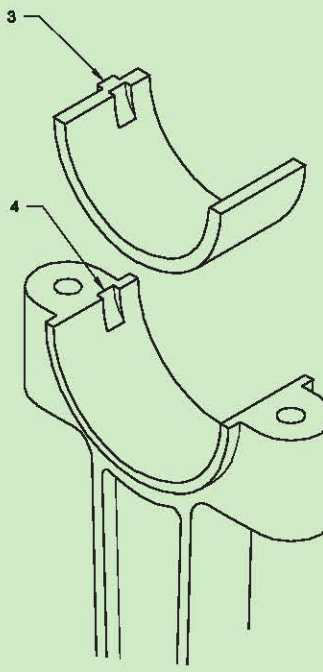
14 Tighten camshaft thrust plate bolt.

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.

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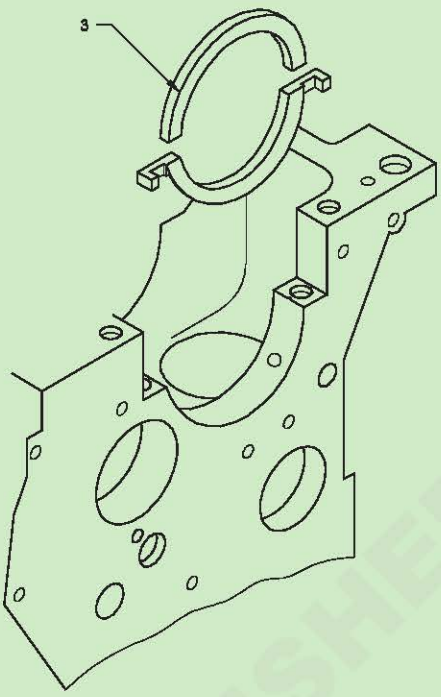
Fig 2



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

18 Check for free rotation of crank shaft.

Fig 3



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 crank shaft till it comes to B.D.C. Ensure that the connecting rod does not dislodge from the crank shaft 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.

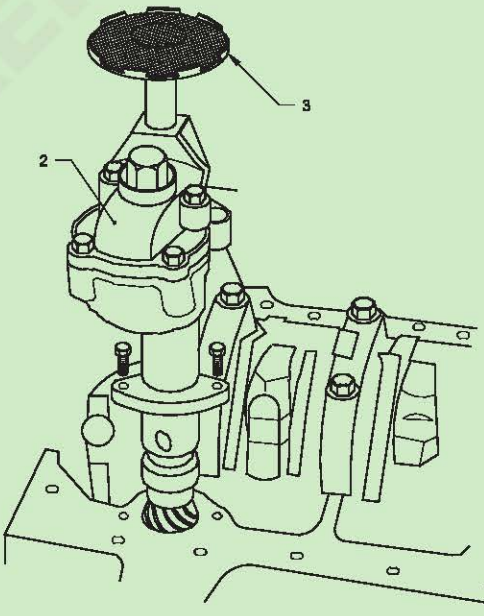
7 Rotate the crank shaft and check for free rotation. Repeat the above steps for fitting all the remaining pistons.

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 Mount the engine on the stand properly.

Fig 1



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)

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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.

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TASK 3 : **Fitting cylinder head assembly, rocker arm assembly**

Refer EX. No. 1.8.51 Skill Sequence

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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.

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.

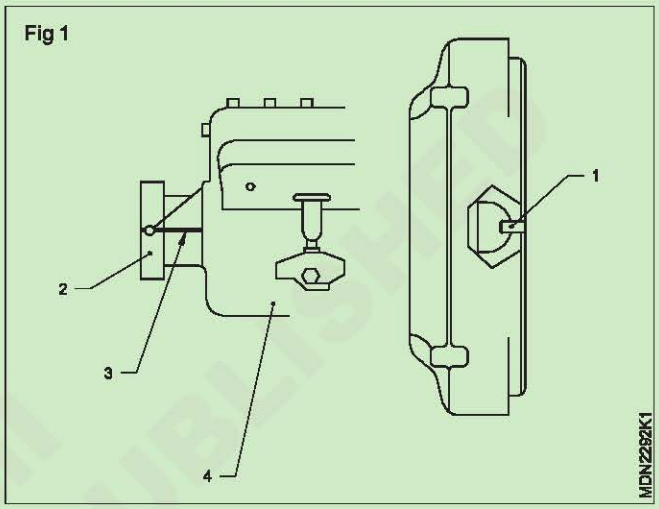
7 Connect high pressure lines and fix the clamp.

8 Fit overflow lines.

9 Fit oil filter assembly and connect the oil pipes.

10 Fix the gasket on the water pump body.

Fig 1



11 Fit the water pump and fix the fan. 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.

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TASK 5 : **Adjusting tappet clearance**

Refer Ex. No. 1.8.51

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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.

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10 Connect the pressure pipes between injectors and fuel injection pump.

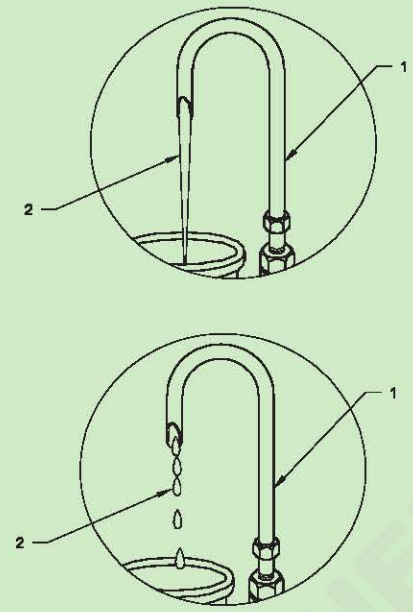
11 Place the valve door gasket over the cylinder head.

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.

Fig 1



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TASK 7 : **Bleed the fuel system**

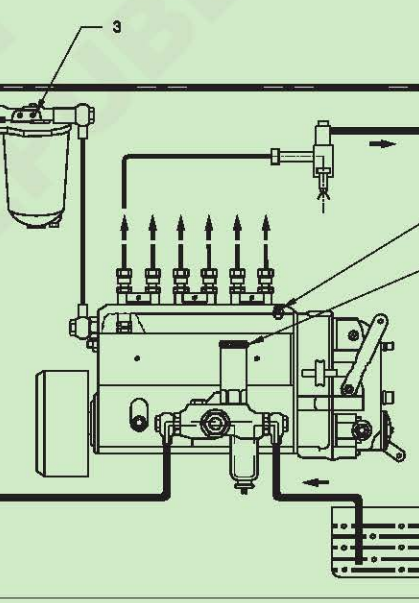
1 Loosen bleeding screw (3) of filter one or two turns.

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)

Fig 1



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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

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

Equipments/Machineries

- Multi cylinder diesel engine - 1 No.

Materials/Components

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

PROCEDURE

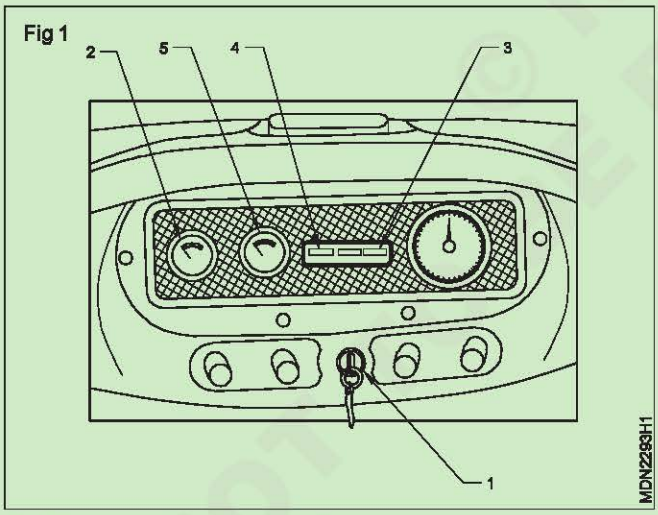
1 Check the water level in the radiator and top up if needed.

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)

Fig 1



5 Observe the ammeter (2) on the instrument pannel. The indicator of the meter will show slightly on the discharge side (-ve side) of the meter and the ignition bulb (3) will glow red and also the oil pressure indicator (4) will glow.

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 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

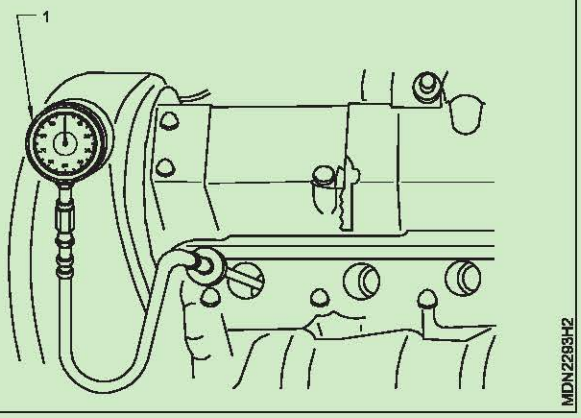
22 Install the compression gauge `1' on the first cylinder.

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)

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.

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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

• Trainee's tool kit	- 1 No.
• Torque wrench	- 1 No.
• Mallet, Drift punch	- 1 No.
• Puller	- 1 No.

Equipments/Machineries

- Multi cylinder diesel engine

Materials/Components

• Tray	- 1 No.
• Cotton cloth	- as reqd.
• Kerosene	- as reqd.
• Soap oil	- as reqd.
• Lube oil	- as reqd.
• Engine drive belt	- as reqd.
• Timing belt	- as reqd.

PROCEDURE

TASK 1: **Removing and replacing cam belt**

Refer Ex. No. 1.8.59

TASK 2 : **Replacing 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

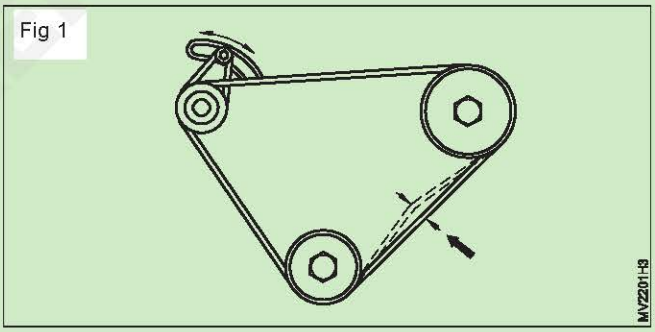
8 compare it with the new belt.

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)

Fig 1



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, re-adjust the engine drive belt tension.

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Checking and replacing the radiator hoses

Objectives: At the end of this exercise you shall be able to
- **check the radiator rubber hoses**
- **drain the coolant from the radiator**
- **replace the hoses and top up the coolant.**

Requirements

Tools/Instruments

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

Equipments/Machineries

- Running diesel engine - 1 No.

Materials/Components

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

PROCEDURE

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

2 Check swelling, cracking and leaking of the hoses.

3 Allow to cool the engine.

4 Keep a tray below the engine

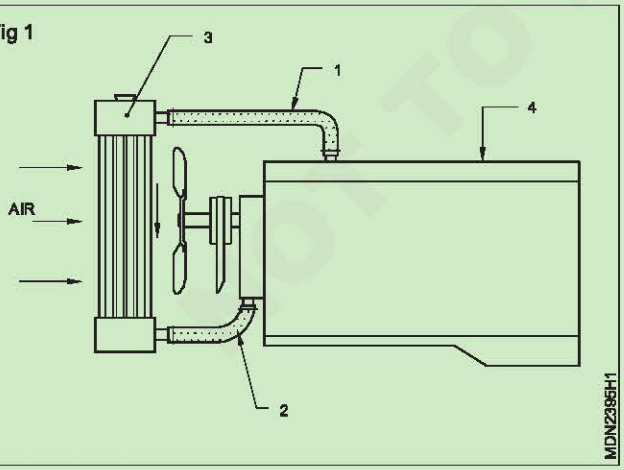
5 Open the drain cock of radiator and drain water completley

6 Close the drain cock.

7 Remove all the clamps by using screw driver

8 Remove the top and bottom, of the hoses.

Fig 1



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

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

11 Apply sealing compound inside of the new hoses.

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

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

14 Refill the coolant in cooling system by using the funnel

15 Start and run the engine for few minutes.

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

17 Stop the engine and allow to cool

18 Open the radiator cap

19 Check the coolant level, top up if necessary.

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Testing the leakage in cooling system

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

Requirements

Tools/Instruments

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

Equipments/Machineries

- Multicylinder diesel engine - 1 No.

Materials/Components

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

PROCEDURE

1 Remove the radiator cap

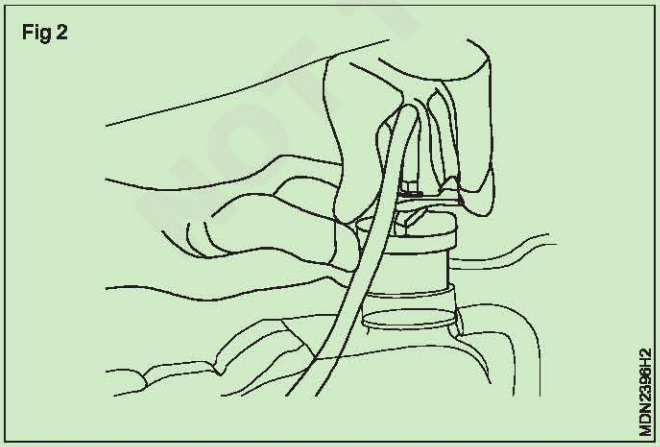
Before removing the radiator cap squeeze the upper radiator hose to check for pressure in the system. Determine no pressure inside, otherwise slowly remove (Fig 1)

Fig 1



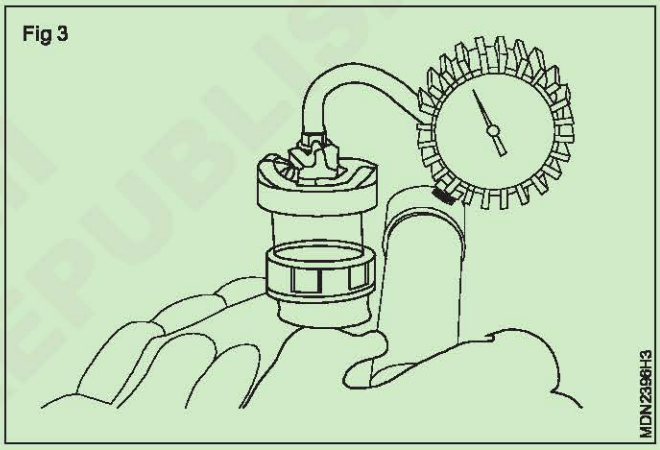
2 Make sure the radiator is full, and attach the pressure tester to the filler neck of the radiator (Fig 2).

Fig 2



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

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

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

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

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

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Overhauling of radiator and check the pressure cap

Objectives: At the end of this exercise you shall be able to
- **check the radiator cap**
- **remove the radiator from the frame**
- **clean the radiator**
- **assemble the radiator**
- **adjust fan belt tension.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Box spanner set - 1 Set.

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

TASK 1: **Dismantling**

1 Remove the radiator cap (1).

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

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

4 Disconnect the top and bottom water hoses.

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

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

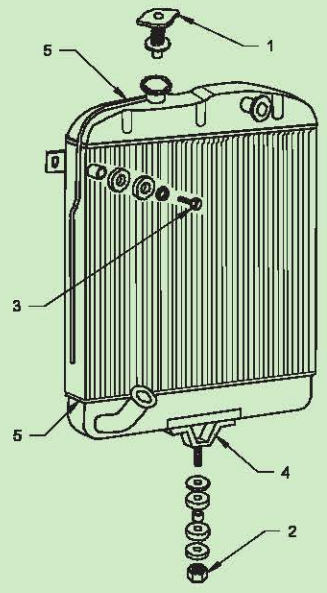
7 Remove the bracket if provided.

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.

Fig 1



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TASK 2: **Cleaning and inspection**

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

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

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

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

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

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

7 Clean the thermostat valve

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

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TASK 3: **Assembling**

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

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

3 Fix the radiator stay bracket.

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

5 Fix the thermostat valve and pressure cap

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

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

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

Check the radiator pressure cap

- Carefully touch the radiator hose and feel its hot.

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

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

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

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

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

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

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

Note: Too much pressure in the system can result damage

Fig 1

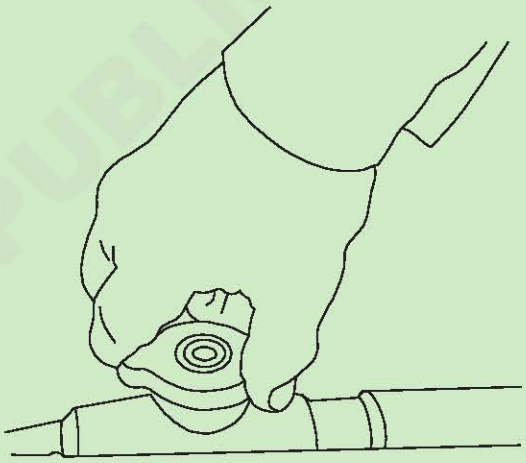
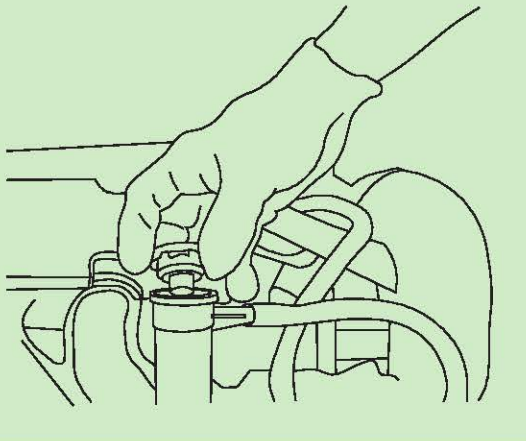


Fig 2



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Testing the thermostat valve

Objectives: At the end of this exercise you shall be able to
- **remove the thermostat valve**
- **inspect and test the thermostat valve**
- **refit and test the thermostat valve**

Requirements

Tools/Instruments

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

Equipments/Machineries

- Work bench - 1 No.

Materials/Components

- Cotton cloth - as reqd.
- Kerosene - as reqd.
- Soap oil - as reqd.
- Coolant - as reqd.
- Gasket - as reqd.
- 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.

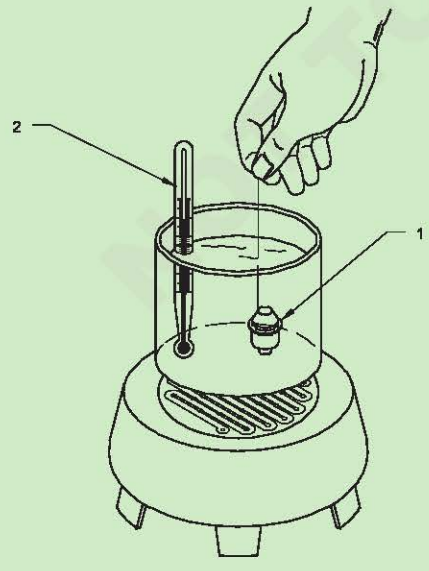
4 Tie the thermostat valve's collar with a thread.

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.

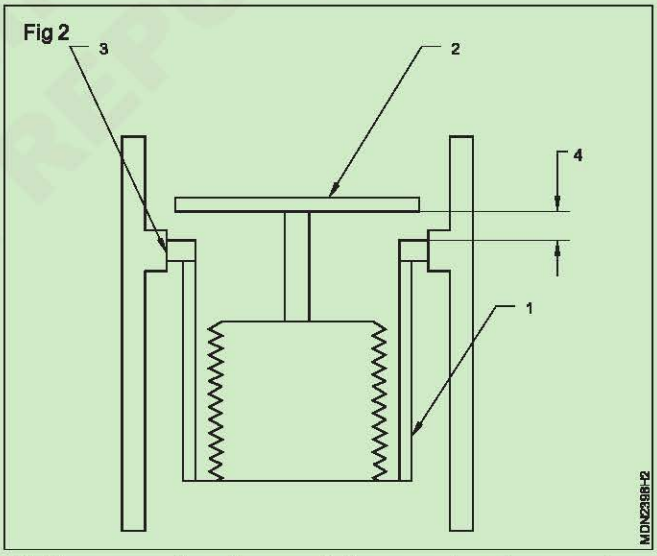
Fig 1



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)

Fig 2



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

11 Fit the thermostat in the thermostat case.

12 Fit the thermostat cover in the thermostat case.

Practice on reverse flushing radiator

Objectives: At the end of this exercise you shall be able to
- **clean and reverse flush the radiator.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

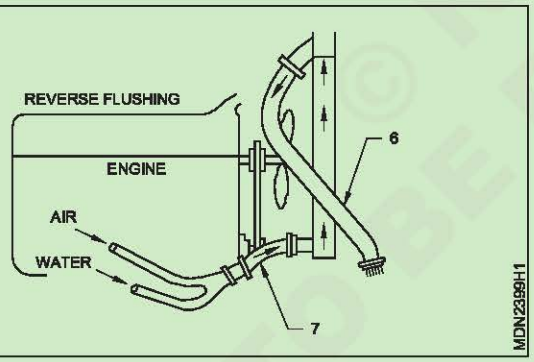
1 Remove the radiator upper and lower hose

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

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

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

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/ cm^2 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.

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Overhauling the water pump

Objectives: At the end of this exercise you shall be able to
- **dismantle the water pump**
- **inspect the parts of a water pump**
- **assemble the water pump.**

Requirements

Tools/Instruments

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

Equipments/Machineries

• Multi cylinder diesel engine	- 1 No.

Materials/Components

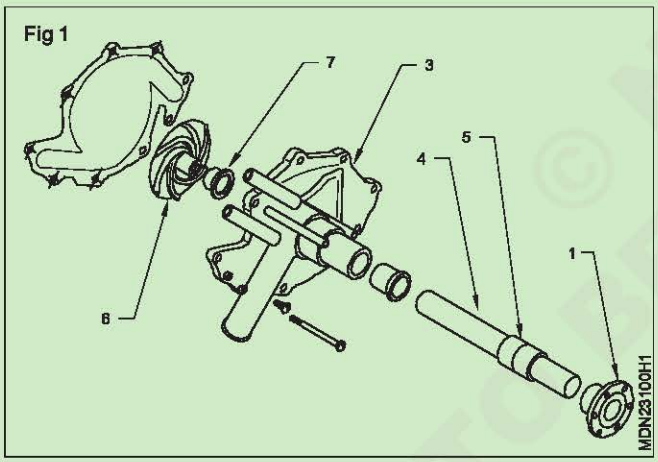
• Tray	- 1 No.
• Cotton cloth	- as reqd.
• Kerosene	- as reqd.
• Soap oil	- as reqd.
• Coolant	- as reqd.
• Grease	- as reqd.

PROCEDURE

TASK 1: **Dismantling**

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

Fig 1



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

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

4 Remove the water pump rear cover, if provided.

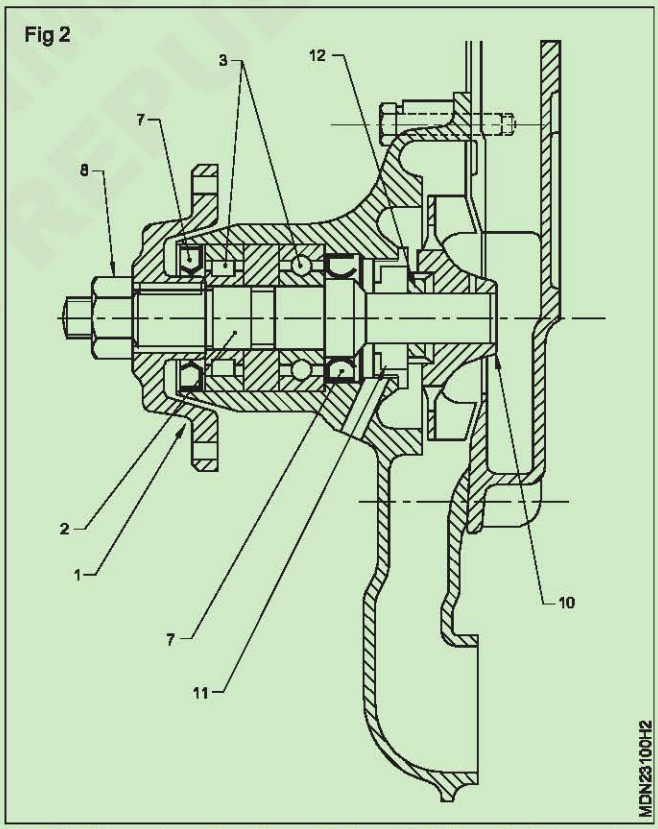
5 Unscrew the oil seal holder and remove the oil seal shims and gasket.

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

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

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

Fig 2



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.

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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.

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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.

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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

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Changing the engine oil

Objectives: At the end of this exercise you shall be able to
- **drain the engine oil**
- **fill the engine oil to a specified level**
- **check the engine oil pressure at different r.p.m.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machineries

- Multicylinder diesel engine - 1 No.

Materials/Components

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

PROCEDURE

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

2 Stop the engine.

3 Unscrew the engine oil dipstick.

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

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

6 Unscrew the pan drain plug and drain oil completely.

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

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

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

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

11 Refit the oil filling cap.

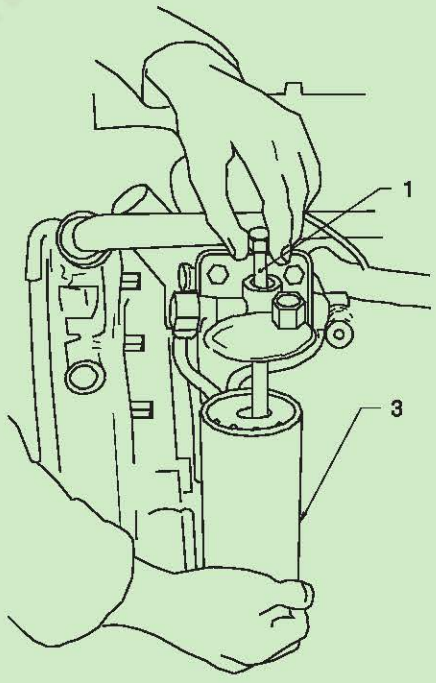
12 Start the engine and warm up.

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



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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

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

Equipments/Machineries

- Multi cylinder diesel engine - 1 No.

Materials/Components

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

Fig 1



3 Take out the oil pump (2) along with the strainer (3).

4 Remove the strainer assembly (3) from the pump.

5 Remove the oil pump end cover (4) (Fig 2).

6 Remove the pump cover packing (5).

7 Remove the idler gear (6) from the oil pump housing(7).

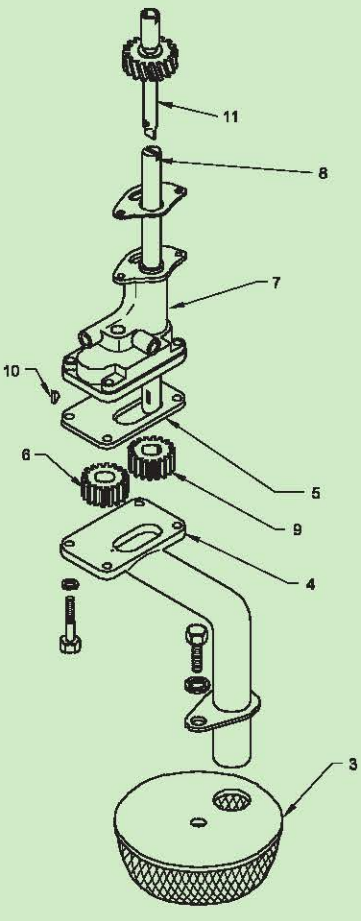
8 Remove the driving gear (9) with the shaft (8).

9 Press out the driving gear from the drive shaft.

10 Remove the woodruff key (10) from the driving shaft.

11 Remove the driving gear by using the puller.

Fig 2



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TASK 2: **Cleaning and Inspection**

1 Clean all the parts by kerosene oil.

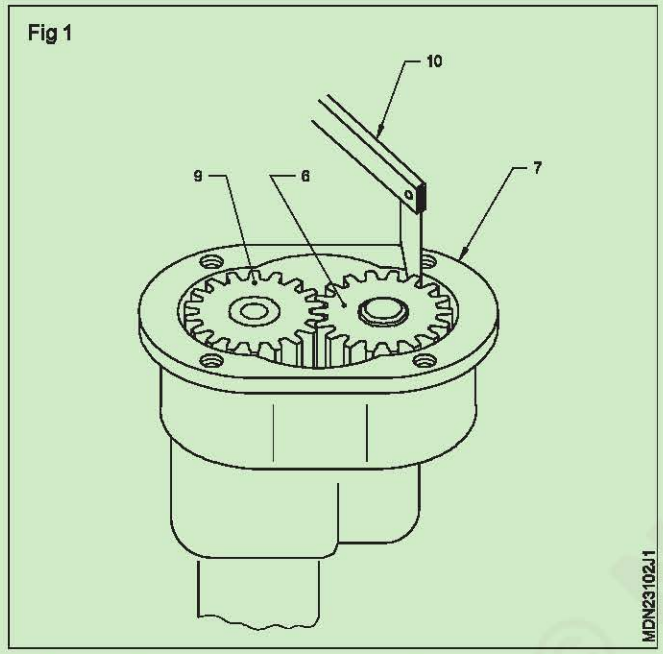
2 Clean the suction pipe by compressed air.

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).

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.

Fig 2

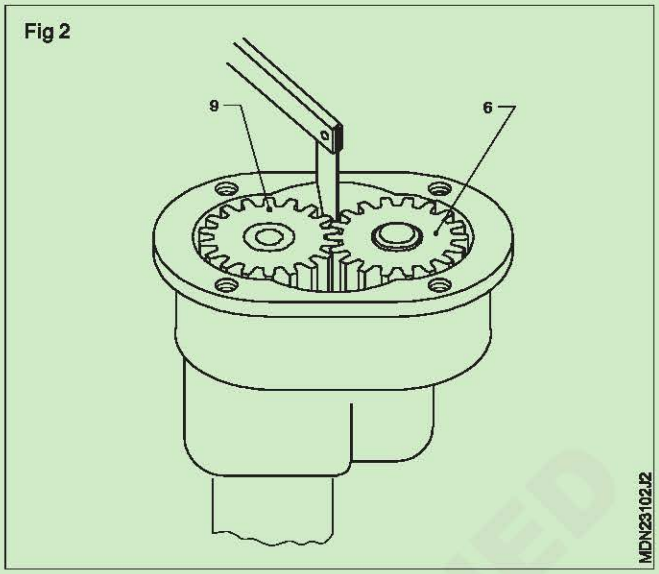
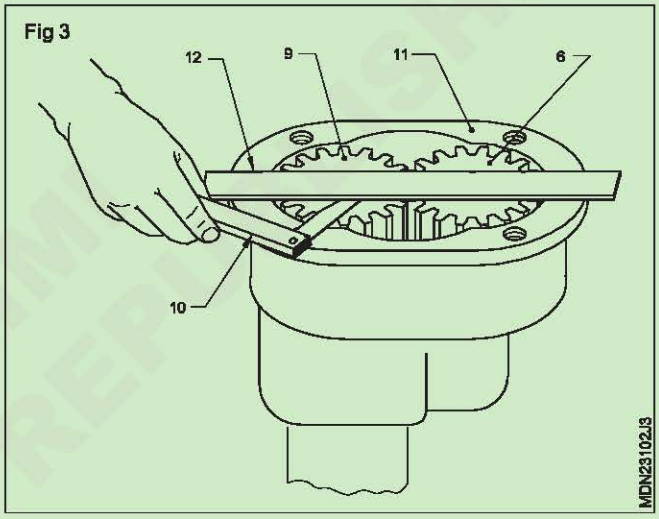


Fig 3



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

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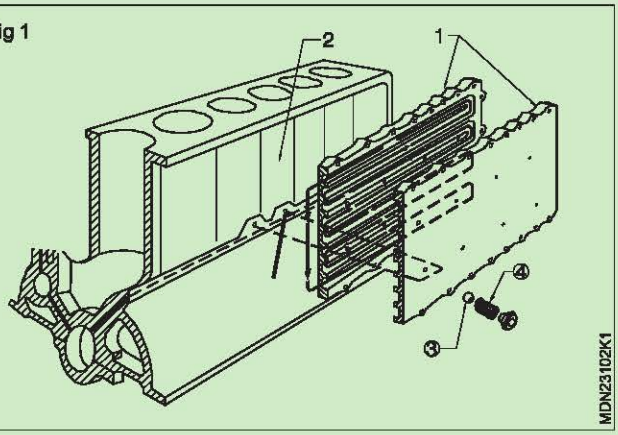
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TASK 4: **Servicing of oil cooler**

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

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

Fig 1



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.

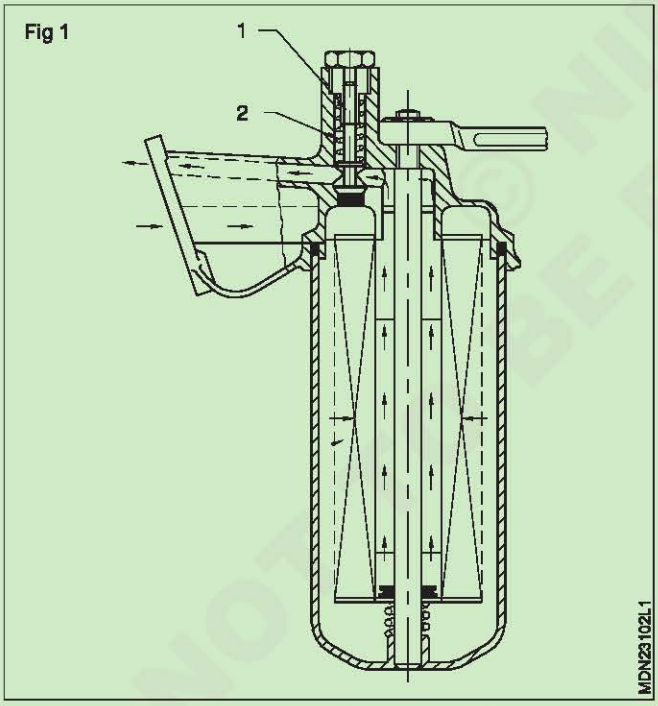
TASK 5: **Adjust oil pressure relief valve**

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&2).

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.

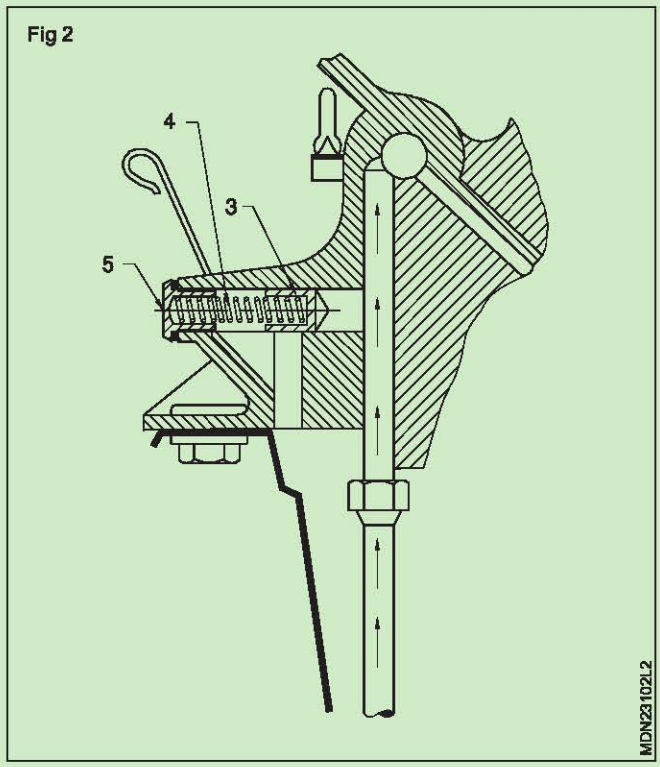
13 Start the engine and warm up.

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.

Fig 2



Servicing dry and wet air cleaner and charge air cooler

Objectives: At the end of this exercise you shall be able to
- **service the dry type air cleaner**
- **service the oil bath type air cleaner.**
- **dismantle charge air cooler and inspect, clean test and refit into the engine.**

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

1 Open the bonnet.

2 Unscrew the bolt or wing-nut (1) of the air cleaner with the help of a spanner or plier (Fig 1).

3 Remove the top cover (4) with the filter element (5) and gasket (6).

4 Loosen the nuts/fixing clip (7) fixing the air cleaner on the inlet manifold.

5 Remove the bottom case (8) of the air cleaner.

6 Clean the air cleaner housing and cover with cloth.

7 Inspect the filter element (5). If it is clogged, replace the same.

8 Blow off the dust from the inside element by compressed air.

9 If the element is heavily dirty, wash it with a household type detergent

10 After washing rinse the detergent out of the element and dry it completely

11 Check visually the cleaned element (5) for puncture or damage. Discard if it is found punctured or damaged.

12 Check the plastic or rubber gasket ring (6) for smoothness which acts as a gasket

13 Place the new or old element (5) in the lower housing (8).

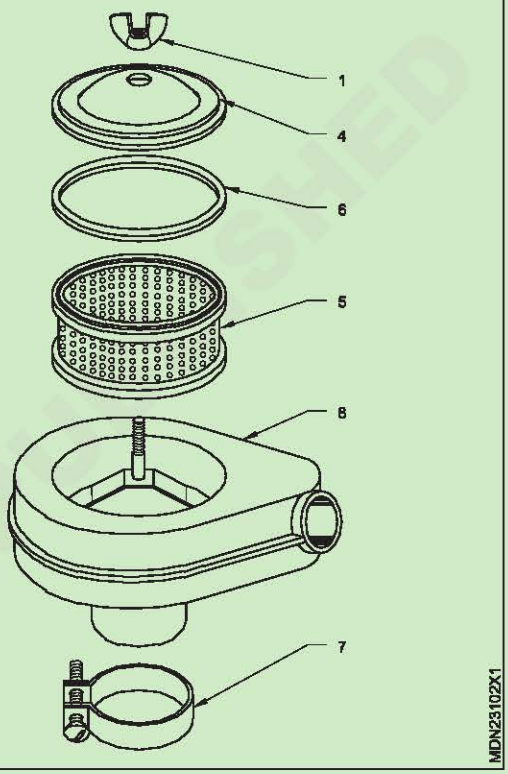
14 Put the plastic gasket ring (6) on the element (5).

15 Put the top cover (4) on the element (5).

16 Tighten the wingnut (1) with the help of a plier.

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

Fig 1



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

1 Open the bonnet of the vehicle.

2 Unscrew the bolt or wing-nut (1) on the top cover (2) by hand or plier (3) (Fig 1).

3 Remove the top cover (2) with the element (5) and gaskets (6 & 9).

4 Loosen the nuts/fixing clip (7) of the lower portion (10) of the air cleaner.

5 Remove the bowl (8) from the inlet manifold.

6 Drain the oil from the bowl (8) and clean the sludge.

7 Using a piece of cardboard, block the opening of the air intake on the inlet manifold to avoid entry of foreign material.

8 Pour a little diesel/ kerosene over the air cleaner element (5). Hold it in vertical position. Rotate and stir the element by hand until all the dust is absorbed by the oil. Drain the used oil. Repeat the procedure until all the dust or dirt is removed from the wire mesh.

9 Blow compressed air under reduced pressure over the wire mesh from the opposite side and dry the element.

10 Clean the bottom case (bowl) (8) of the air cleaner with diesel/kerosene and wipe with clean cloth.

11 Check the filter element and the wire mesh for damage and clogging of dust. If damaged, replace with a new one.

12 Check the gasket ring (6) and clean it; if damaged replace the gasket ring.

13 Check the threads of the top cover mounting bolts/ wing-nut (1).

14 Check the air cleaner bowl (bottom case) for damage.

15 Mount the bowl (bottom portion) on the engine manifold by tightening the fixing nuts or bolts of the clip (7).

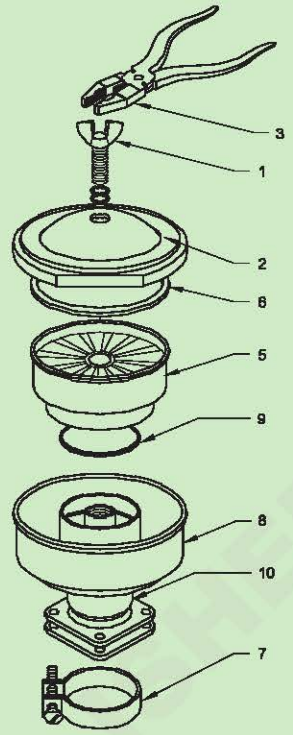
16 Refill the air cleaner bowl /housing up to the oil level mark with clean, recommended grade of oil.

17 Place the gasket (9) and install the filter element (5) in the housing bowl(8).

18 Place the gasket ring (6) and fit the cover (2) by tightening the wing-nut (1).

19 Start the engine and check the performance of the engine for smooth running.

Fig 1



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

1 Remove charge air cooler mounted along side or a head of radiator by removing the bolts.

2 Disconnect hose pipe connection from both LHS & RHS.

3 Clean external fins by controlled water jet.

4 Clean interior passage by pressurised water and dry the same.

5 Check for leaks by blocking one end and applying air pressure in the other end and dip the CAC completely in water.

6 Look for leaking air bubbles.

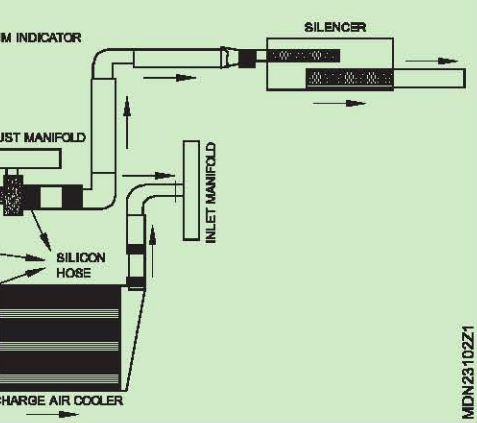
7 If there is a leakage follow the manufacturer's guide line to repair it.

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.

Fig 1



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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

• Trainee's tools kit	- 1 No.
• Socket spanner set	- 1 No.
• Torque wrench	- 1 No.
• Outside micrometer	- 1 No.
• Cylinder bore gauge	- 1 No.
• Piston ring expander	- 1 No.
• piston ring compressor	- 1 No.
• Feeler gauge	- 1 No.

Equipments/Machineries

• Multicylinder diesel engine	- 1 No.
• Air compressor (automotive)	- 1 No.

Materials/Components

• Kerosene	- as reqd.
• Soap oil	- as reqd.
• Lubricant Oil	- as reqd.
• Cleaning cloth	- as reqd.
• Emery paper	- as reqd.
• Grease	- as reqd.
• Piston ring	- 1 Set
• Exhauster	- 1 No
• gasket material	- as reqd.

PROCEDURE

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

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).

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).

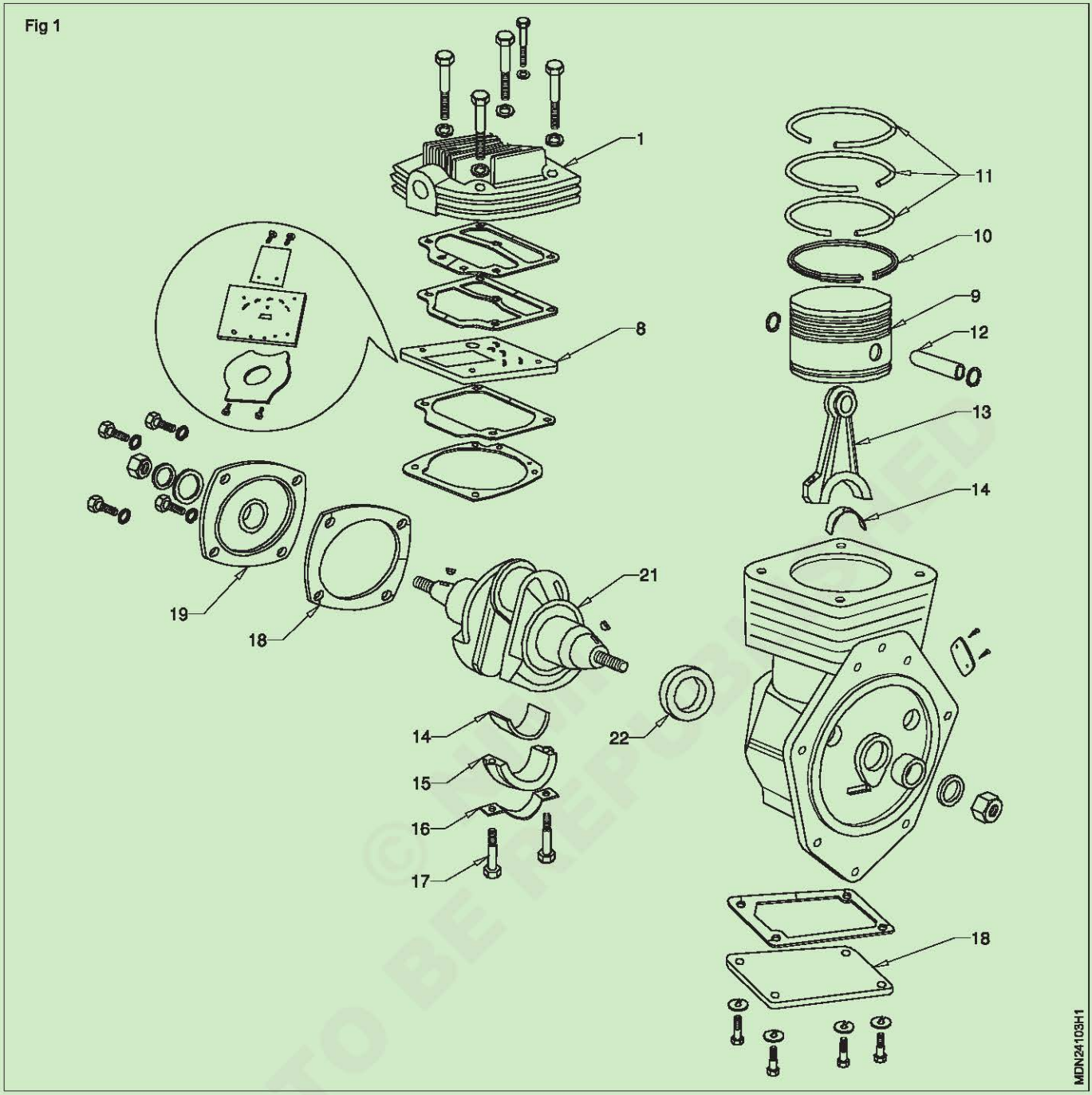
14 Remove gudgeon pin (12) & connecting rod (13) from piston.

15 Remove end cover (19) alongwith gasket (18).

16 Take out crankshaft (21) and thrust washer (22).

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Fig 1



TASK 2: **Cleaning and inspection**

1 Clean the air compressor parts.

2 Clean oil passages in crank shaft and connecting rod and check for free flow of air.

3 Inspect the cylinder bore for wear, taper and ovality. Recommend for reboring if required.

4 Check ring clearance in piston groove.

5 Inspect connecting rod for cracks damages

6 Inspect the crank shaft journal for wear/taper and ovality.

7 Check clearance between crankshaft journals and bearings, if required replace the bearings.

8 Inspect the inlet and delivery reed valve. If necessary replace them.

9 Check crankshaft thrust washer for any damage.

10 Check piston and cylinder head for crack, damage etc.

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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 over- lap 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.

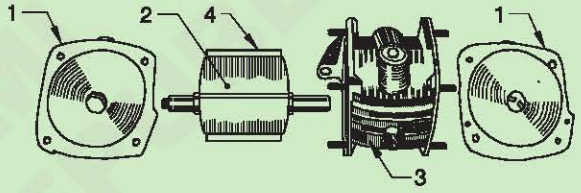
2 Remove drive connection.

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).

Fig 1



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.

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Overhauling the turbo charger

Objectives: At the end of this exercise you shall be able to
- **remove turbo charger from vehicle**
- **dismantle turbo charger**
- **clean, replace or repair defective parts**
- **assemble and check turbo charger**
- **refit turbo charger on vehicle and start the engine.**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

Removal

1 Park the vehicle on level surface and choke the wheels.

2 Make sure the engine is cool-down. Open the hood and remove the battery cables.

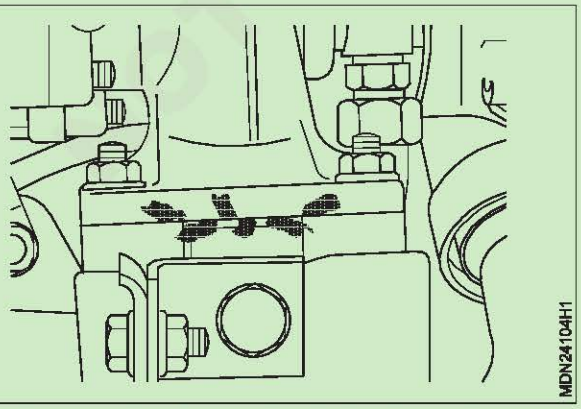
3 Remove the compressor side hose clamp of hose pipe.

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).

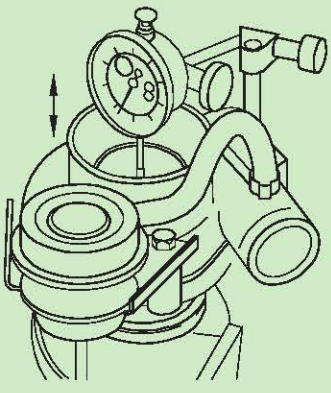
Fig 1



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

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)

Fig 2



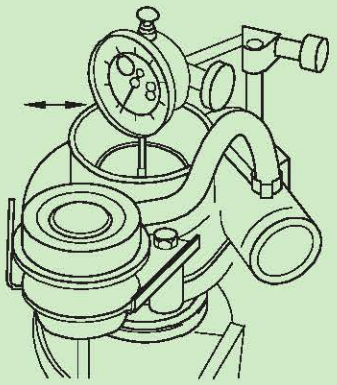
9 Check the redial movement at compressor impeller nose using a dial gauge (Fig 3).

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.

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Fig 3

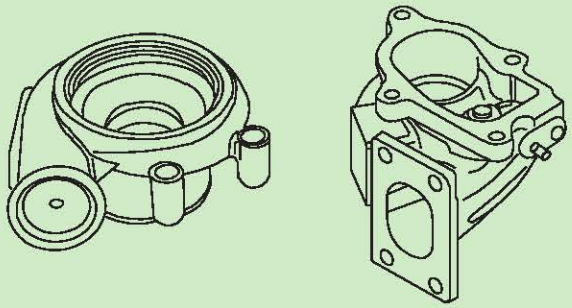


MDN24104H3

Dismantling/Cleaning

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

Fig 4



MDN24104H4

11 Remove actuator and placed in tray.

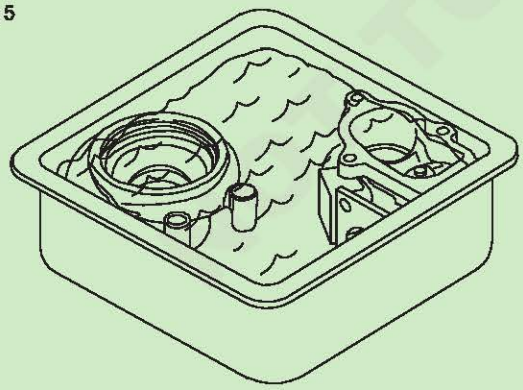
12 Remove 'V' band clamp and remove turbine body.

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).

Fig 5



MDN24104H5

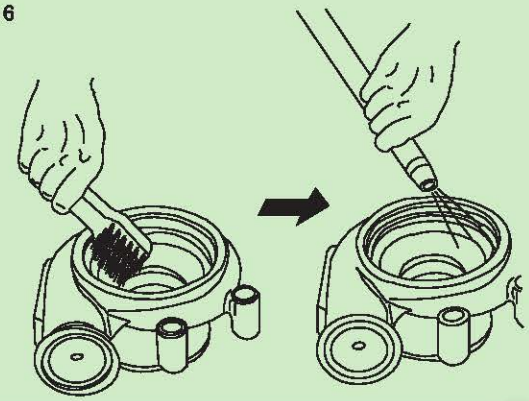
16 Remove impellor shaft with bearing.

17 Remove "O" rings from both side of turbo charger body.

18 Remove thrust plate and "O" ring from turbo charger body.

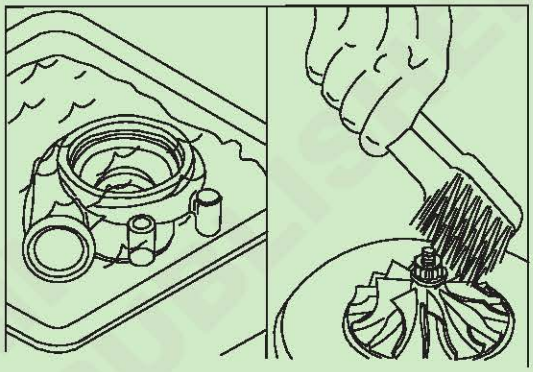
19 Clean the above parts with kerosene except rubber parts (Fig 7 to 9).

Fig 6



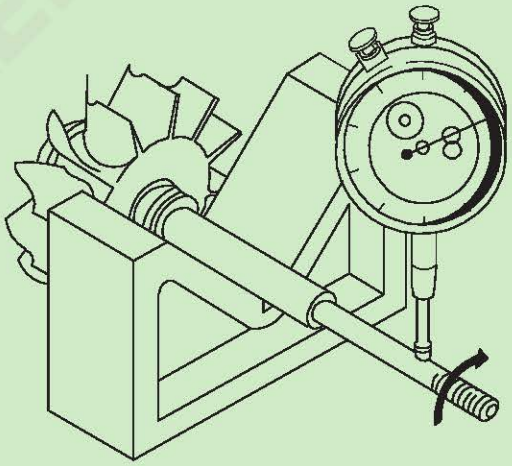
MDN24104H6

Fig 7



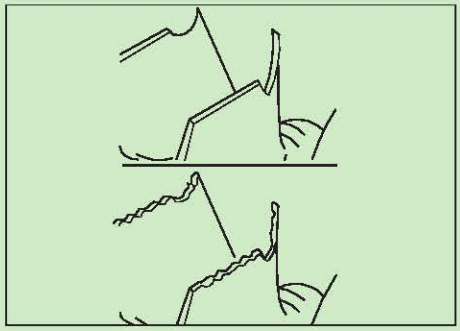
MDN24104H7

Fig 8



MDN24104H8

Fig 9



MDN24104H9

Inspection and repair

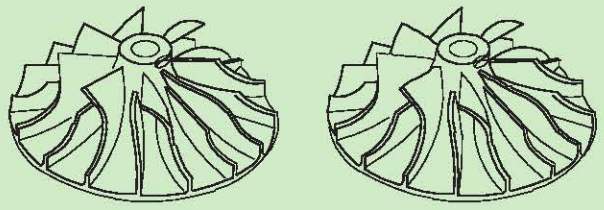
20 Inspect bearing and shaft free play. (Fig.8)

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

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

23 Replace faulty parts, if necessary.

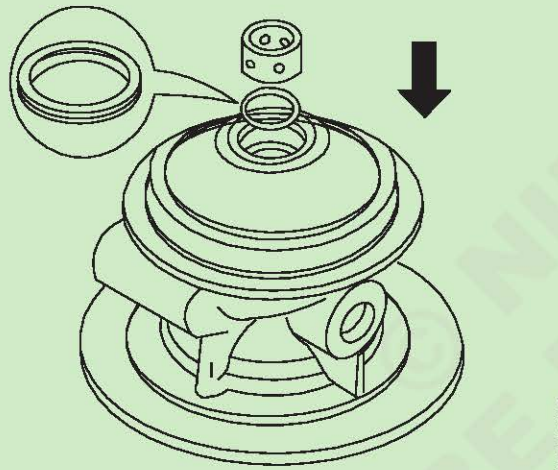
Fig 10



Assembling and testing (Fig.15)

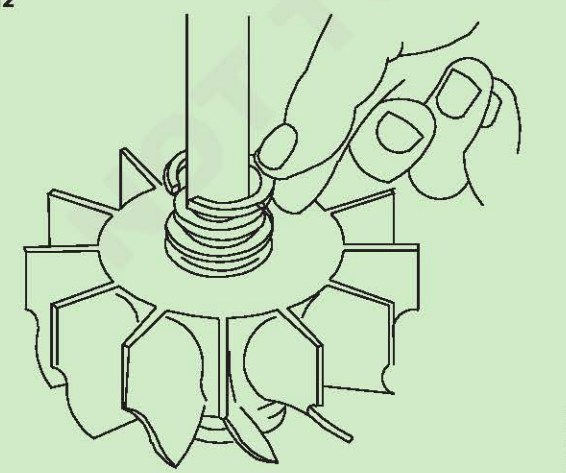
24 Assemble rubber "O" ring and thrust washer in turbo charger body (Fig 11).

Fig 11



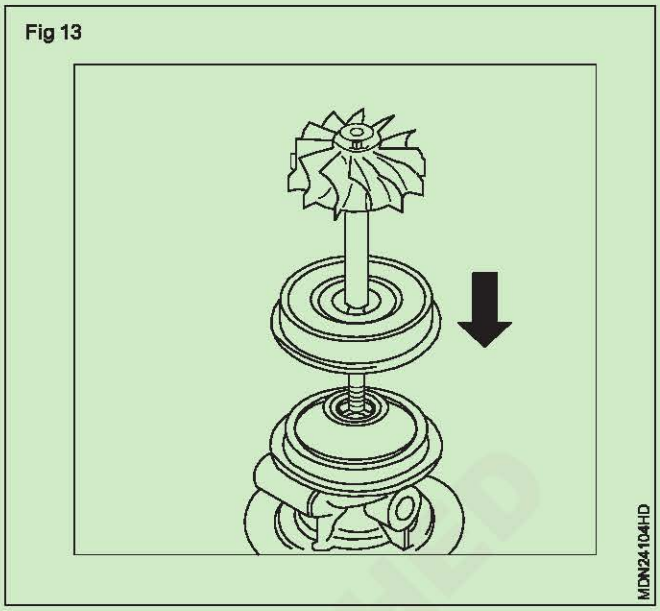
25 Fit external circlip of thrust washer and insert impeller shaft along with bearing (Fig 12).

Fig 12



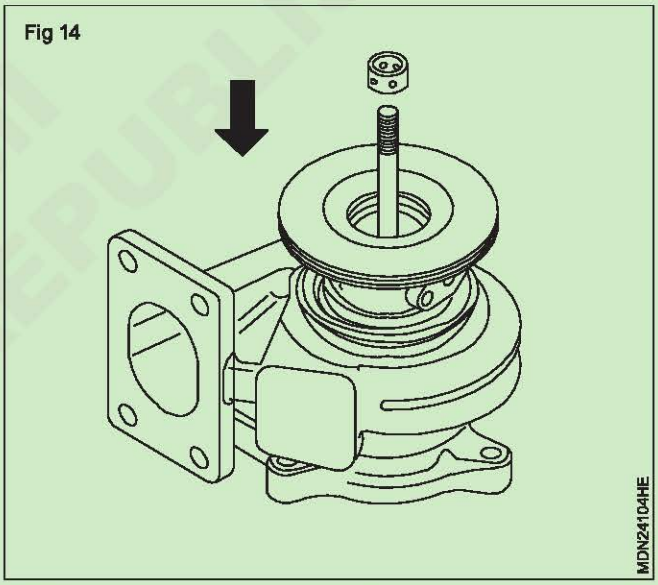
26 Fit both the impellers with impeller ruts (Fig 13).

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.

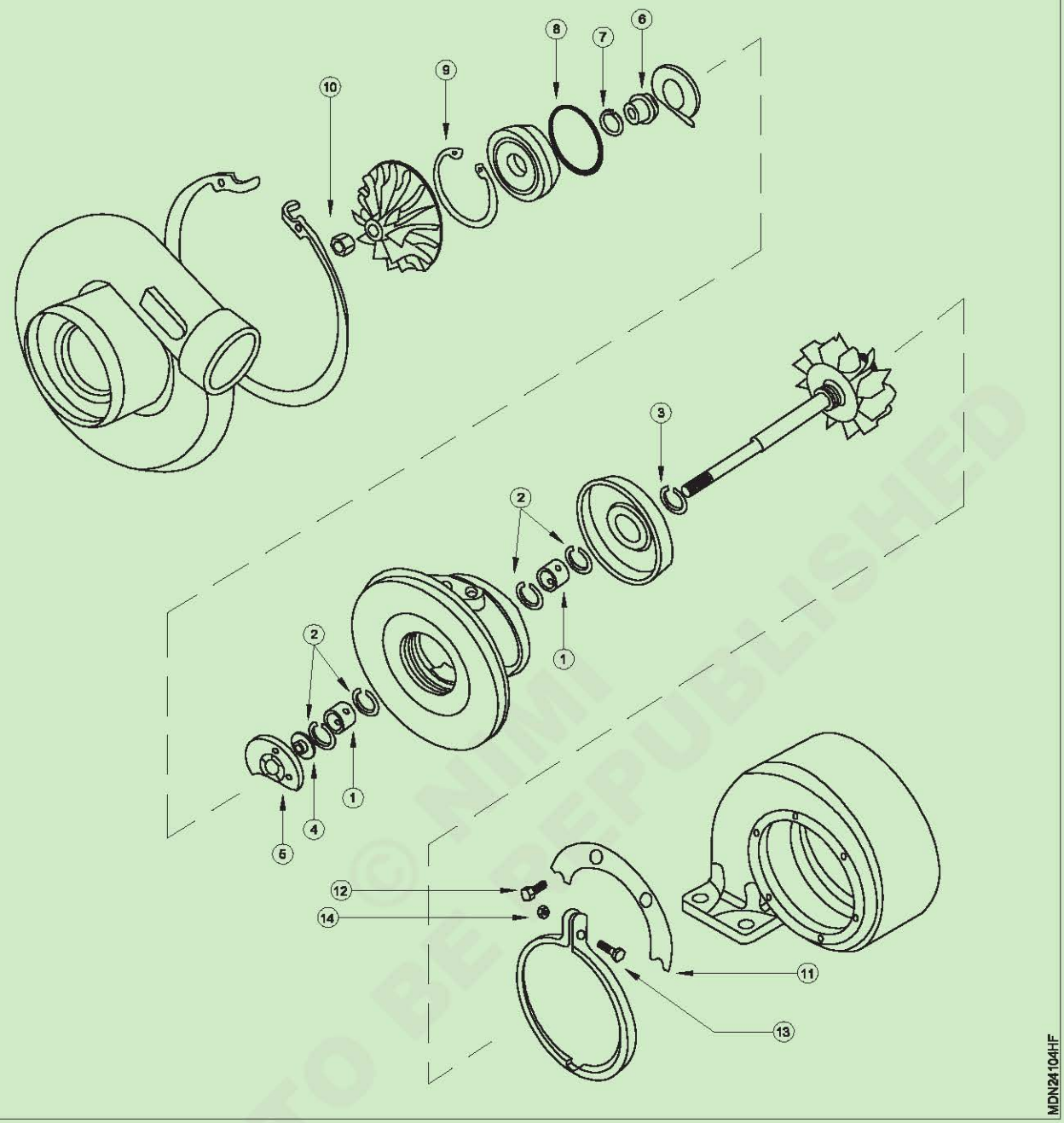
Refitting

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

Objective: At the end of this exercise you shall be able to
- **examine the exhaust system of an engine in off position.**

Requirements

Tools/Instruments

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

Equipments/Machineries

- Light motor vehicle - 1 No.

Materials/Components

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

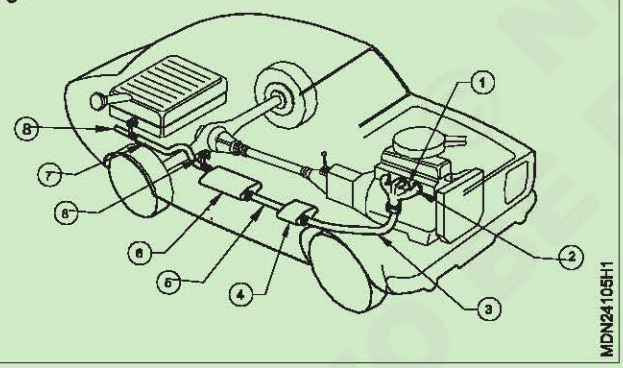
PROCEDURE

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

Fig 1



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 deteriorated parts in exhaust system

10 Visually check the exhaust pipe for dent and damages

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Servicing the exhaust system

Objectives: At the end of this exercise you shall be able to
- **remove and clean the manifold, silencer, tail pipe and refit**
- **remove and clean the catalytic converter, muffer and refit it.**

Requirements

Tools/Instruments

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

Equipments/Machineries

• Diesel engine	- 1 No.

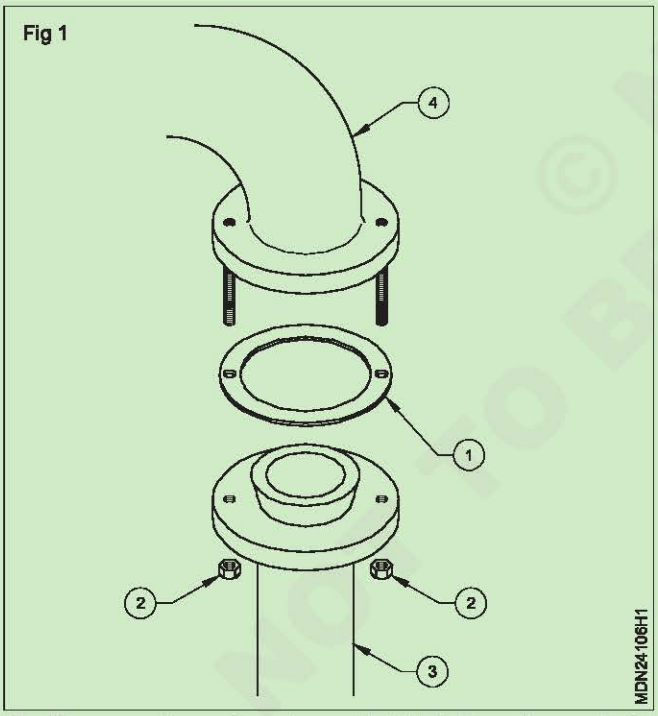
Materials/Components

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

PROCEDURE

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

Fig 1



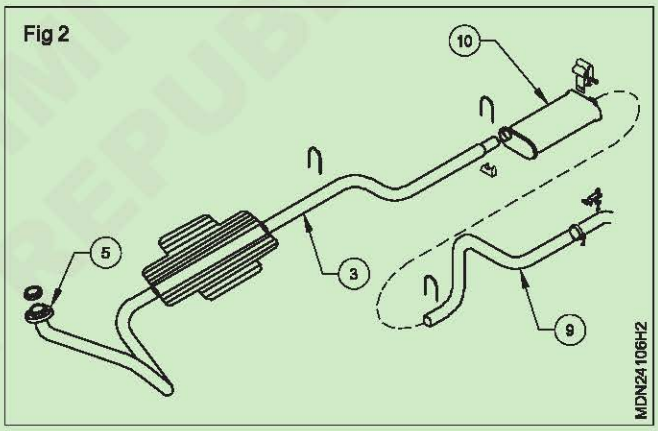
2 Remove the exhaust manifold (4) from the cylinder head.

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).

Fig 2



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)

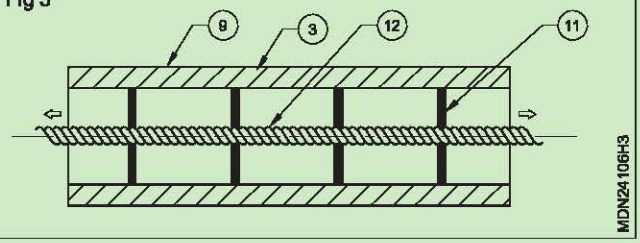
10 Insert a wire rope (12) in the exhaust pipe (3) and tailpipe (9) till it comes out at the other end. Clean the exhaust pipe and tailpipe by passing a wire rope through (Fig 3).

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.)

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Fig 3



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.

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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

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

1 Start the engine

2 Identify leak in between the engine head and exhaust manifold joint (Gasket)

3 Confirm the leakage by spraying soap water on it.

4 Stop the engine and allow to cool

5 Remove and clean the surface and studs with the help of wire brush and emery paper.

6 Place a new gasket, align and tighten it with recommended 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 it.

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.

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Servicing the fuel tank and fuel lines

Objectives: At the end of this exercise you shall be able to
- **remove and clean the fuel tank**
- **remounting the fuel tank**
- **replace banjo bolts and washers**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

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

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

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

3 Remove fuel tank from the vehicle.

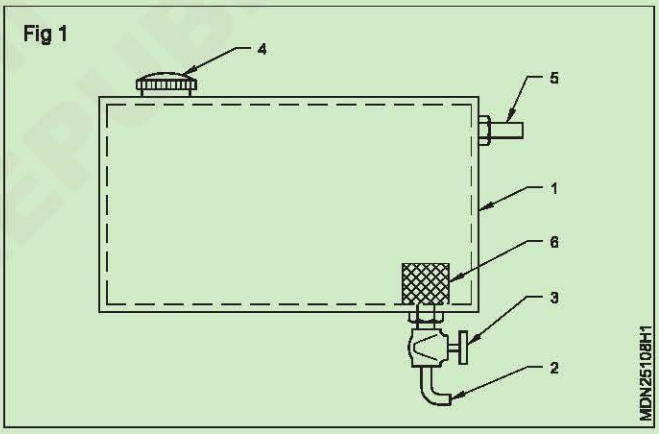
4 Clean outside and inside of the fuel tank with diesel and wash it with water pressure.

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

6 Dry tank with air pressure.

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

Fig 1



TASK 2: **Remounting of fuel tank**

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

2 Place the fuel tank on vehicle and fit it.

3 Connect the pipe lines with fuel tank

4 Fill the tank with fuel.

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).

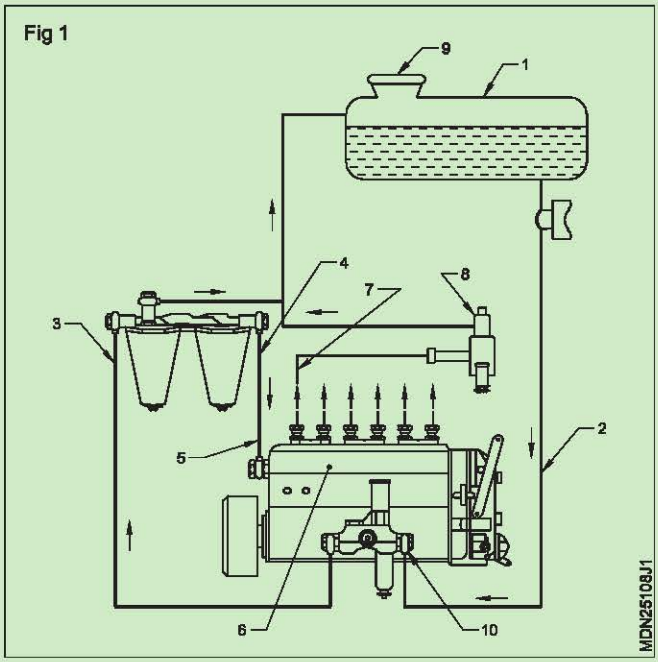
- Fuel tank all soldering edges (1).
- Fuel feed line (2)
- Fuel filter connection inlet (3) and outlet pipes (4).
- Connection (5) to fuel injection pump (6).
- Connection (7) to injectors (8).

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.

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Fig 1



5 Start the engine.

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

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

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Overhauling the fuel feed pump in diesel engine

Objectives: At the end of this exercise you shall be able to
- **overhaul the mechanical fuel feed pump**
- **overhaul the electrical fuel feel pump**

Requirements

Tools/Instruments

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

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

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

Dismantling (Fig 1)

1 Disconnect the fuel lines of the feed pump.

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

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

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

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

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

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

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

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

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

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

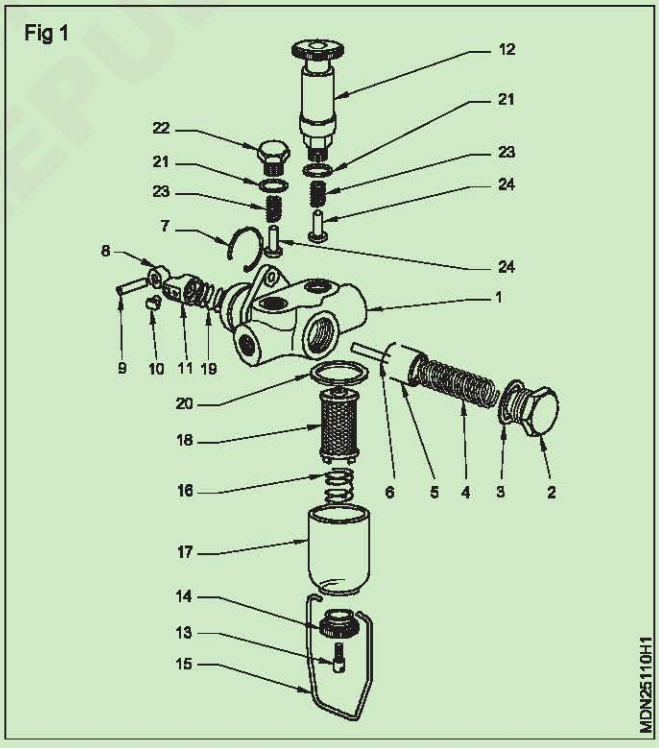
12 Check the tension of all the springs, and replace if necessary.

13 Check the valve seats.

14 Check the gaskets, and replace if necessary.

15 Check the filter clamping nut threads.

Fig 1



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TASK 2: **Assembling**

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

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

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

4 Fit the hand priming pump.

5 Fit the filter assembly.

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

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

8 Tighten the feed pump mounting screws uniformly.

9 Connect the inlet fuel line.

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

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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 fuel pump and fit the fuel pump in the engine

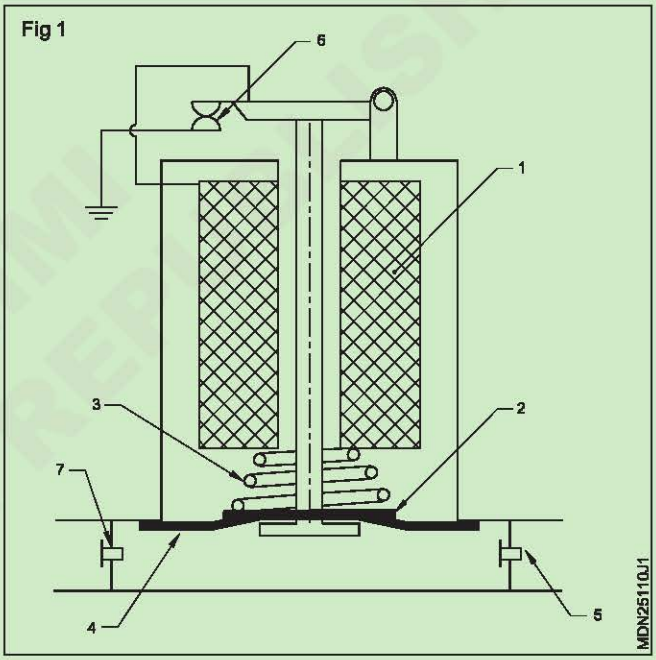
15 Connect the wiring with insulation switch

16 Connect the battery terminal

17 Check its operation at high speed and idle speed.

18 Ensure no loose connection and leak in fuel pump.

Fig 1



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Remove and replace the fuel filter and bleed the system

Objectives: At the end of this exercise you shall be able to
- **dismantle and replace filter element**
- **bleed the fuel system.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No,

Equipments/Machineries

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

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cotton cloth - as reqd.
- gasket - as reqd.
- filter element

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.

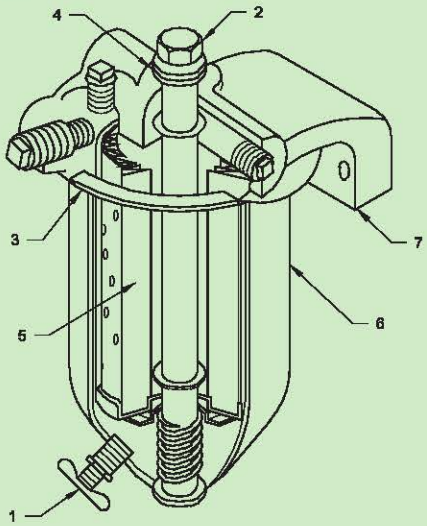
11 Fit drain plug in the filter housing

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

Fig 1



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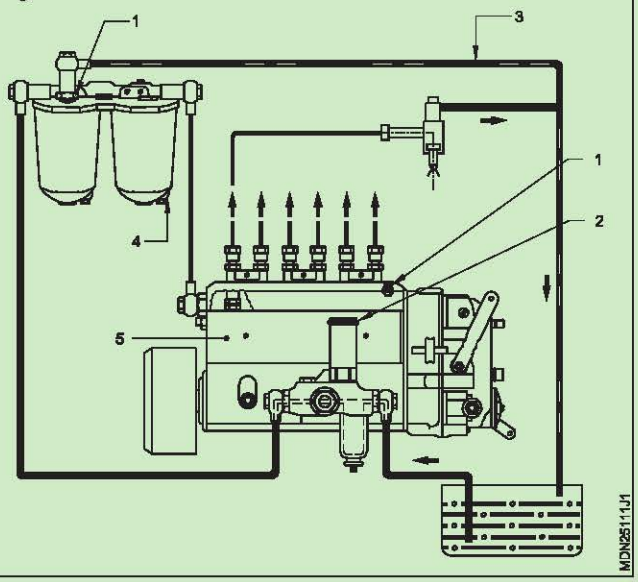
TASK 2: **Bleeding**

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).

Fig 1



4 Tighten the bleeding screw (1) again.

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

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

8 Tighten the bleeding screw (1) again.

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

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

11 Start the engine and check to performance.

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Removing and refitting the F.I.P

Objectives: At the end of this exercise you shall be able to
- **remove the F.I.P from the engine**
- **check the injection timing by the spill cut off method**
- **set the fuel injection pump timing.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machineries

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

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cleaning cloth - as reqd.
- New gasket - as reqd.
- Swan neck pipe - 1 No.

PROCEDURE

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

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

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

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

4 Disconnect the fuel feed pump fuel line connections

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

6 Remove F.I.P from the engine

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

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

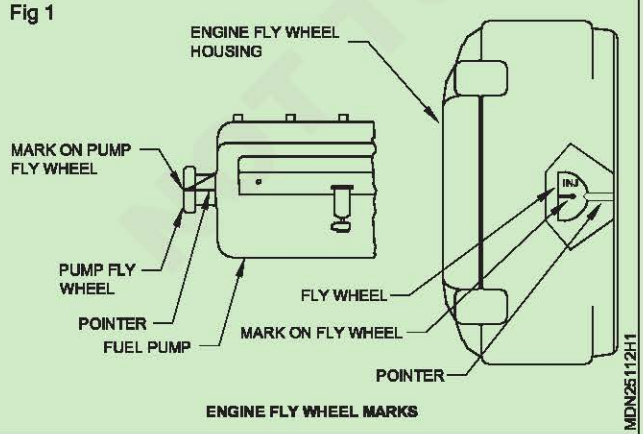
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TASK 2: **Setting timing of the fuel injection pump in relation to the engine**

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)

Fig 1

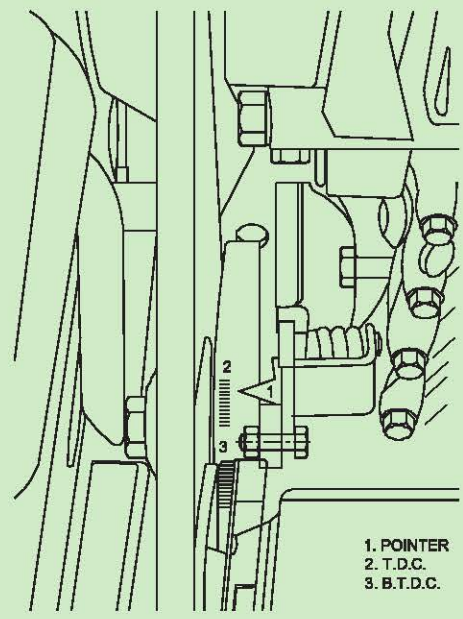


ENGINE FLY WHEEL MARKS

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

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

Fig 2



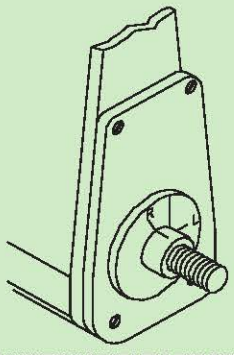
ENGINE TIMING MARKS

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

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

Fig 3



MARKS ON FUEL INJECTION PUMP

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

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

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

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

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

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

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

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

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

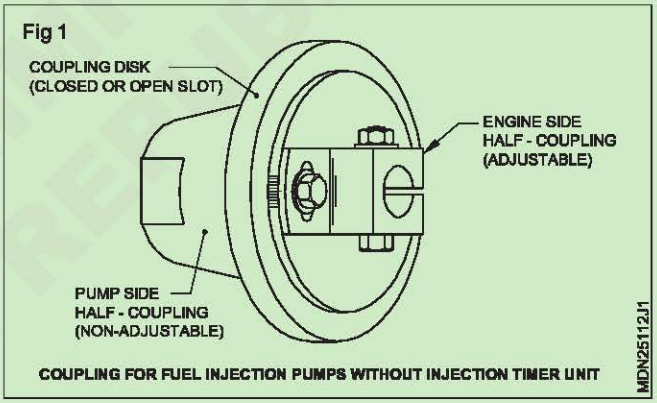
2 Measure the end clearance between the coupling flange and the coupling disc of the drive. (Use a feeler gauge) (Minimum clearance is 0.02" or 0.5 mm)

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

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

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

Fig 1



COUPLING FOR FUEL INJECTION PUMPS WITHOUT INJECTION TIMER UNIT

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

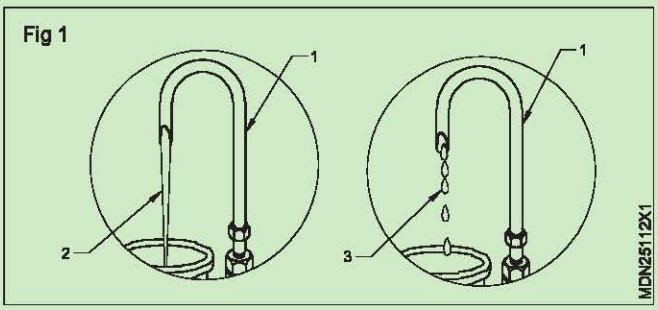
1 Disconnect the first injector pipe at the FIP's end.

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

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

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

Fig 1



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

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

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

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

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

Overhauling and testing the fuel injector

Objectives: At the end of this exercise you shall be able to
- **dismantle the injectors**
- **inspect and assemble injector**
- **testing injectors.**

Requirements

Tools/Instruments

• Trainee's tools kit	- 1 No.
• Injector cleaning kit	- 1 No.

Equipments/Machineries

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

Materials/Components

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

PROCEDURE

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

1 Remove overflow line of injectors.

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

3 Remove injector clamp.

4 Remove the injectors from cylinder head

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

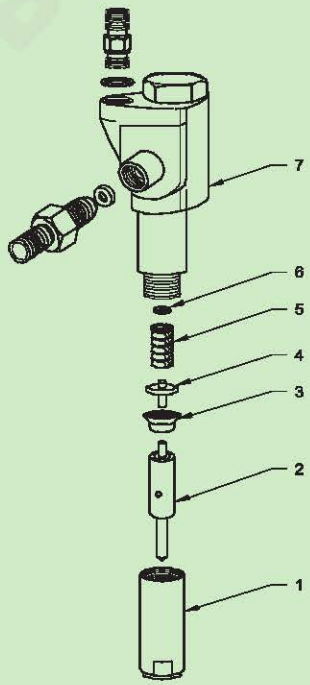
6 Clean the nozzle tip and wipe off the dirt from the injectors.

7 Hold the injector in inverted position.

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

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

Fig 1



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

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

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

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

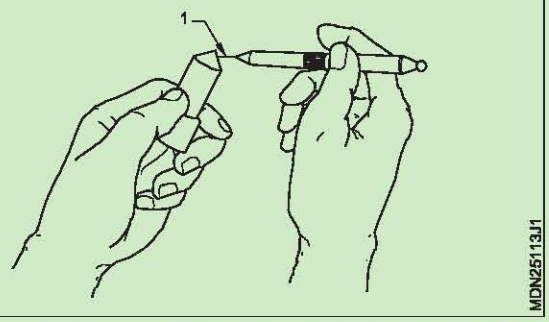
4 Inspect the nozzle body (7) for damage.

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

6 Rinse nozzle needle and nozzle with clean testing oil.

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Fig 1



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 of injectors**

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 all spray holes of nozzle.

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

5 Open the shut off valve knob.

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

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

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

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

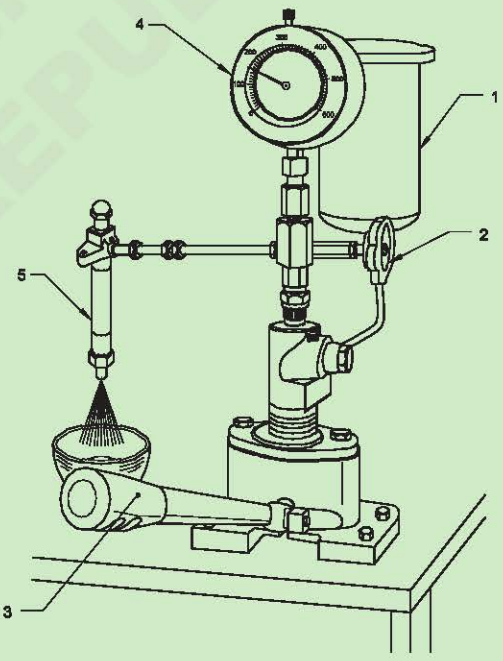
10 Remove injector (5) from injector tester.

11 Fit injector on engine with new seating washer.

12 Connect high pressure pipe.

13 Connect over flow pipe.

Fig 1



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General maintenance of fuel injection pumps

Objective: At the end of this exercise you shall be able to
- **carry out maintenance of F.I.P.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machineries

- Multicylinder diesel engine - 1 No.

Materials/Components

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

PROCEDURE

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

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

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

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

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

6 Check the high pressure line mounting and leakages

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

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

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

10 Lubricate the accelerator linkage and ensure the proper operation

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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 tool kit - 1 No.

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 - 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 starter switch.

Do not hold the starter switch for longer time to start

9 Release the starter switch immediately after engine starts.

10 Raise the engine speed slowly with help of accelerator lever (or) throttle lever.

11 Observe the engine speed to conform the engine runs smoothly without 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 ventur throat.

15 Loosen the idling adjusting nut with ring spanner

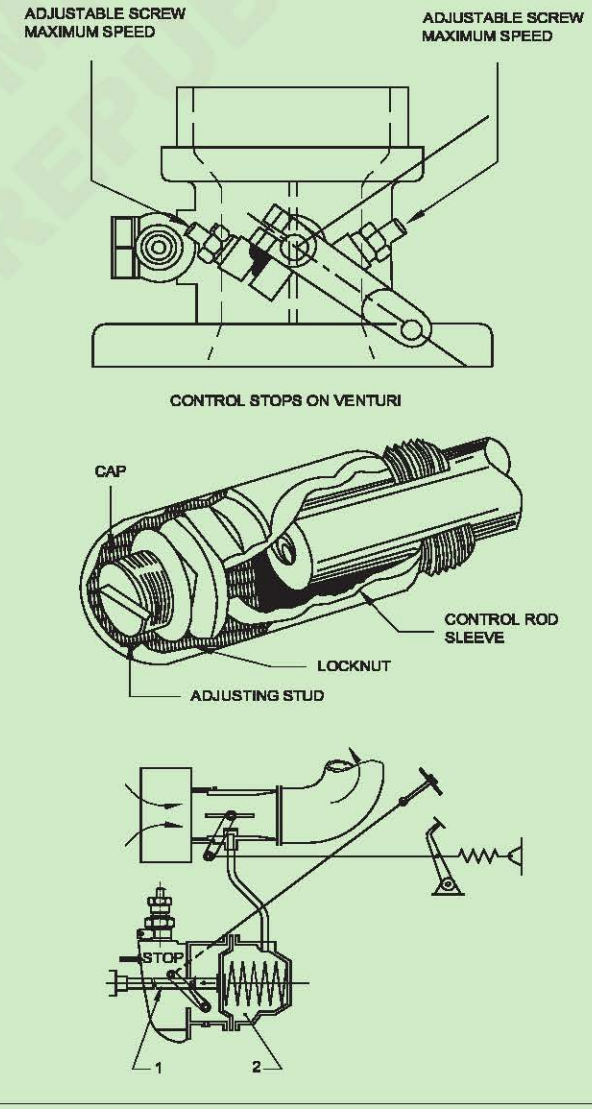
16 Adjust the idling screw with screw driver and set the proper idling speed RPM of the engine, as specified by the manufacturer.

17 Keep the screw driver and lock the nut in position.

18 Adjust the maximum speed similarly. (Fig 1)

19 Start the engine and check idling and high speed smooth performance

Fig 1



Adjusting the idling speed of mechanical governor

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

- **adjust the idling and high speed operation of the engine with mechanical governor.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.

Equipments/Machineries

- Multi cylinder four stroke diesel engine with mechanical governor - 1 No.
- 12 volt battery with cables - 1 Set.

Materials/Components

- Cleaning tray - 1 No.
- Cotton cloth - as reqd.
- Soap oil - as reqd.
- Diesel - as reqd.
- Lubrication oil - 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 the 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 F.I.P shaft and housing.

8 Switch on the ignition 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 run 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 manufacturers specification (or) manual.

16 Start the engine and check the idle and high speed operation performance

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

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

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Exercise 1.11.93

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

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

Equipments/Machineries

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

Materials/Components

- Kerosene - as reqd.
- Diesel - as reqd.
- Soap oil - as reqd.
- Cotton waste - as reqd.

PROCEDURE

1 Check the engine oil, water level before starting the engine

2 Start the engine and run at 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 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 remove the faulty injector from the cylinder head

10 Place it in a tray and dismantle the injector and clean the dismantled injector parts and inspect the parts.

11 Replace the damaged or wornout parts

12 Assemble the dismantled parts of the injector and adjust it.

13 Test the injector with injector testing machine.

14 Fit the injector on the particular cylinder.

15 Start the engine observe the engine R.P.M and its smooth running.

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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, CO_2, O_2, AFR/NO_x**
- **understand the result.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- 4/5 gas analyser - 1 No.
- Screw Driver - 1 No.

Equipments/Machineries

- Running vehicle 1 No.

PROCEDURE

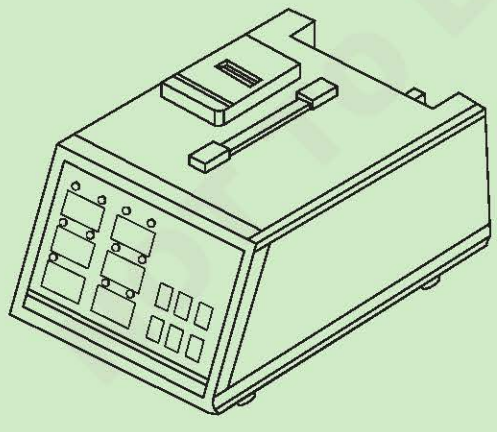
TASK 1: **Installation**

Note: Safety instructions

This procedure applies to the product of 4/5gas analyzer

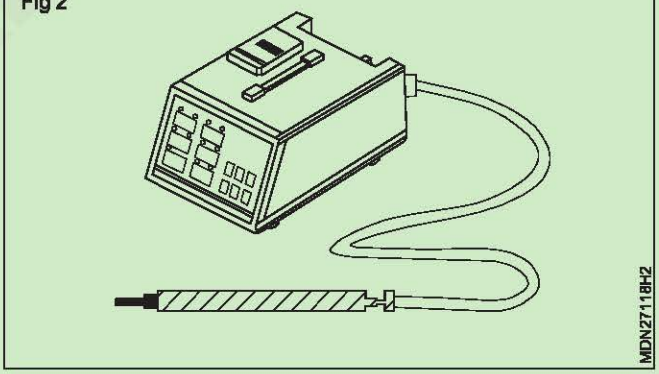
This analyzer (Fig 1) is an equipment to measure the gas emission density of an Automotive enabling to diagnose the Automotive status and its preventive maintenance so that it can provide a function to prevent the air pollution in advance.

Fig 1



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.

Fig 2



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.

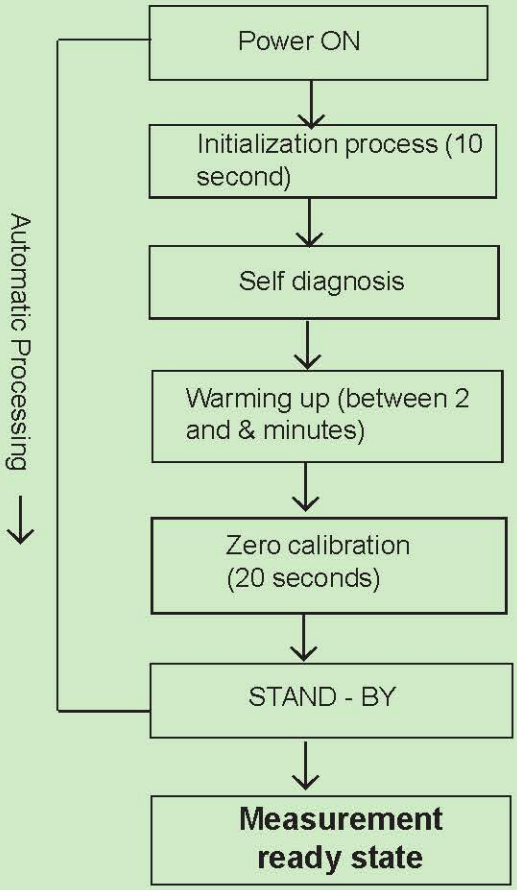
4 Verify again the connection status of the analyzer and then turn on the power switch.

TASK 2: **Measurement**

Measurement Mode

1 Place the probe in the clean air to perform the [Zero calibration].

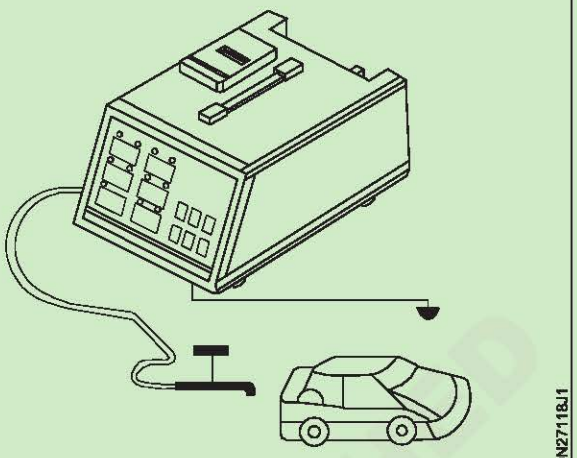
2 Push the probe deep into the exhaust outlet of the vehicle (Fig 3) and measure exhaust gas by pressing measurement key. (Fig 2)



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)

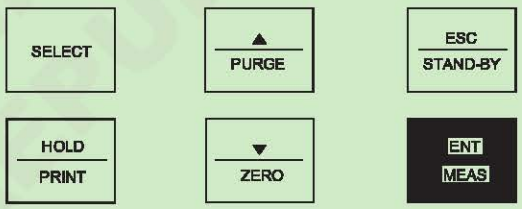
Fig 1



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

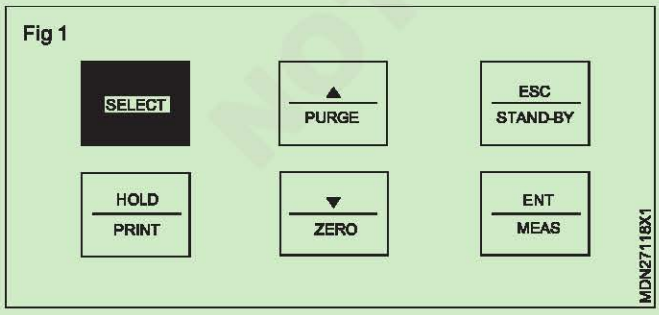


TASK 3: **Leak test**

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

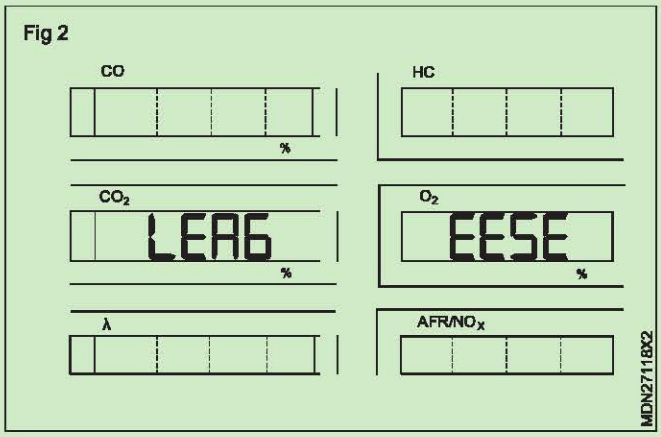
1 Press the SELECT key (Fig 1) once in the stand-by mode to select the Leak Test mode

Fig 1



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.

Fig 2



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'.

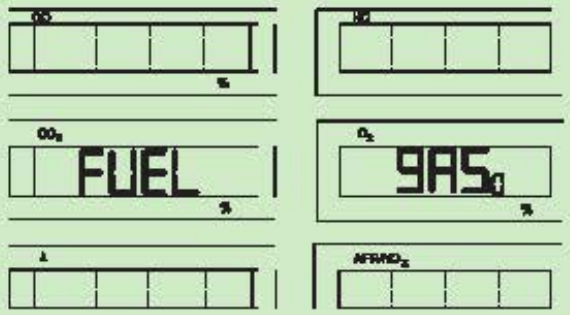
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TASK 4: **Selection of fuel**

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.

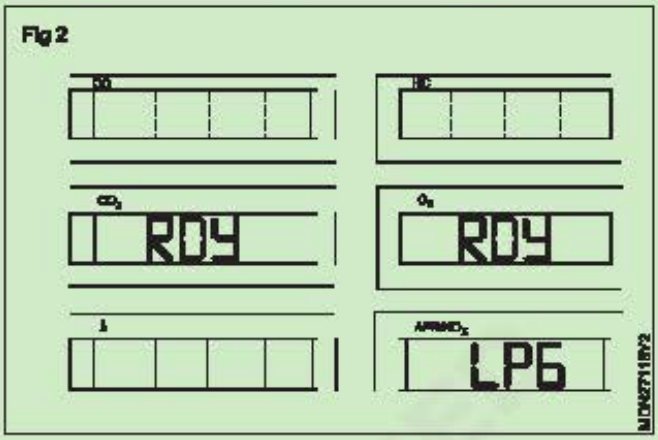
Fig 1



3 Press ENT key to setup the selected fuel.

4 For Example, If the "LPG" fuel is selected, the window indicates as shown in the below (Fig 2)

Fig 2

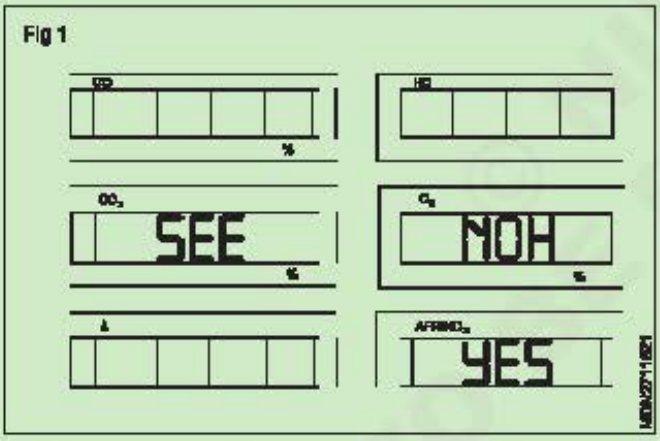


TASK 5: **NO_x setup**

It is a function selecting where to attach NO_x sensor.

1 Press select key for eight times in standby mode

Fig 1



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

Fig 2



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 NOx, CO_2, and O_2, in addition to HC and CO a mechanic gets a better look at the efficiency of the engine (Fig 3). Maximum limits for the measures 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 drive ability problem.

	IDLE	2500 RPM	PROBABLE CAUSE
HC ppm CO% CO_2% O_2% NO_x ppm	0–150 1–15 10–12 0.5–2.0 100–300	0–75 0–0.8 11–13 0.5–1.25 200–1,000	Normal reading
HC ppm CO% CO_2% O_2% NO_x ppm	0–150 3.0+ 8–10 0–0.5 0–200	0–75 3.0+ 9–11 0–0.5 100–500	Rich mixture
HC ppm CO% CO_2% O_2% NO_x ppm	0–150 0–1.0 8–10 1.5–3.0 300–1,000	0–75 0–0.25 11 1.0–2.0 1,000+	Lean mixture
HC ppm CO% CO_2% O_2% NO_x ppm	50–850 0–0.3 5–9 4–9 300–1,000	50–750 0–0.3 6–10 2–7 1,000+	Lean misfire
HC ppm CO% CO_2% O_2% NO_x ppm	50–850 0.1–1.5 6–8 4–12 0–200	50–750 0–0.8 8–10 4–12 100–500	Misfire

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

• Trainee's tool kit	- 1 No.
• Digital multimeter	- 1 No.
• 12V battery	- 1 No.
• Scan tool	- 1 No.

Equipments/Machineries

• Diesel Vehicle	- 1 No.

Materials

• PCV solvent/lacquer thinner	- as reqd.
• Baniyan cloth	- as reqd.
• PCV valve	- 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.

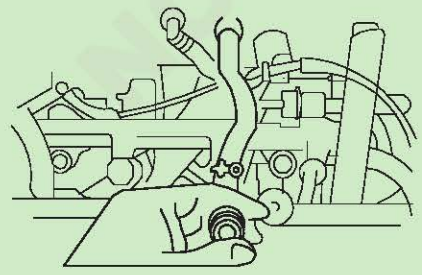
3 Check hoses for connection, leakage, clog and deterioration. Replace as necessary

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).

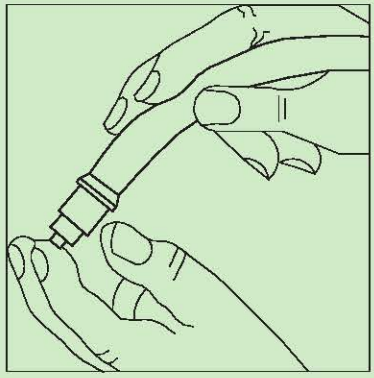
Fig 1



3 Run engine at idle speed.

4 Place your finger over end of PCV valve (1) as shown in Fig 2 to check for vacuum. (Fig 2)

Fig 2



5 If there is no vacuum, check for clogged valve.

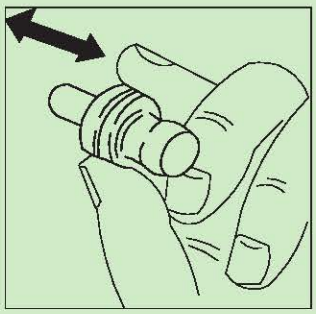
6 Try cleaning it and to observe if it is working by with PCV solvent or lacquer thinners or immersing it in carburettor cleaner. There should be no gummy deposits or discoloration on a clean valve.

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.

Fig 3



MDN27119H3

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 1: **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 Warn up engine to normal operating temperature.

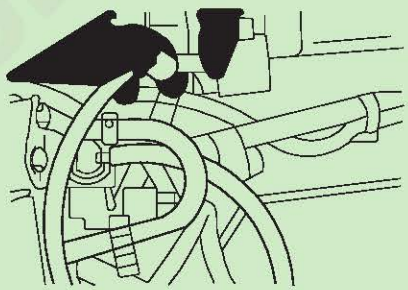
5 Disconnect purge hose as shown in (Fig 1) (1) from EVAP canister

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).

Fig 1



MDN27118J1

TASK 2: **Vacuum passage inspection**

1 Start engine and run it at idle speed.

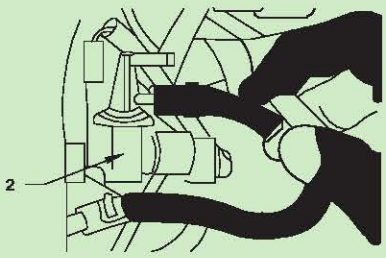
2 Disconnect vacuum hose from EVAP canister purge valve (Fig 1) (2). With finger placed against hose disconnected, check that vacuum is applied.

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

Fig 1



MDN27119X1

TASK 3: **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)

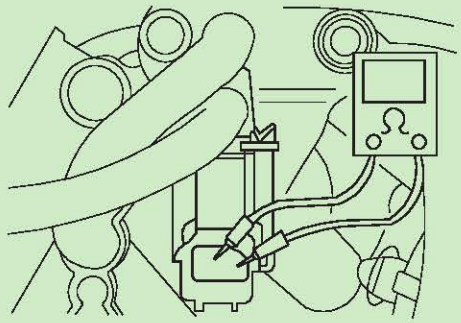
3 Resistance of EVAP canister purge valve to be 30-34 at 20°C

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.

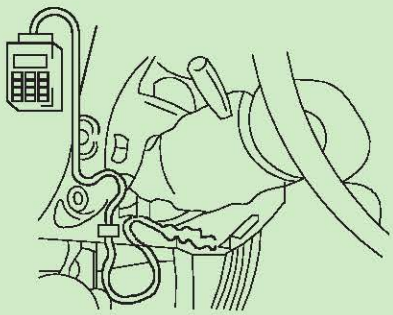
Fig 1



TASK 4: **Use of scan tool**

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

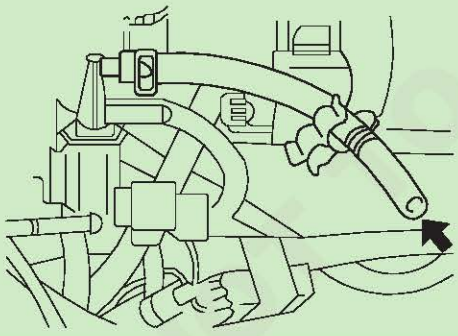
Fig 1



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)

Fig 2



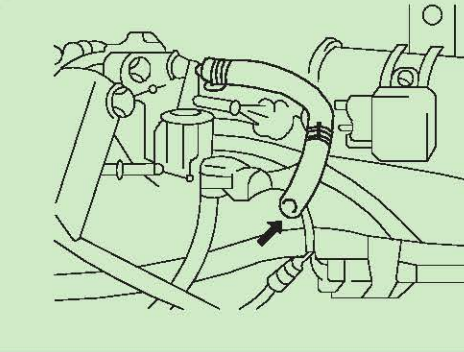
4 Open EVAP canister purge valve by executing "EVAP CANI PURGE" under "MISC TEST" mode of SUZUKI scan tool with ignition switch ON. In this state, blow hose "A". Air should come out of nozzle "B". (Fig 3) (for other scan tool ref to scan tool manual)

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

Fig 3



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

• Trainee's tool kit	- 1 No.
• Screw driver set	- 1 No.
• Box spanner set	- 1 No.
• Digital multimeter/ohmmeter	- 1 No.

Equipments/Machineries

• Diesel vehicle	- 1 No.

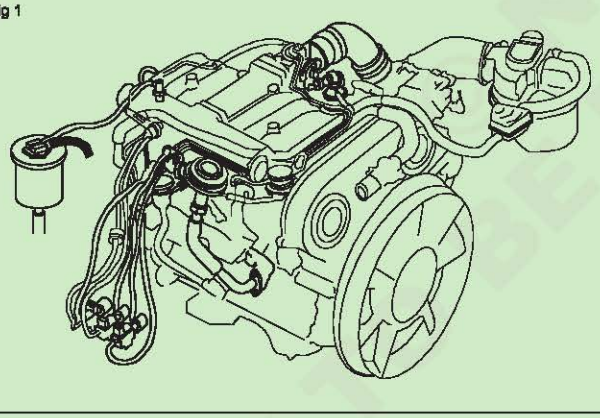
Material

• Tray	- 1 No.
• Cotton waste	- 1 No.
• Kerosene	- as reqd.
• Vacuum hose	- as reqd.
• EGR valve	- 1 No.

PROCEDURE

1 Locate the EGR valve (Fig1)

Fig 1



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)

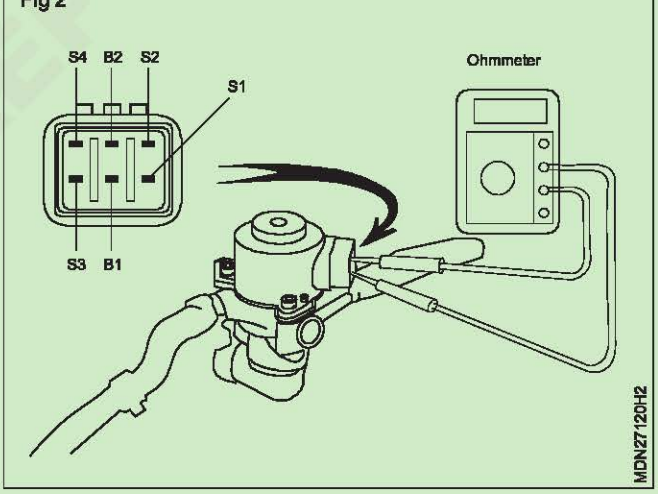
4 Inspect exhaust gas recirculation valve resistance

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

Fig 2



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

14 If not, Inspect EGR valve operation

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Fig 3

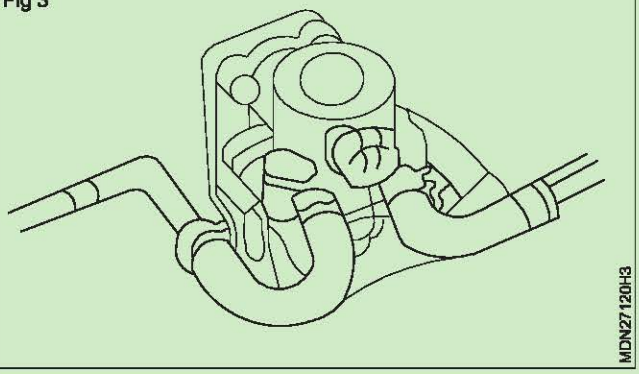


Fig 4

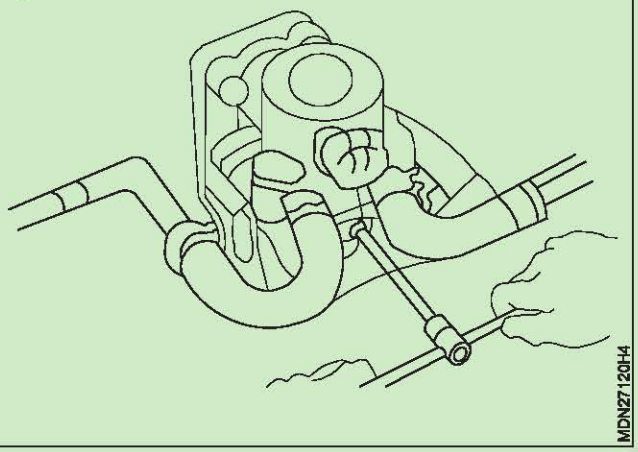
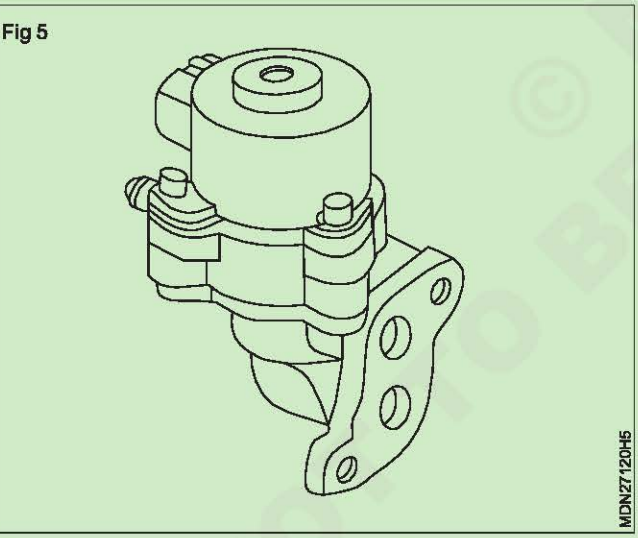


Fig 5



15 Apply battery voltage to terminal B1 and B2,and while repeatedly grounding (Fig 6) (*S4) - (S4 and *S3)- (S3 and *S2)- (S2 and *S1) - (S1 and *S4) in sequence, and check that the valve moves towards the open position.(Hint: Keep the terminal marked with an asterisk (*) grounded to the next grounding.)

Fig 6

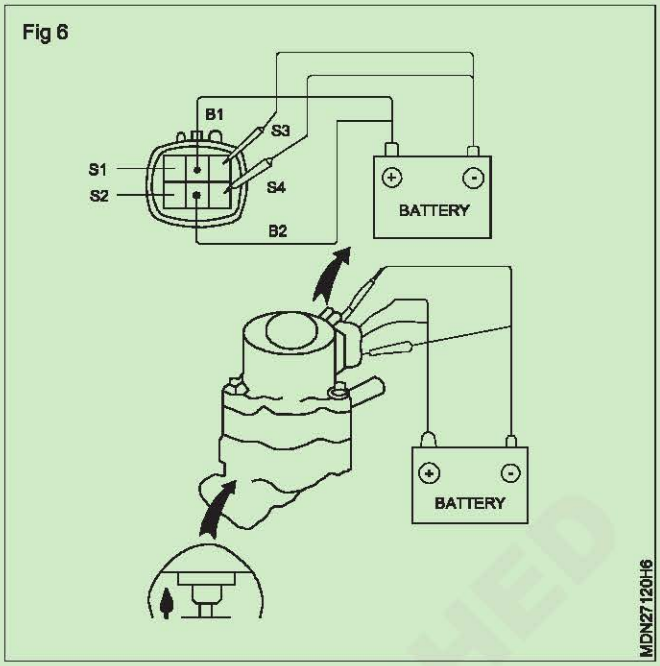
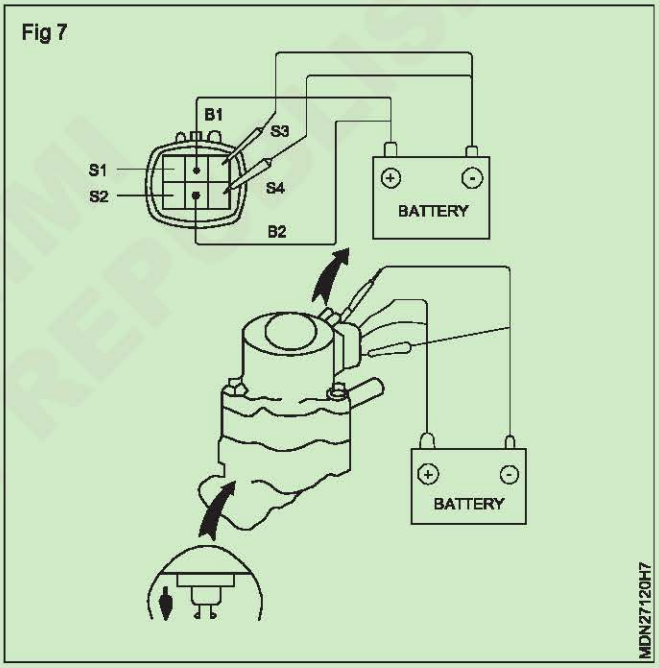


Fig 7



16 Apply battery voltage to terminal B1 and B2,and while repeatedly grounding (Fig 7)(*S1) - (S1 and *S2)- (S2 and *S3)- (S3 and *S4) - (S4 and *S1) in sequence, and check that the valve moves towards the closed position.(Hint: Keep the terminal marked with an asterisk (*) grounded while proceeding to the next grounding.

17 Perform this operation after opening the valve by performing the step above.

18 If operation is not as specified, replace the EGR Valve assembly.

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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

• Trainee's tools kit	- 1 No.
• Socket spanner set	- 1 No.
• 12 volt lead acid battery	- 1 No.
• Test lamp and cables	- as reqd.

Equipments/Machineries

• Diesel engine with charging system	- 1 No.

Materials

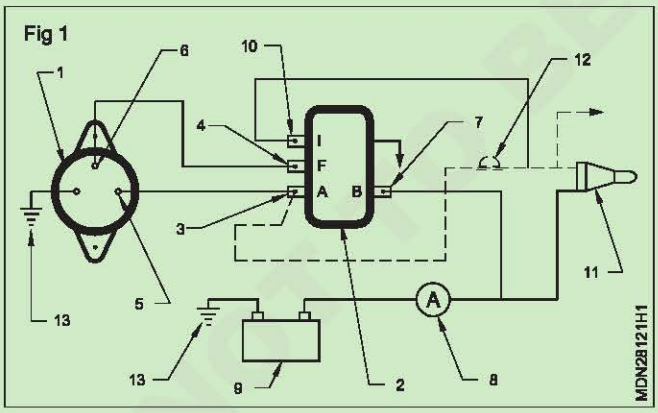
• Kerosene	- as reqd.
• Emery paper	- as reqd.
• Rotor	- as reqd.
• Banian cloth	- as reqd.
• Grease	- as reqd.
• Diodes	- as reqd.
• Bearing	- 2 Nos.

PROCEDURE

TASK 1: **Identify the alternator circuit**

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

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.

— — — — — — —

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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.

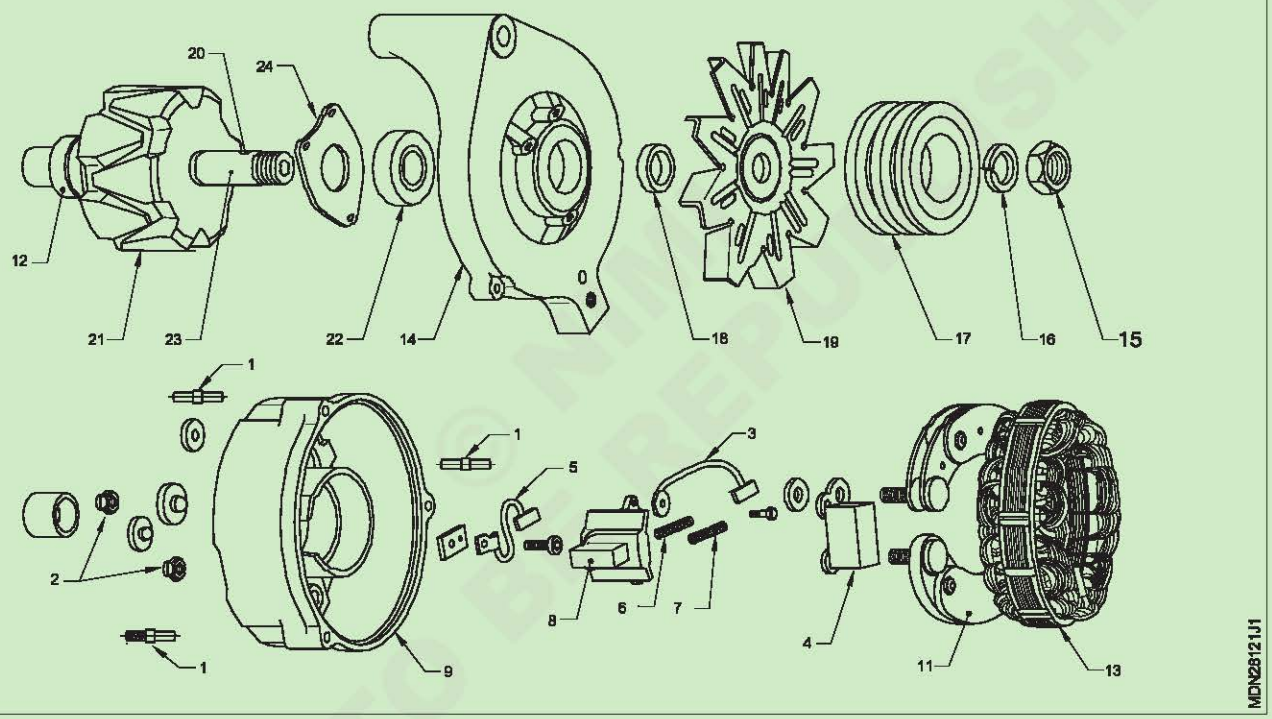
11 Take out the slip-ring end bracket (11).

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).

Fig 1



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.

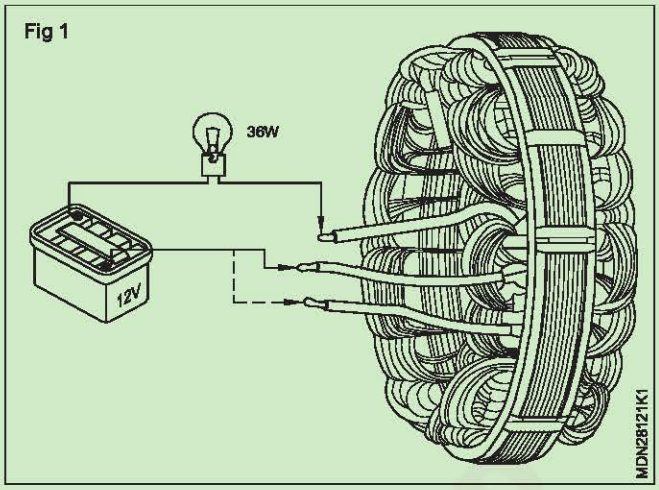
TASK 5: **Test for open circuit in the stator**

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.

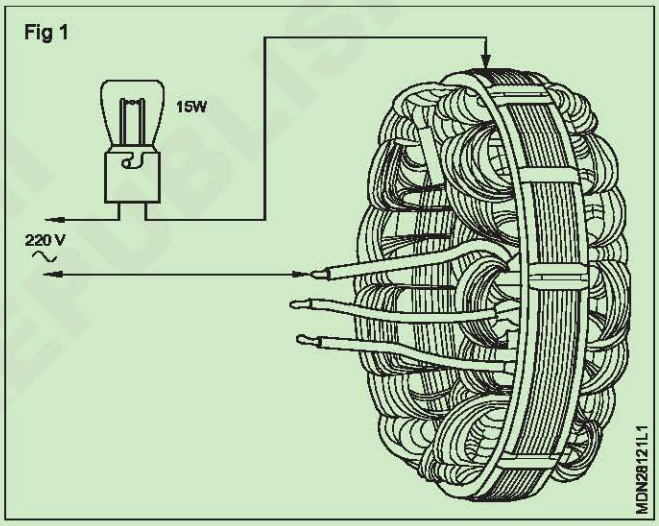
Fig 1



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 v/15 w test lamp in series between the stator laminators and each one of the three stator lead one by one. The lamp should not glow. It the test lamp glows then the stator winding is defective, renew the same (Fig.1).

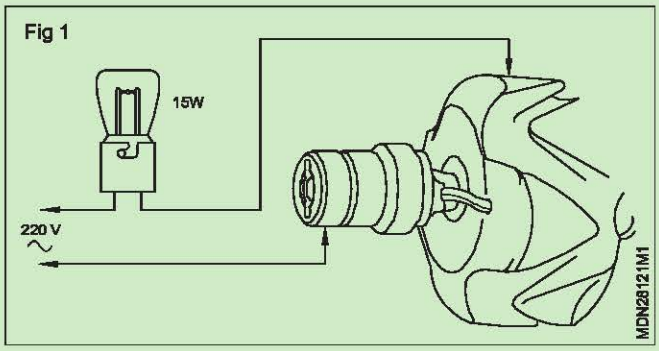
Fig 1



TASK 7: **Test for short circuit in rotor**

1 Check the rotor winding insulation by connecting to a 220 V AC mains with a 220 volt/15 watt test lamp in circuit between either of the slip-rings and the rotor body. The lamp should not glow. If the lamp glows then the rotor winding is defective; rotor assembly need renewal (Fig 1).

Fig 1



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TASK 8: **Test for open circuit in rotor winding**

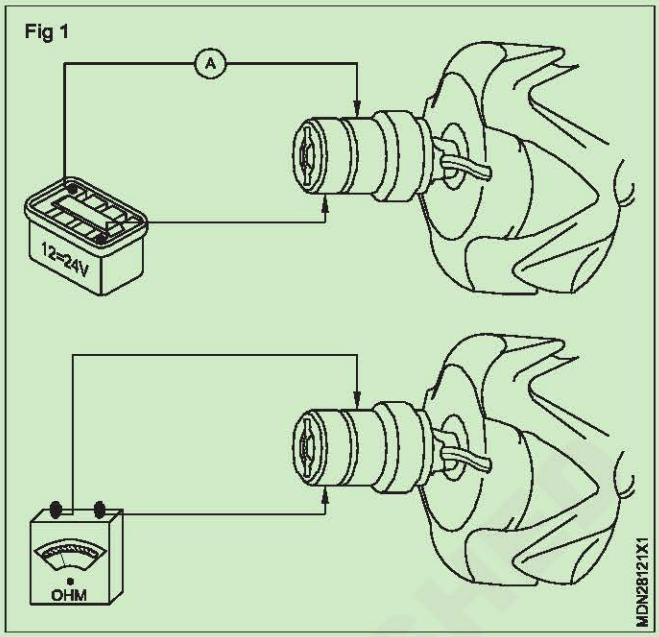
1 Check the motor winding continuity by connecting a 12 V/ 24 V battery and the moving coil ammeter between the slip-rings. (Fig 1)

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.

Fig 1



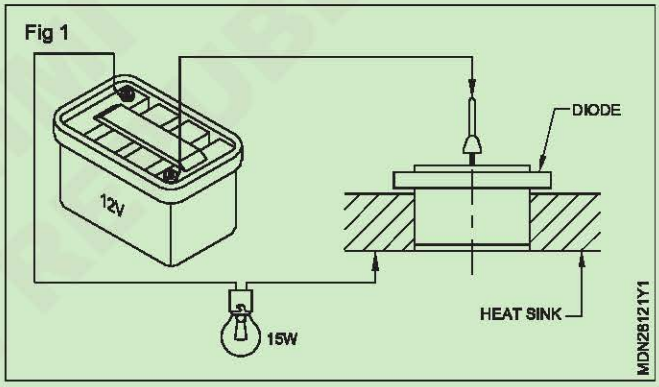
TASK 9: **Testing diodes**

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.

Fig 1



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.

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Refitting alternator on the vehicle and testing

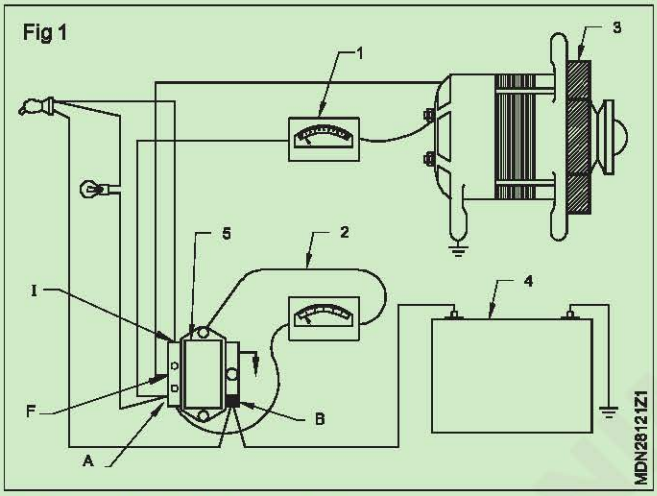
Objectives: At the end of this exercise you shall be able to
- **refit an alternator to the diesel engine**
- **connect the battery to the circuit**
- **test the alternator's performance**
- **adjust the fan belt play.**

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)

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.

Overhauling and testing of starter motor

Objectives : At the end of this exercise you shall be able to
- **remove the starter motor from the engine**
- **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

• Trainee's tools kit	- 1 No.
• Socket spanner set	- 1 No.
• Star/screw driver set	- 1 No.
• Circlip plier	- 1 No.
• Multimetre	- 1 No.
• Crowbar	- 1 No.
• 'V' block	- 2 No
• Dial gauge	- 1 No.

Equipment/ Machine

• Running engine	- 1 No.
• Vernier caliber	- 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**

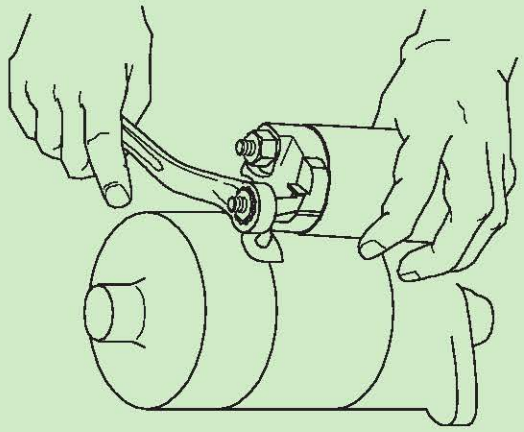
1 Disconnect the earth lead from the battery.

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.

Fig 1



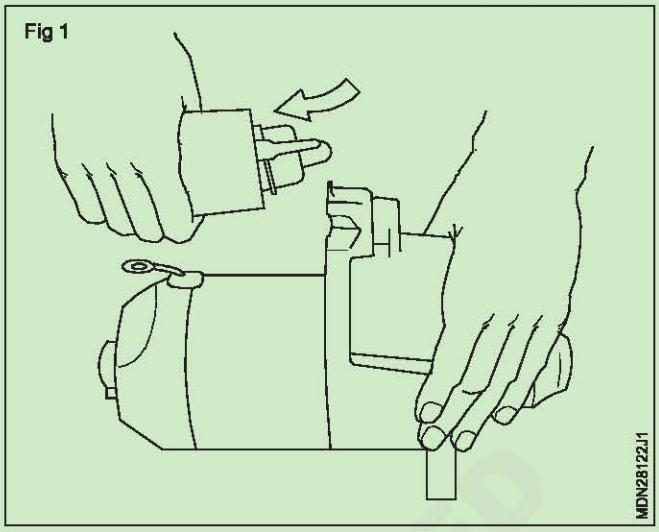
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TASK 2: **Removal of the Solenoid switch assembly**

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)

Fig 1

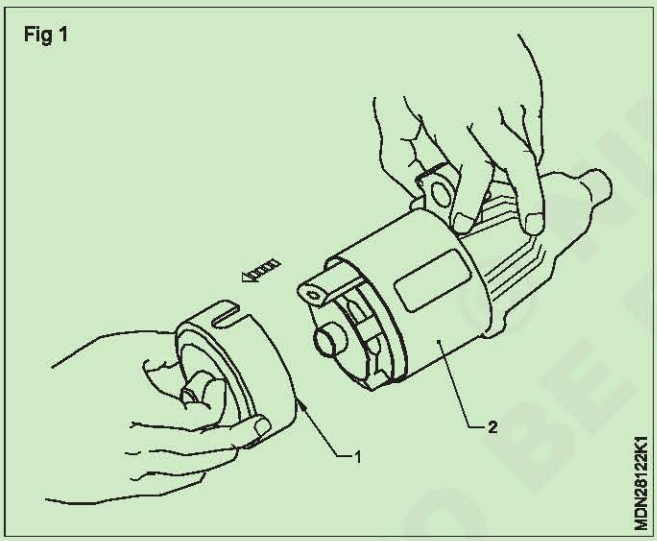


TASK 3: **Dismantling of the motor assembly**

1 Remove the through bolts.

2 Remove the commutator end cover (1). (Fig 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.

Fig 2

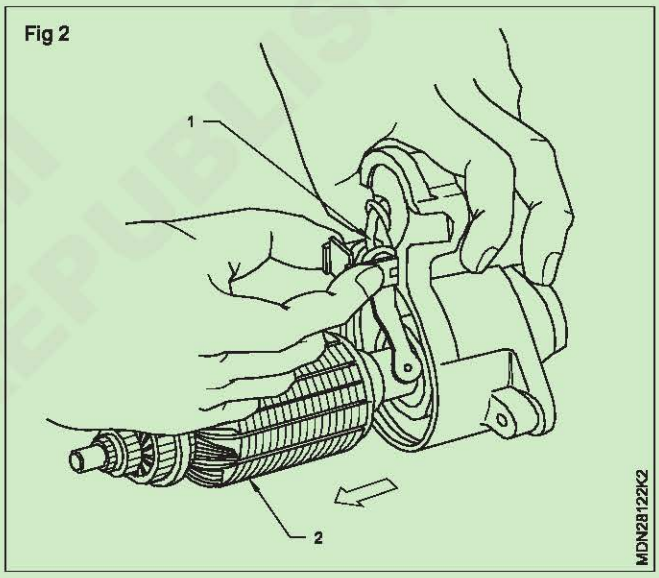
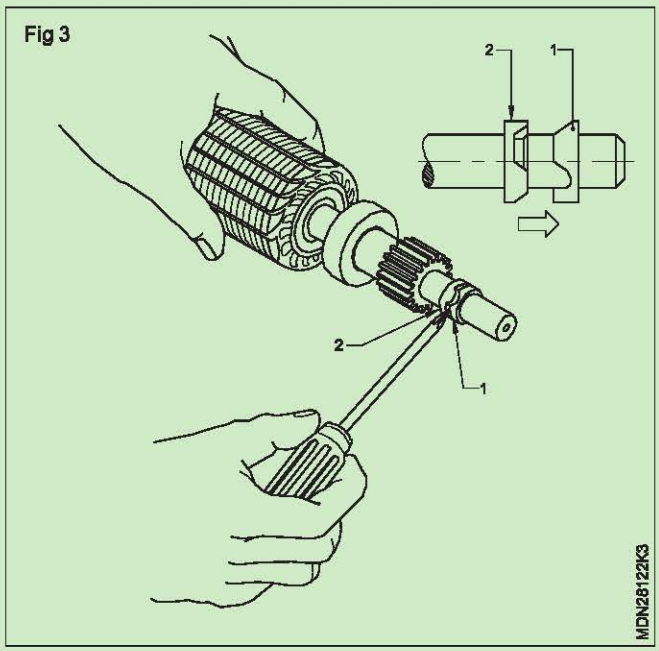


Fig 3

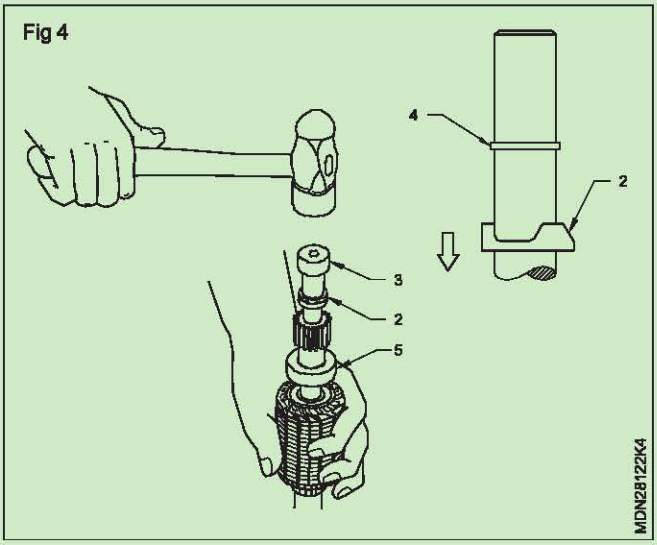


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9 Using a 14 mm socket (3) push the rear stop collar (2) downwards. (Fig 1).

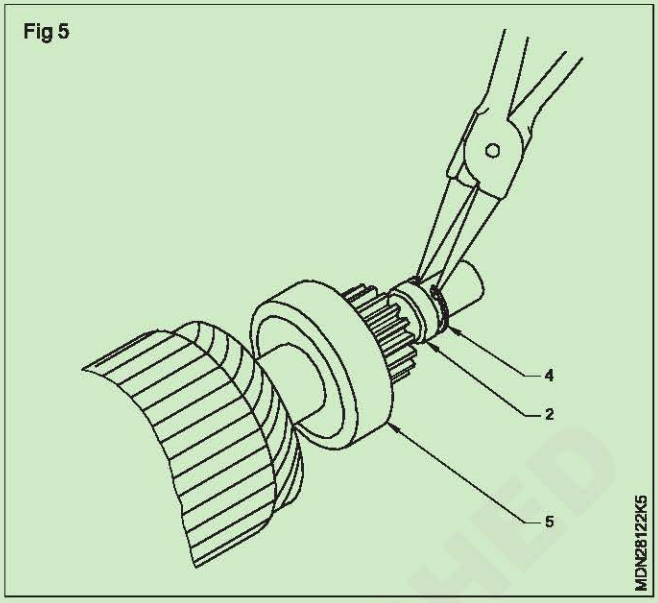
10 Remove the armature circlip (4) by using a circlip plier, and with the help of a screw driver.

Fig 4



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

Fig 5

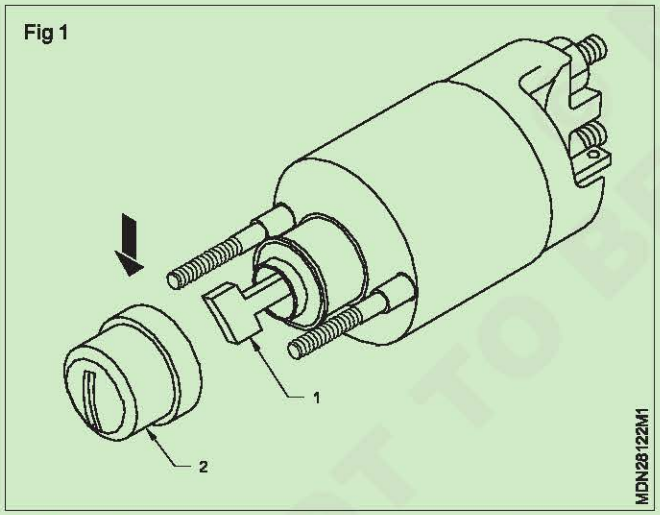


TASK 4: **Magnetic Switch (Solenoid switch)**

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

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

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 1) 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)

Fig 2

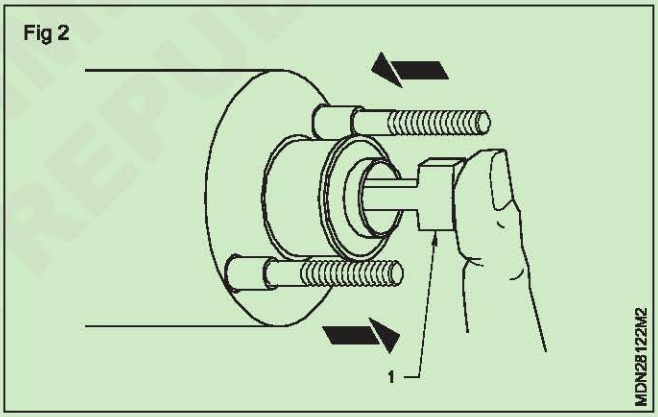
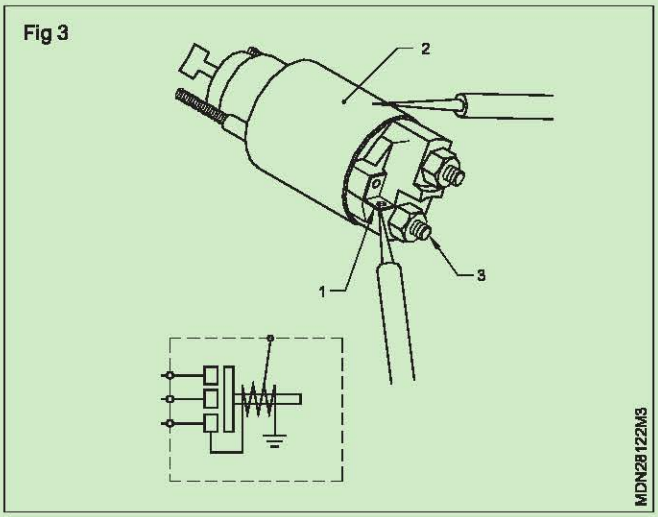


Fig 3



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TASK 5: **Armature for ground**

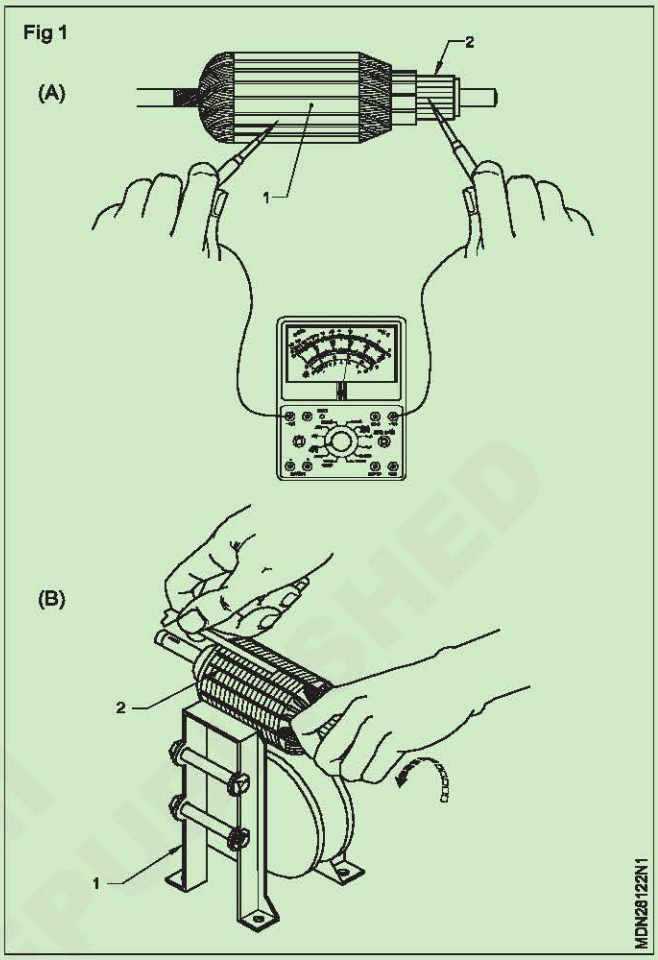
1 Using an ohmmeter test for continuity between the commutator (2) and armature core (1). The ohmmeter will indicate infinite resistance if the insulation is in sound condition. (Fig 1A)

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)

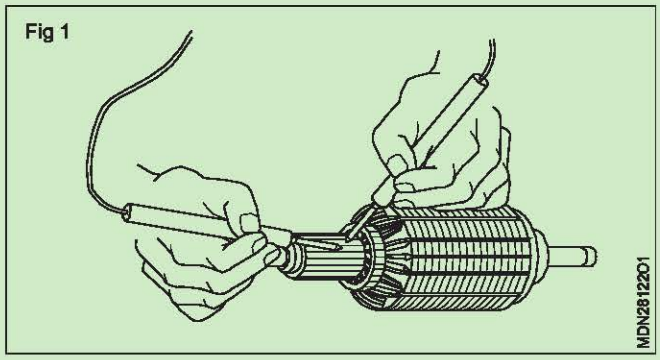
5 The steel strip will vibrate if a coil is shorted. Then replace the armature.



TASK 6: **Open circuit**

1 Check for continuity between each pair of adjacent commutator segments, using an ohmmeter. (Fig 1).

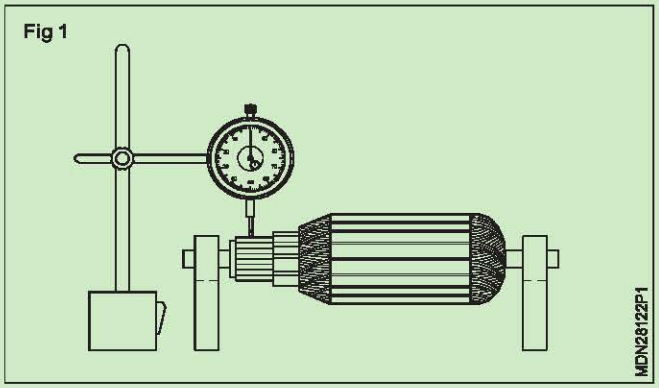
2 If there is any discontinuity the ohmmeter needle will not deflect. Replace the armature assembly. (Fig 1)



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)

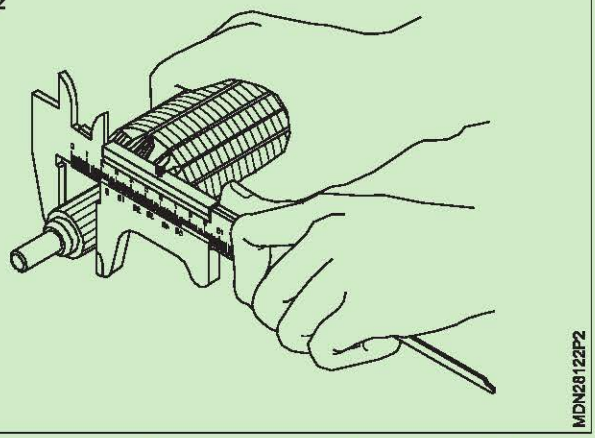


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3 Correct it on lathe if required. (Fig 2)

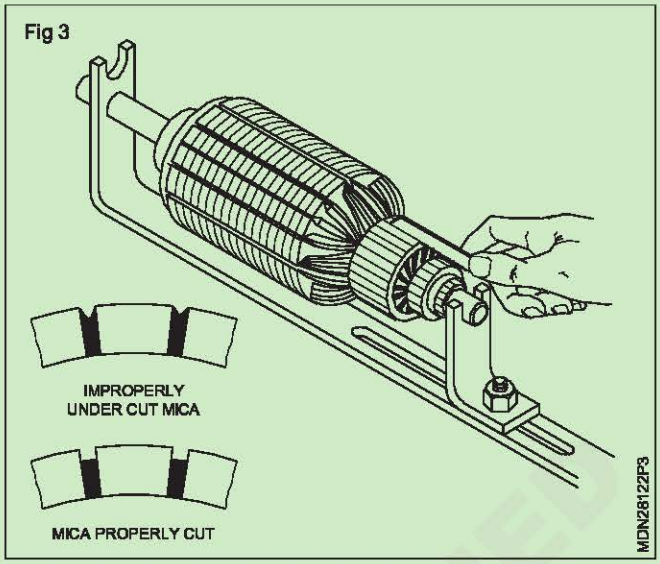
4 Check for wear and replace the commutator if the diameter is below limit. (Fig 2)

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)

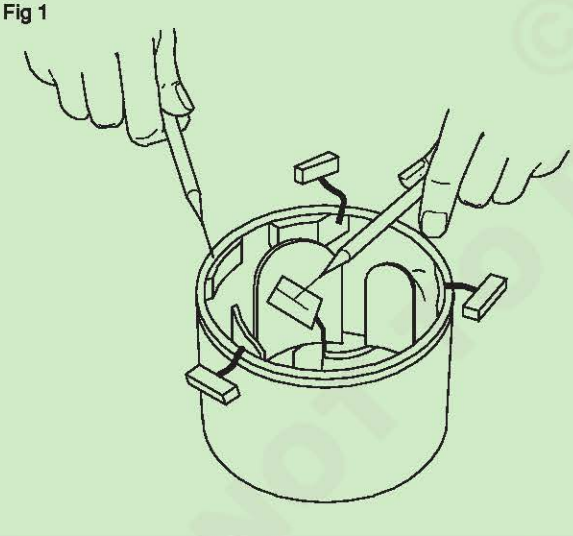
Fig 3



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.

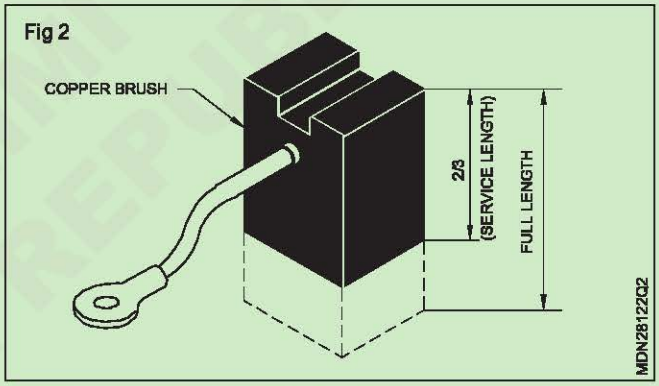
Fig 1



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.

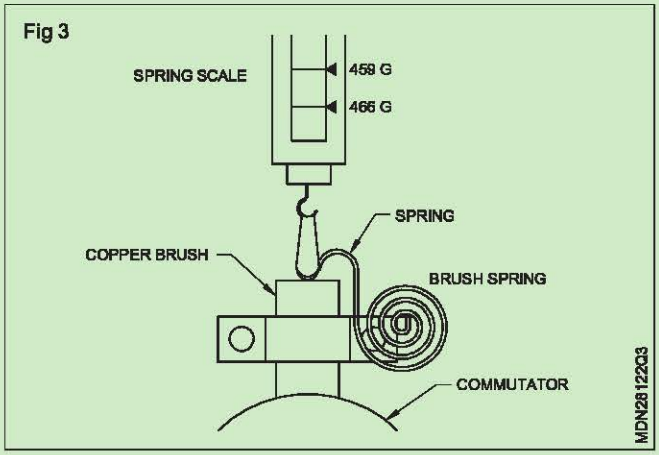
3 Check the brush springs (1) for tension, rust or breakage. (Fig 2)

Fig 2



4 Check brush holder for insulation and earth (Fig 3)

Fig 3



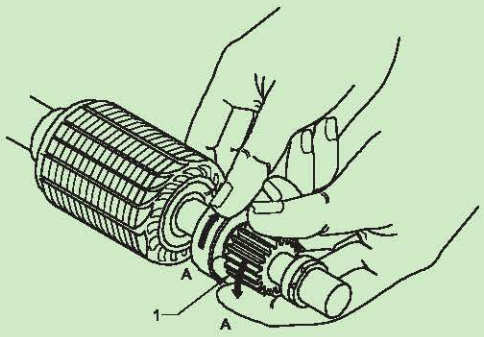
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TASK 9 : **Over-running clutch**

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)

Fig 1



3 Armature shaft and drive end cover bush

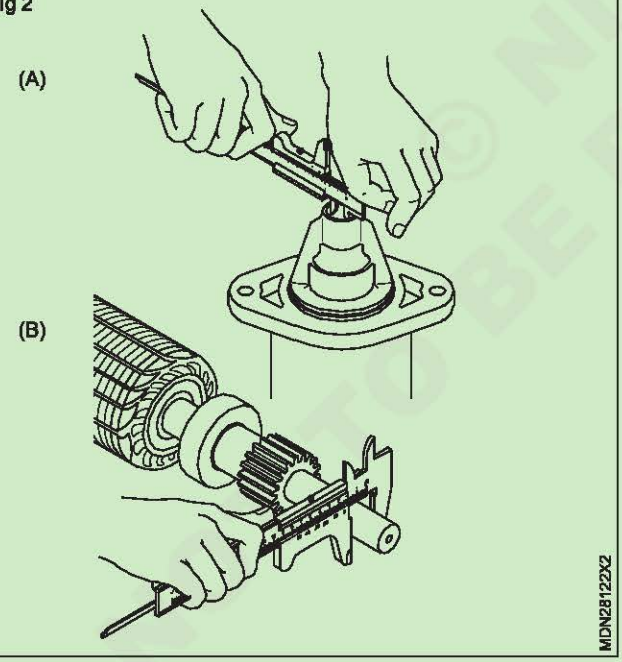
4 Using a 10 mm rod, take out the bush cap.

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)

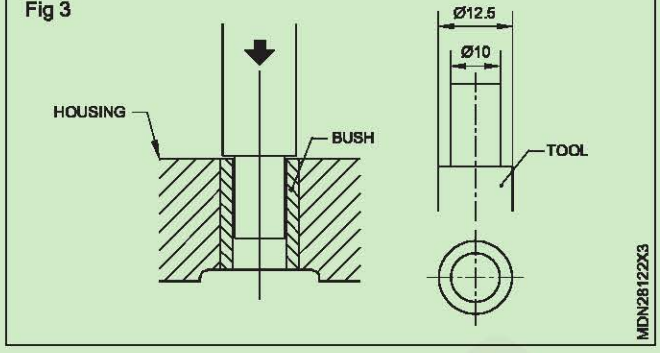
7 If clearance exceeds the limit, replace the bush.

Fig 2



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

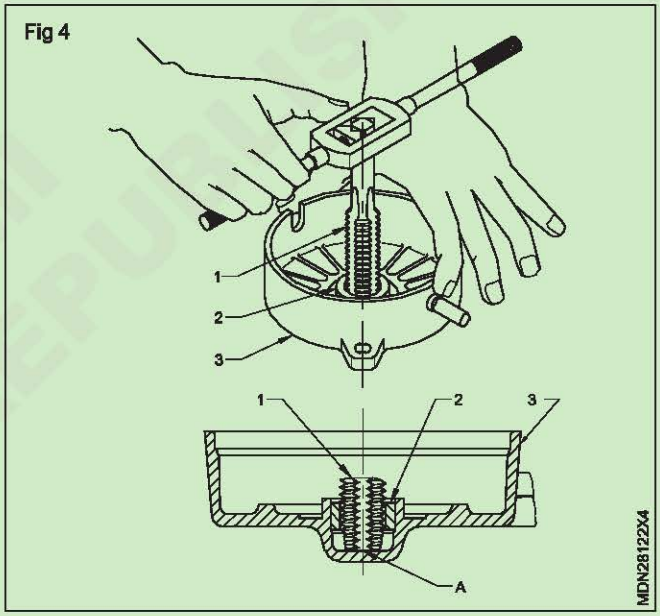
Fig 3



9 Measure the outer diameter of armature shaft at the commutator end.

10 If clearance exceeds the limits, replace the bush. (Fig 4)

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 arbor 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).

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Fig 1

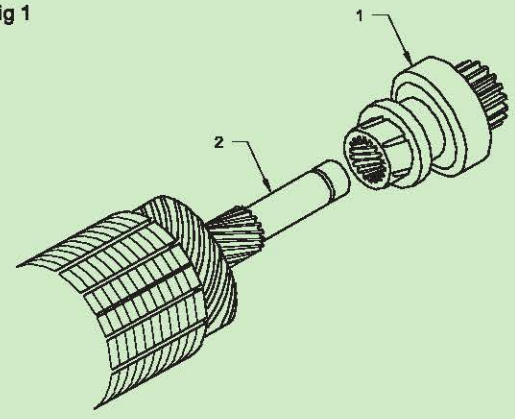


Fig 2

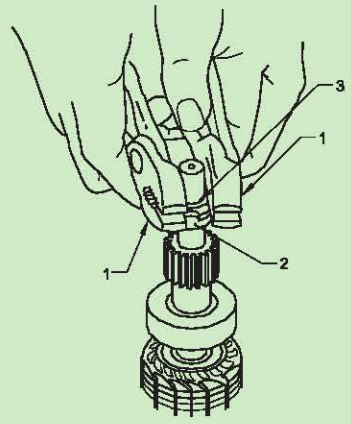
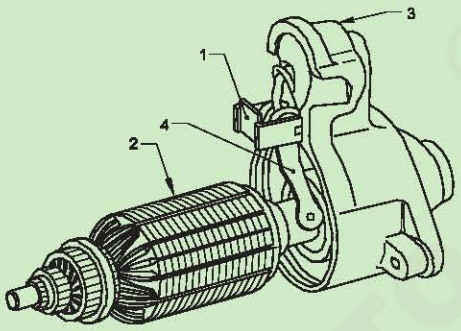


Fig 3



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.

Fig 4

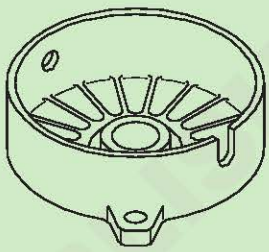
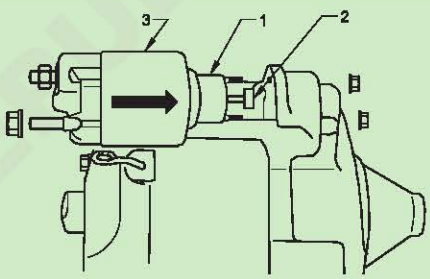


Fig 5



TASK 11: **Performance test and remounting**

1 Pull in test

– Hold starting motor in vice or stand.

– Disconnect fled 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.

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Fig 1

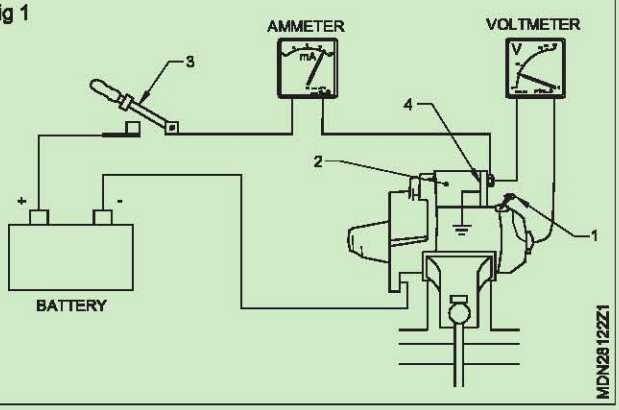
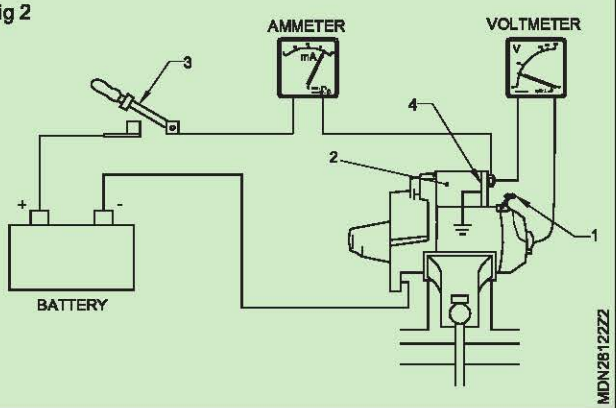


Fig 2



5 Place the starter motor in its position on the vehicle.

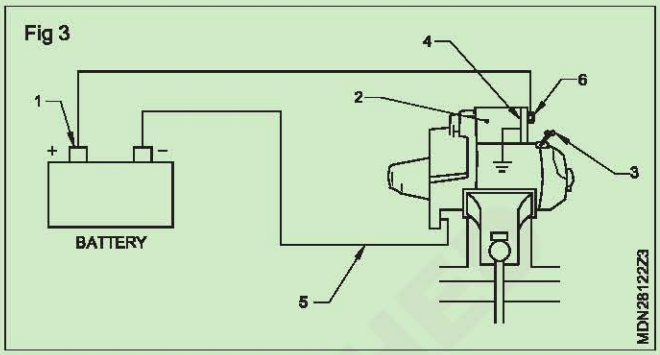
6 Tighten the two mounting bolts.

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.

Fig 3



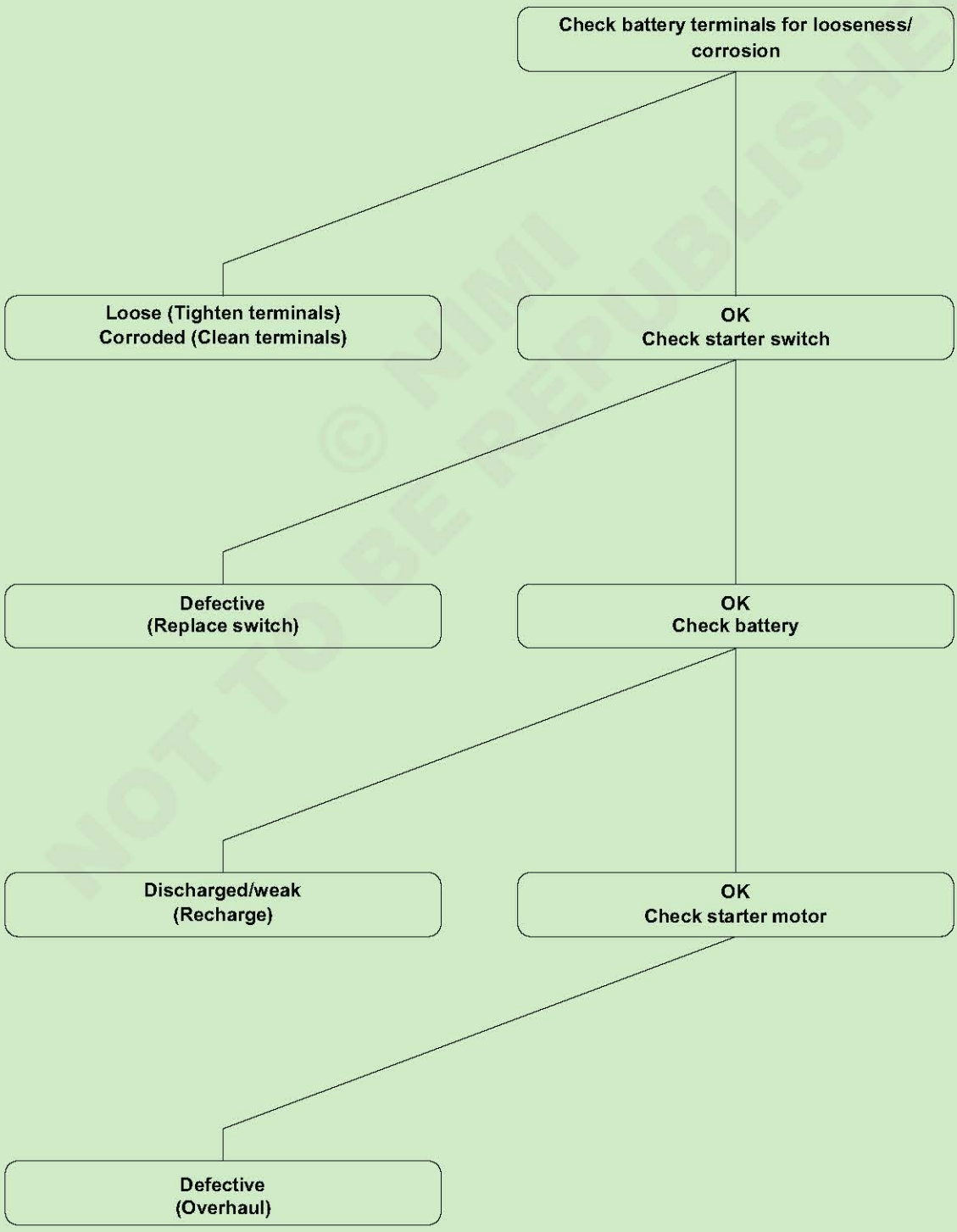
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Diesel engine trouble shooting

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

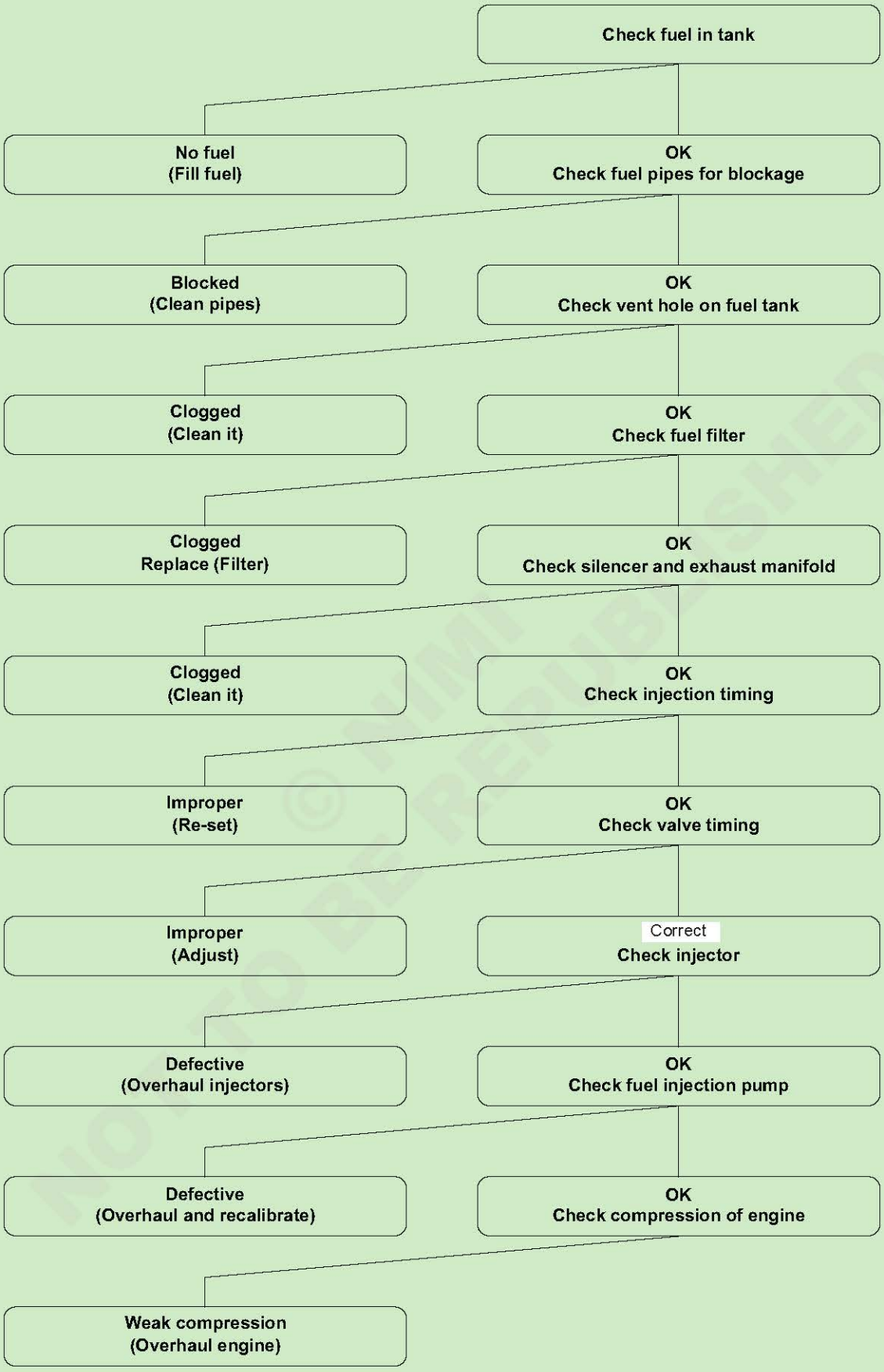
- **rectify the causes for engine does not start (Mechanical)**
- **rectify the causes for engine does not start (Electrical)**
- **rectify the causes for high fuel consumption**
- **rectify the causes for engine over heating**
- **rectify the causes for low power generation**
- **rectify the causes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

(I) Engine does not start (electrical causes)



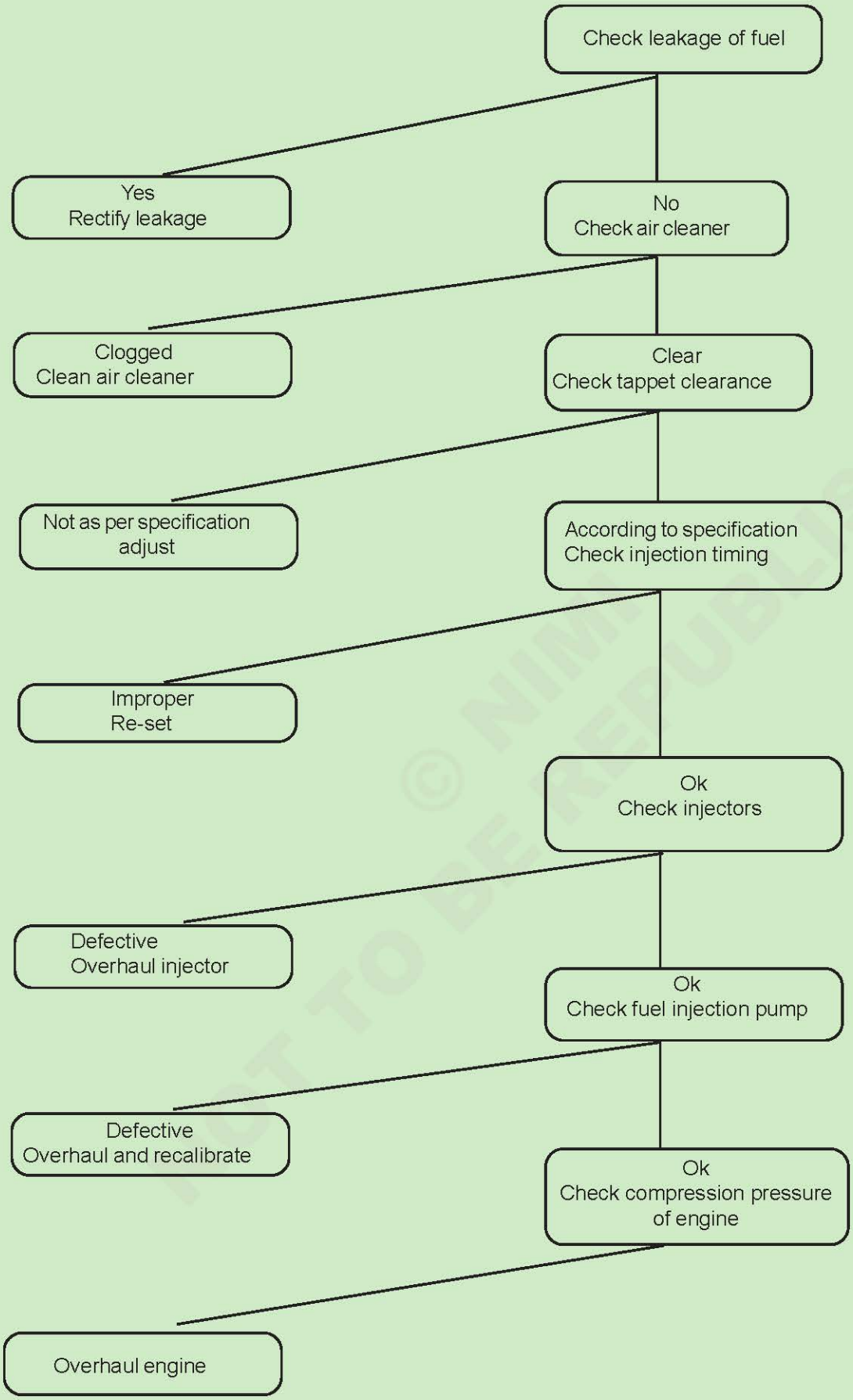
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(II) Engine does not start (mechanical causes)



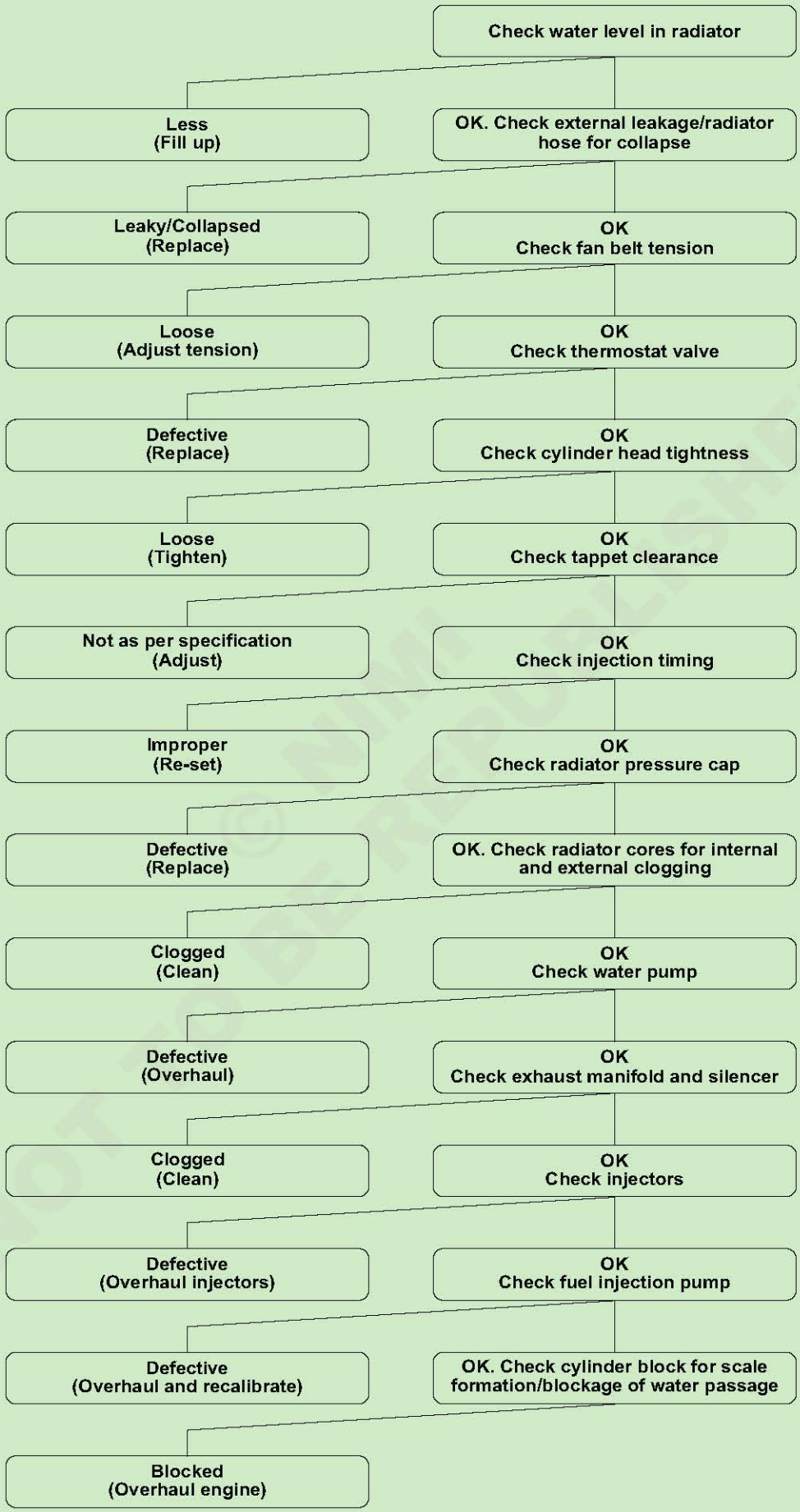
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(III) High fuel consumption (diesel)



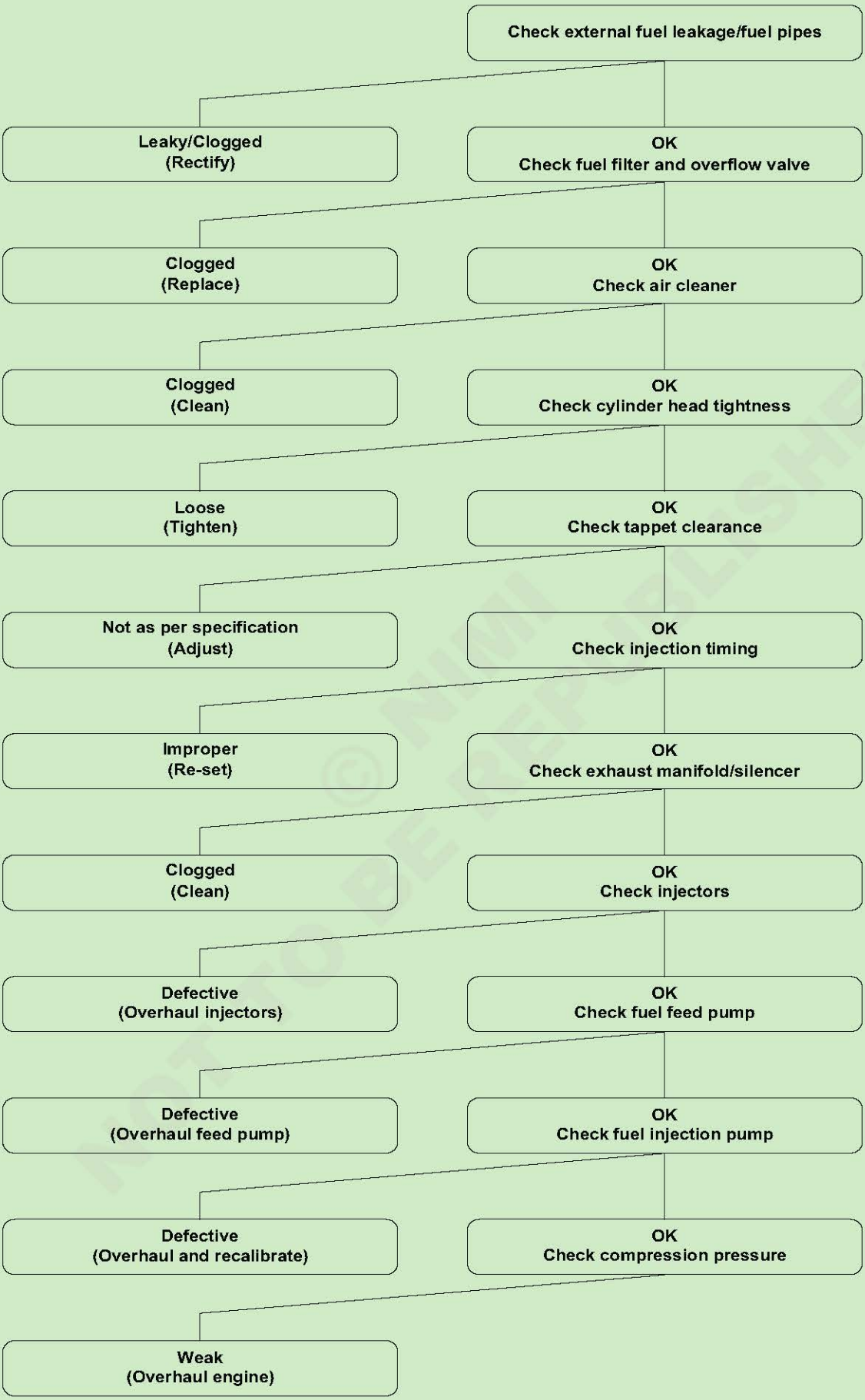
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(IV) Engine over heating



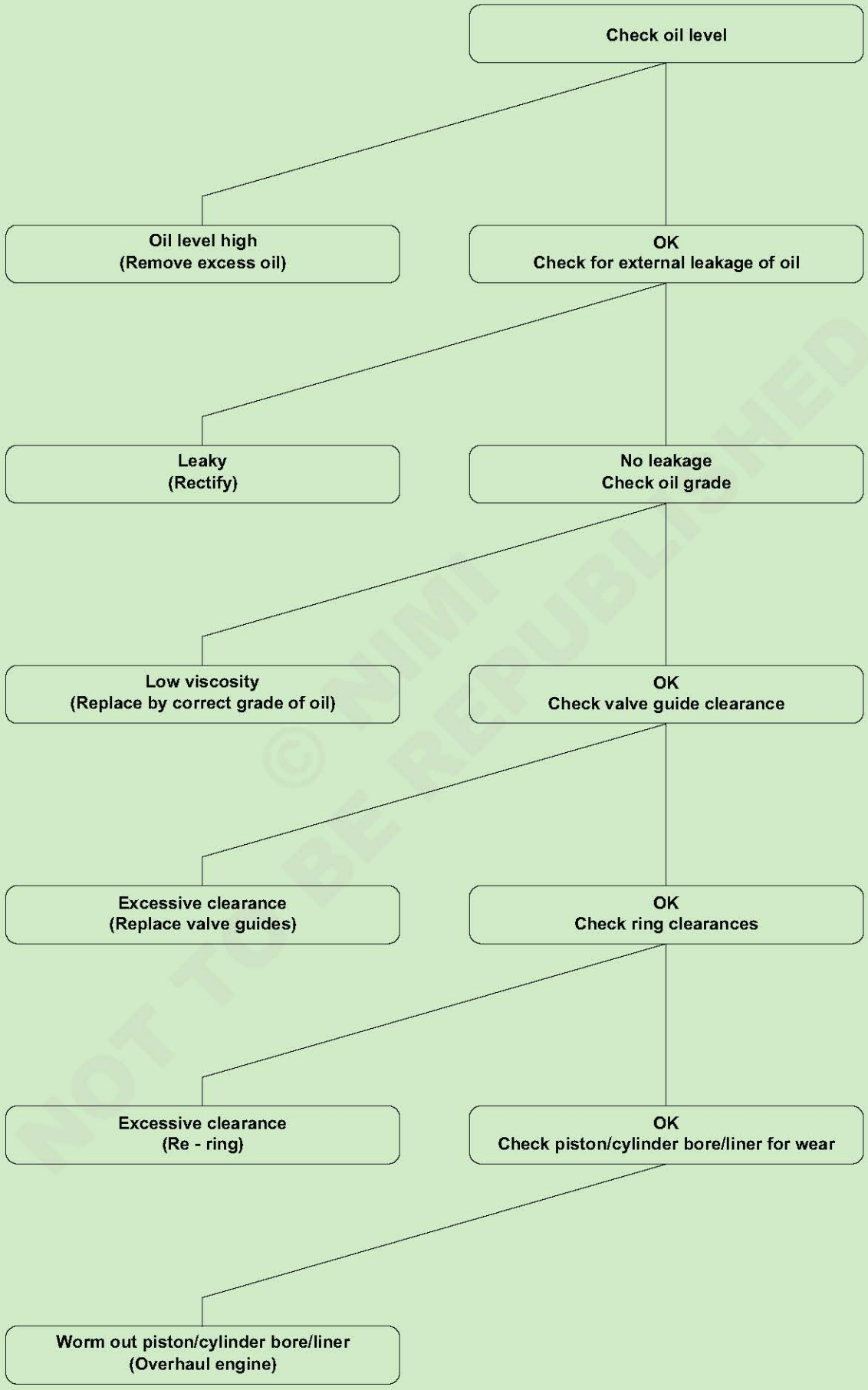
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(V) Low power generation



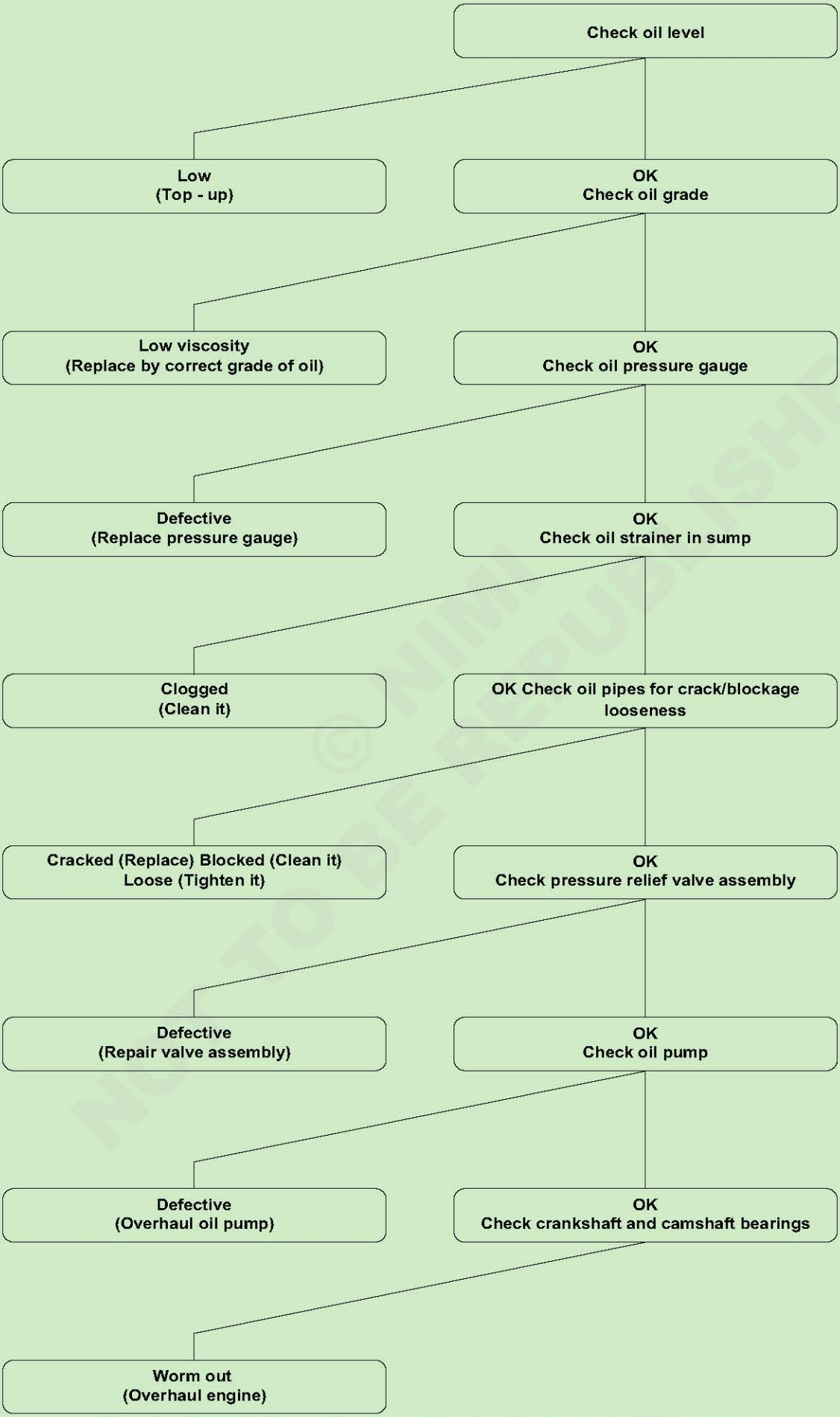
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(VI) Excessive oil consumption



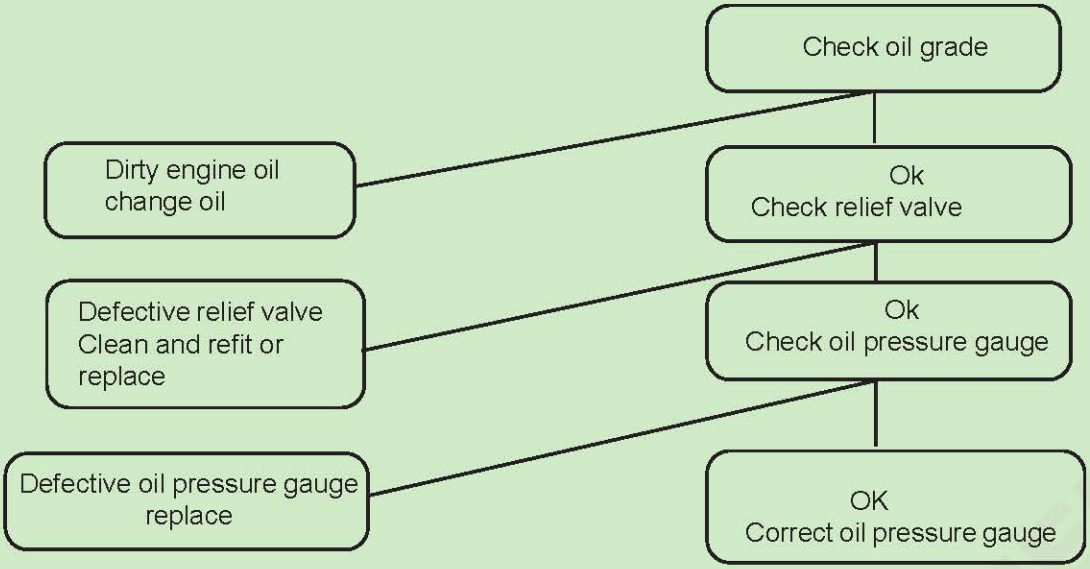
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(VII) Low oil pressure

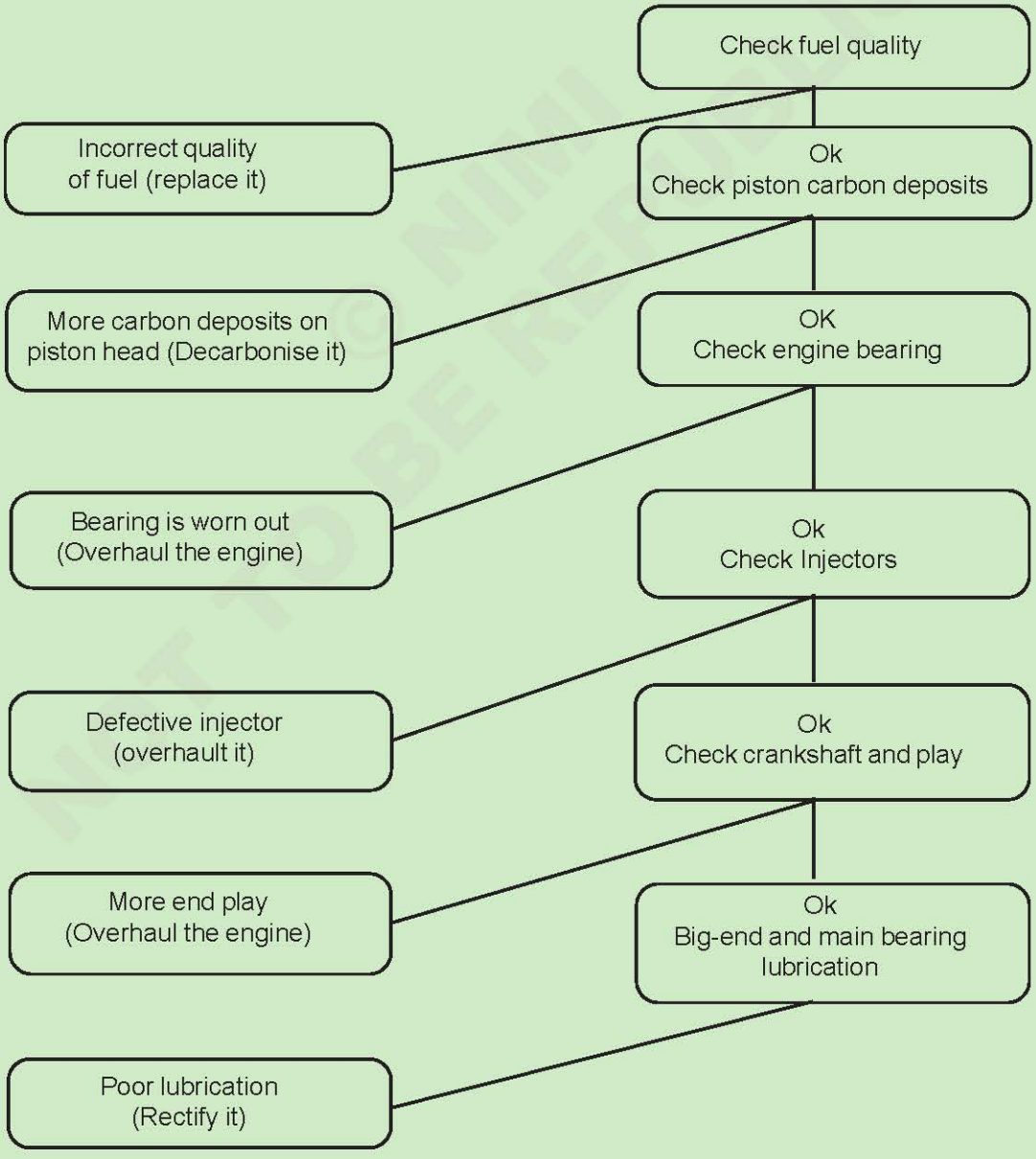


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(VIII) High oil pressure



(IX) Engine noise



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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 turbo-charger 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	●	●	●	●				●			

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